BC Hydro Seed: Technical, Environmental, and Socio-economic Study

Emery Barnes Park and Nelson Park/Lord Roberts Annex: Proposed Underground Substations

Prepared for:

BC Hydro
333 Dunsmuir Street
Vancouver, British Columbia

Stantec

1100 – 111 Dunsmuir Street
Vancouver, British Columbia

Sign-Off Sheet

This document titled BC Hydro Seed: Technical, Environmental and Socio-economic Study was prepared by (“Stantec”) for the account of BC Hydro (the “Client”) to provide information regarding a preliminary idea to build two underground substations in Downtown Vancouver. This report was undertaken based on a pre-design stage level of information (i.e., highly conceptual), and the potential for effects may change as the design evolves. As the designs develop, better predictions on environmental and socio-economic effects can be made. Mitigation measures will also evolve so that potential adverse effects are either avoided or reduced to an acceptable level. If the seed concept is not approved, and BC Hydro adopts its traditional approach of building two above-ground indoor substations in Downtown Vancouver, Stantec recommends additional studies be undertaken to confirm that construction impacts for an above-ground indoor substation would be comparable, and that operational impacts regarding safety, visual impact and noise would be greater than an underground substation.

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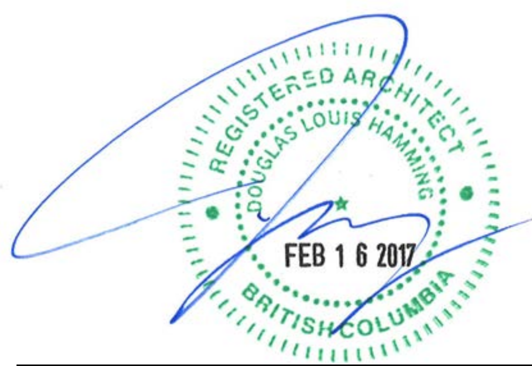
Nalon Smith, B.Sc., MLA
Landscape Architecture Lead



Doug Hamming, MAIBC
Architecture Education Lead

PROFESSIONAL
PROVINCE OF
E. A. C. CVACI
37396
BRITISH COLUMBIA
ENGINEER

Andrei Cvaci, MBA, P. Eng., PMP, LEED AP BD+C
Civil Engineering Lead

Sana Talebi, B.Sc., P.Eng.
Atmospheric Lead

Jonathan Chui, P.Eng., INCE
Acoustic Lead

Matthew Ramsay, M.Sc., P.Ag.
Urban Forestry Lead

Frank Bohlken, B.Sc., MRM
Socio-Economic Lead

Megan Willie, M.Sc., R.P.Bio.
Wildlife Lead

Stantec

Neal Cormack, B.Eng., P.Eng.
Responsible Engineer

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Executive Summary

Project Overview

To increase the reliability of existing electrical infrastructure and address growing demand for electricity in the downtown core, ageing existing substations, and seismic issues, BC Hydro is looking to expand their transmission infrastructure in downtown Vancouver. The "seed" concept being proposed by BC Hydro involves deviating from the traditional approach of building substations above ground, and adopting an alternative approach by building two new substations below ground. The land above and adjacent to the substations would be used for a new school, daycare spaces and improved parks for the local communities and the property rights compensation could be used for additional benefits such as new and refreshed park(s), another new school, and additional recreational facilities in the downtown core.

The proposed concept includes building an underground substation on Vancouver Park Board (VPB) property under Emery Barnes Park in Downtown, and for the West End, building a new underground substation on Vancouver School Board (VSB) property next to Nelson Park. Construction of the first underground substation at Nelson Park/Lord Roberts Annex in the West End would start as soon as 2020, and the second underground substation at Emery Barns Park in Yaletown starting in 2036. The proposal also includes improved green spaces at Emery Barnes Park and Cathedral Square Park in the short-term, as well as upgrades to the Cathedral Square substation.

Stantec was commissioned by BC Hydro to study the potential effects of the proposed Projects at Emery Barnes Park and Nelson Park/Lord Roberts Annex based on conceptual designs. This report was prepared at the request of the VPB and VSB. The VPB also provided direction on the detailed scope of work, and VSB provided general direction on their requirements. This report includes a brief overview of baseline conditions, potential Project impacts, key mitigation measures and recommendations for future studies. The study has been broken down into three main parts in order to specifically recognize the impacts and mitigation measures based on ownership of land. The Lord Roberts Annex land is owned by the VSB, whereas the Nelson Park and Emery Barnes Park lands are owned by VPB. The studies are also intended to support consultation with the public and other stakeholders prior to the separate and concurrent decision making process by BC Hydro, the VPB and VSB at the end of March 2017.

Next Steps

If the concept is not approved by all parties, it is Stantec's understanding that BC Hydro will advance its traditional approach of building two above-ground indoor substations, likely within a 3 block radius of the proposed project locations. Stantec recommends additional studies be undertaken to confirm that construction impacts for an above-ground indoor substation would be comparable, and that operational impacts regarding safety, visual impact and noise would be greater than an underground substation.

If the concept is approved by all parties at the end of March 2017, leasing agreements for the lands will be negotiated and finalized and BC Hydro would move forward with more detailed deigns in consultation with the public and other stakeholders. The British Columbia Utilities Commission, a regulatory agency of the Provincial Government, will also act as a decision maker through its administration of the *Utilities Commission Act*. Additional provincial and municipal permits and authorizations may also be required to advance the construction of the proposed projects.

Construction Schedule and Areas Impacted

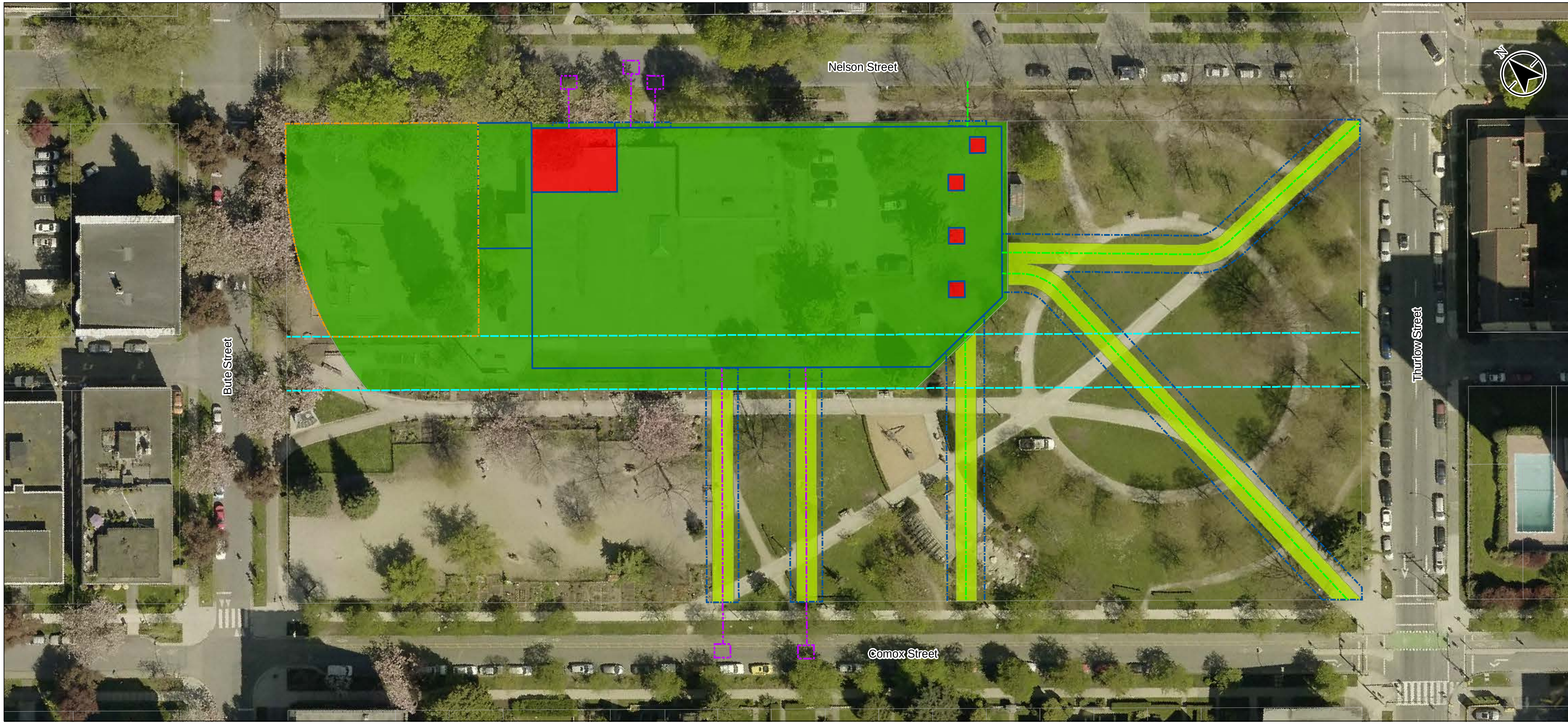
The proposed underground substations at Emery Barnes Park and Lord Roberts Annex would have similar construction sequences and schedules. Total construction time of each project will be approximately five years.

The first three years will include excavation, construction of the substation underground concrete structure and enclosing the structure. For Lord Roberts Annex, the next two years would include fit-out of the substation, installation of the transformer equipment and construction of the green space above the substation. For Emery Barnes Park, the reconstruction of the park would be completed within one year while the fit-out of the substation and installation of the transformer equipment would take the full two additional years.

Laying of the cables from the street, underground through the parks, to the substations would require one to two months within the five-year timeline.

Construction of the school would be sequenced with the construction of the substation at Lord Roberts Annex, with completion about four months ahead of the substation.

A summary of the permanent and temporary areas impacted by the proposed projects is described in Table ES-1 below and presented in Figures ES-1 for Nelson Park/Lord Roberts Annex, and Figure ES-2 for Emery Barnes Park.



- Statutory Right Of Way
- Proposed Statutory Right Of Way
- Temporary Work Area
- Proposed Distribution Duct
- Proposed Transmission Duct
- Proposed Substation
- Property Line

Construction Impact and Duration

- Permanent
- Temporary, min. 3 years
- Temporary, 1-2 months

0 10 20 metres

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Stantec

Project Location 123220737

Vancouver, BC

Prepared by L. Trudell 2017-02-15

Reviewed by L. Thompson 2017-02-15

Client/Project

Lord Roberts School Annex / Nelson Park

BC Hydro SEED Program Study

Figure No.

ES-1

Title

Lord Roberts School Annex / Nelson Park Construction Impact and Timelines

Notes

1. Coordinate System: NAD 1983 UTM Zone 10N
2. Base features: DataBC, Government of British Columbia (GovBC); Surrey History National Topographic System, GovBC; CanVec v12,Government of Canada (GC)
3. Orthoimagery: City of Vancouver Open Data catalogue 2015

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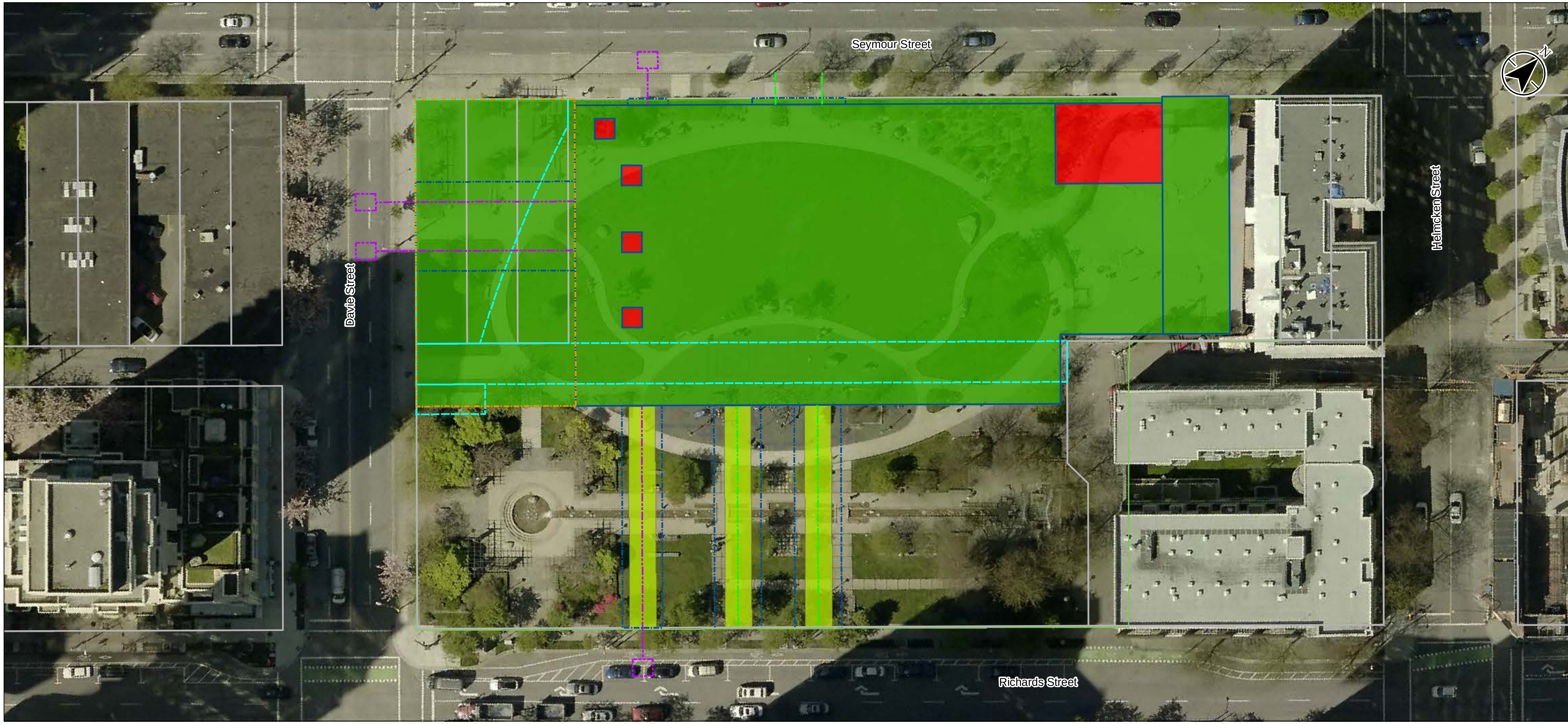

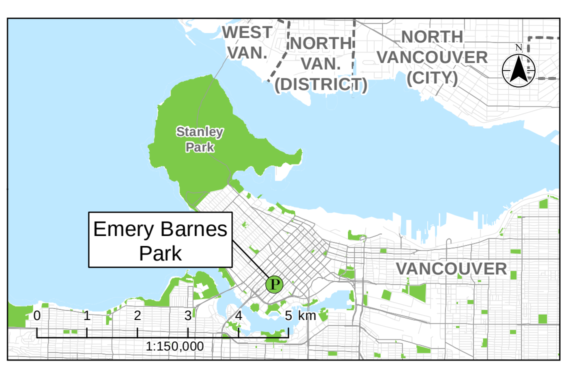

Road segment
- Statutory Right Of Way
- Proposed Statutory Right Of Way
- Temporary Work Area
- Proposed Distribution Duct
- Proposed Transmission Duct
- Proposed Substation
- Property Boundary

Construction Impact and Duration
- Permanent
- Temporary, min. 3 years
- Temporary, 1-2 months

0 10 20 metres

1:600 (At original document size of 11x17)

Stantec

Project Location: Vancouver, BC

123220737
Prepared by L. Trudell 2017-02-15
Reviewed by L. Thompson 2017-02-15

Client/Project
Emery Barnes Park

BC Hydro SEED Program Study

Figure No.
ES-2

Title
Emery Barnes Park
Construction Impact and Timelines

Notes
1. Coordinate System: NAD 1983 UTM Zone 10N
2. Base features: DataBC, Government of British Columbia (GovBC); Surrey History National Topographic System, GovBC; CanVec v12,Government of Canada (GC)
3. Orthoimagery: City of Vancouver Open Data catalogue 2015

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Table ES-1 Construction Impact and Duration

Site	Construction Impact and Duration	Area (m^2)	Percent
Lord Roberts Annex	Permanently Lost: BC Hydro Infrastructure	228	4%
	Temporary Lost: Substation Construction (min. 3 years)	6,177	96%
	Temporary Lost: Cable Installation (1-2 months)	0	0
	Not impacted	0	0
	Total Area	**6,405**	
Nelson Park	Permanently Lost: BC Hydro Infrastructure	0	0
	Temporary Lost: Substation Construction (min. 3 years)	0	0
	Temporary Lost: Cable Installation (1-2 months)	1,171	10%
	Not impacted	10,487	90%
	Total Area	**11,658**	
Emery Barnes Park	Permanently Lost: BC Hydro Infrastructure	228	3%
	Temporary Lost: Substation Construction (min. 3 years)	4,014	45%
	Temporary Lost: Cable Installation (1-2 months)	400	4%
	Not impacted	4,326	48%
	Total Area	**8,967**	

At the Lord Roberts Annex site, construction of the underground substation will temporarily impact an area of 6,405 m^2 or 100% of the VSB lands for approximately three years. Once construction is complete, 228 m^2 or 4% of the VSB lands will be permanently lost due to the space required for BC Hydro infrastructure, including the vehicle access/intake structure and exhaust shafts. The remaining 6,177 m^2, or 96% of the land will be available for the new school and sports field.

At Nelson Park, installing the underground cables will temporarily impact an area of 1,171 m^2, or 10% of the park for approximately one to two months. Once construction is complete, there will be no permanent loss to the park area, or VPB lands due to BC Hydro infrastructure.

At Emery Barnes Park, construction of the underground substation will temporarily impact 4,014 m^2, or 45% of the park for approximately three years. Installation of the underground cables will also temporarily impact 400 m^2, or 4% of the park for approximately one to two months. Once construction is complete, 228 m^2 or 3% of the VPB lands at Emery Barnes park will be permanently lost due to the space required for BC Hydro infrastructure, including the vehicle access/intake structure and exhaust shafts. The remaining 97% of the VPB land will be available to park users.

Options to incorporate the vent shafts into the design of the new school and park, or allocate them to the perimeter of the properties may further reduce the amount of permanently lost space.

Lord Roberts Annex

Background

Opened in 1972, the Kindergarten to Grade 3 Lord Roberts Annex (the Annex) currently has an enrollment of 140 students. The Annex is connected to Nelson Park, a well-used greenspace for the highly-densified neighbourhood.

The Annex has a Facility Condition Index (FCI) of 0.75. A rating of 0.60 or above does not meet requirements and needs immediate attention to most of its building systems. Most of the building systems are at the end of their life cycle and the risk for system failure is high.

The VSB requires a significantly larger capacity full K to 7 school to replace its current K to 3 Lord Roberts Annex school which is too small to serve current and future school population in the West End. There is also a need for additional childcare in the West End as well as additional all-weather play field space.

Proposed School Project

The seed concept proposes to replace the existing Annex with a -510 capacity modern 21st Century multi-storey school that will cater to kindergarten to grade seven with underground parking facilities. The exterior play areas will be located to south and east of the school with a new artificial turf play field located on top of the roof of the substation to the east.

The new state of the art school is proposed to be net-zero energy use, Passivhaus and/or LEED Gold Certified and would include many more classrooms than currently available at the Annex. It would include a larger gymnasium, library, and multipurpose room that could provide up to 45 spaces for before-and-after school childcare. A City of Vancouver (COV) 0 to 4 childcare is also proposed to be located on the top floor of the new school. The model of combined school and childcare would be a partnership agreement between the VPB and COV to provide much needed non-profit childcare spaces to the West End. This model is currently being implemented at three other replacement schools: Nelson Elementary school which is currently in construction and, Fleming Elementary school and Tennyson Elementary school which are currently in design.

Environmental Studies

Vegetation

As of 2014, the urban forest canopy cover in the West End neighbourhood was approximately 18.6% (City of Vancouver 2014a). Lord Roberts Annex school property has an existing canopy cover of 36%. A total of 39 trees were recorded on the school grounds during a recent field survey, of this total 38 are ≥20 cm diameter at breast height (DBH). No invasive plants, noxious weeds or rare plant species were observed during field surveys.

Based on the conceptual design of the substation, most (approximately 95%) of the existing canopy cover will be lost within the Lord Roberts Annex school property during construction, including 36 trees that are ≥ 20 cm DBH, and one tree that is < 20 cm DBH. This temporary loss of urban canopy includes the loss of ecological functions provided by the urban forest within the park such as habitat for pollinators and urban wildlife, as well as values such as shade. However, the temporary loss of urban canopy can be replaced in the long-term so that there is no net-loss of trees.

Various mitigation measures are recommended for each phase of the Project. Mitigation measures during construction are intended to protect retained trees along the perimeter of the Project footprint and relocate smaller trees within Nelson Park or to nearby parks or streets. Recommended mitigation measures during construction also guide the handling and transportation of soils to reduce erosion and sedimentation, as well as reduce the risk of introduction of invasive plant species. The risk of flooding or drought to trees would be mitigated through surface run-off and groundwater management. Mitigation measures would be implemented to maintain pre-construction drainage patterns to reduce long-term adverse effects on vegetation.

Mitigation measures following construction include working with the VPB to replace the number of trees required by the City of Vancouver. Although large trees cannot be replanted on top of the substation and underground infrastructure, other vegetation such as grass, small shrubs, or possibly small trees (e.g., <5 m height, and <15 cm DBH, at maturity) could be replanted to restore the school grounds following construction and partially offset temporary losses of the urban canopy. A detailed landscape design for the new school grounds would be prepared that incorporates the design constraints presented by the completed Project, while aiming to replace as much of the tree canopy on-site and in-kind as is feasible. The post-construction landscape design for the school grounds would be prepared as a future phase of work following this initial impact and mitigation report.

Final mitigations would be subject to approval by the VSB and VPB.

Electric and Magnetic Fields (EMF)

Stantec Consulting Ltd. contracted Aura Health and Safety Corporation to conduct a study to evaluate the impact of EMF that could result from the Project. Available reports of baseline electric and magnetic field (EMF) measurements around the proposed school site and measurements taken at and above Cathedral Square underground substation (which is similar to the proposed substation) were reviewed. A search of the literature was conducted to find other studies on EMF levels at or near substations, particularly of underground substations. International guidelines and reports on EMF were reviewed to compare predicted exposures with guideline levels and to determine exposure risk to humans. From the exposure and health guideline information, risk categories were assigned. Categories were selected based on two criteria: predicted approximate exposures to human populations, and predicted perceived risk to human populations.

The Lord Roberts Annex is expected to be moved from the current site to the west of the underground substation. As the substation is not expected to produce measurable levels of EMF outside its perimeter and there are no transmission or distribution lines expected to be under the proposed new Annex, the levels above ground at the new Annex are not expected to vary much from the current baseline values at the existing site. A recent review of the literature (2012-2016) indicates there is no new evidence that changes the conclusion of both Health Canada and World Health Organization that there are no confirmed health consequences associated with exposure to low level electromagnetic fields (Exponent, 2017). The risk of impacts from EMF at Lord Roberts Annex is low.

No engineering mitigation strategies would need to be considered as it is expected that the substation and infrastructure would not be impacting the Annex from an EMF perspective. Information sharing and communications in regards to the placement of the substation and transmission and distribution lines may relieve any public perception of risk.

When engineering designs for the proposed substation becomes available, the EMF levels should be modelled for the substation and surrounding areas, and this information should be shared with the public. See Appendix E for additional information on the EMF study completed by Aura Health and Safety Corporation.

Air Quality

Baseline or existing air quality measurements were determined from the two nearest, most representative, continuous air monitoring station in proximity to the Lord Roberts Annex. Generally, the baseline ambient air quality in the vicinity of Lord Roberts Annex is good. Expected sources of criteria air contaminants (CAC) near Lord Roberts Annex include: vehicular traffic, space heating, and other dust sources.

Impacts to air quality were studied based on emission factors from estimated representative off-road excavation and construction equipment. Sources of particulate matter from wind erosion and dust from mobile equipment were not quantified in this study as these sources are difficult to quantify and are highly dependent on the activities/techniques used onsite.

Based on professional judgement and a qualitative assessment of the type, duration and frequency of construction activities, it is predicted that construction of the substation will increase CAC concentrations in the vicinity of Lord Roberts Annex during construction. If best management practices to control CAC emissions are implemented, the degree of change to CAC concentrations is expected to be low. Activities will also be limited to daytime hours, temporary, and irregular in occurrence. As well, impacts would be reversible upon completion of the construction phase. During operations, no air quality impacts are expected as activities will be limited to the venting of air for equipment cooling and maintaining indoor air quality within the substation.

Potential mitigation measures may include, but are not limited to the implementation of best management practices such as watering surfaces prone to wind to suppress fugitive dust, maintaining vehicles in good operating condition, using modern (Tier 3) construction equipment, and reducing idling. Investigating the cause of complaints (if any) may also help yield continuous improvement during construction.

Noise

The acoustic baseline condition was determined by conducting continuous noise measurement within Nelson Park and Lord Roberts Annex on January 20, 2017. During the daytime period, the existing acoustic environment is influenced by local activities within the park (e.g., people, dogs), Lord Roberts Annex (i.e., lunch, recess), natural environment (i.e., wind and birds), and vehicle traffic on the surrounding roads as well as air traffic.

Worst case noise predictions for the construction and operations phase were performed using Cadna/A acoustic modeling software (DataKustik 2015) and in accordance with the internationally accepted sound propagation algorithms (ISO 1993, 1996). During construction, heavy construction equipment such as excavators and jack hammers will generate noise. During operations, noise will be primarily associated with the operation of ventilation equipment for the substation located adjacent to Lord Roberts Annex.

During activities such as jack hammering, the noise level at the nearest point of reception are predicted to be as high as 108.9 dBA., exceeding the noise limit of 85 dBA prescribed in the City of Vancouver Noise By-Law. During operations, noise from the substation ventilation system is predicted to be below the continuous daytime and nighttime quiet zone noise limits of 55 dBA and 45 dBA, respectively for Nelson Park.

Potential mitigation measures to reduce sound levels to allowable limits may include, but are not limited to constructing a 2 m high temporary barrier around the entire construction site to reduce the noise effect by 5 to 10 dBA, and using quieter equipment. Silencers could also be installed on ventilation air inlet and ventilation exhausts. Additional studies could also be implemented to monitor noise levels at night to support a better understanding of ambient conditions, and complete additional modelling once a detailed inventory of construction equipment is known.

Vibration

The vibration study focuses on ground vibration effects from construction equipment, as ground-borne vibration has the potential to affect human health and structural integrity of buildings. The vibration study area extends 200 m out from the project boundary. Vibration effects are not expected during the operation phase of the Project.

There is no available construction vibration guidance for the City of Vancouver or any provincial vibration by-law for construction activities in British Columbia. A such, the City of Toronto Construction Vibration Limit (By-Law No. 514-2008) was referenced for comparison, with a focus on structural damage thresholds. Vibration effects during construction include excavation, earthworks, construction of the facility and drilling activities. Blasting and pile driving activities are not planned for the construction of the Project.

At the Lord Roberts Annex site, the predicted vibration effects due to excavation and drilling at the closest point of reception is below the recommended structural damage threshold level of 8 mm/s. However, the perceptibility threshold varies from person to person and could result in annoyance.

Vibration can be mitigated by reducing the dynamic forces associated with construction equipment or by isolation. Potential mitigation measures to reduce the vibration effects in order to meet the recommended level of 8 mm/s (City of Toronto Construction Vibration Limit) during construction activities include, but are not limited to confining vibration-generating operations to the least vibration-sensitive part of the day, consulting with the community regarding proposed events, or using smaller equipment or alternative equipment when working close to residential buildings.

Subsurface Hydrology and Ground Conditions

The proposed Nelson Park underground substation will require an excavation depth of approximately 37 m below existing ground level. Data from the Geological Survey of Canada map for Vancouver (Map 1486A), Google Earth imagery, and previous Stantec projects in close proximity to the Project site indicates that the Nelson Park site bedrock, comprised of interbedded sandstone and shale, is within 10 m or less of the surface. Glaciated till soils are comprised of clay, silt, sand, gravel, and cobbles with the occasional boulder, overlay the bedrock. Top soil and fill materials likely comprise the upper 1 to 2 m above the till soils. Perched groundwater is expected at variable depths, depending on the season and weather conditions.

Excavation of soil and rock to construct the underground substation structures is likely to cause noise, vibrations, and dust, all of which are associated with normal construction activities. Excavation of bedrock may involve the use of heavier than normal construction equipment which will require consideration to limit potential impact to nearby structures or nuisance to the local public. Ground subsidence associated with temporary groundwater control is considered to be a low risk to the proposed Lord Roberts Annex project. The risk of ground movement associated with the excavation of soil and rock is also considered to be limited.

Suggested activities to mitigate impacts include, but are not limited to: avoiding potentially noisy construction activities (e.g., excavation) during nighttime hours, using noise barriers and protection blankets during excavation to reduce noise transmittal, limiting generation of dust by wetting surfaces during excavation and covering excavated material prior to and during transport. Geotechnical and groundwater investigations should be undertaken during detailed design to confirm all assumptions made during conceptual design. Condition surveys of nearby structure should be conducted to check for defects or structural weaknesses, to assess the potential risk of damage during construction. Special measures can be provided for temporary and permanent stability if required.

Birds and Other Wildlife

Field surveys conducted by two qualified biologists were completed at Lord Roberts Annex on January 18 and 27, 2017, to record observations and assess value for birds and other wildlife. The Lord Roberts Annex property includes 39 urban trees, which support nesting, foraging, and daytime roosting opportunities for urban birds and other wildlife. One mammal and eight bird species were detected during the field survey and one eastern grey squirrel nest and two northwestern crow nests were detected.

Permanent removal or alteration of trees and understory vegetation at Lord Roberts Annex will reduce nesting, foraging, and daytime roosting opportunities for migratory, resident, and overwintering birds as well as other urban wildlife (e.g., racoons, skunks). Tree removal and reduction in canopy cover will further reduce habitat connectivity for some species. Based on the current proposed conceptual design of the Project, 37 trees will be removed. If construction activities at Lord Roberts Annex are scheduled to coincide with the nesting window for migratory birds, there may be increased potential for incidental take (i.e., mortality or destruction) of breeding individuals and nests located in sections of the park that are subject to vegetation clearing. Sensory disturbance due to noise and vibrations, can also result in avoidance behaviour for birds and other wildlife at Lord Roberts Annex. Noise levels at 70 dB are expected to cause disturbance in the vicinity of the noise source for the duration of construction. Current evidence does not confirm that low levels of EMF exposure result in definitive health or behavioral consequences for birds and other wildlife.

Potential mitigation measures to reduce impacts to birds and other wildlife include, but are not limited to avoiding vegetation clearing during the breeding season for migratory birds (March 28 through August 8) and raptors (February 5 through August 31) to avoid incidental take, and implementing waste management practices to reduce potential wildlife attractants. It is recommended that a pre-construction survey be completed by a qualified biologist to re-assess the presence of wildlife habitat features of concern (e.g., raptor nests, wildlife trees) within the park limits prior to vegetation clearing.

Social Studies

Public Safety—Crime Prevention

A desktop study was undertaken based on the design principles and strategies identified by the National Crime Prevention Council's *Crime Prevention Through Environmental Design (CPTED) Guidebook (2003).* Additional secondary sources were also consulted to reflect provincial and municipal approaches.

Potential public safety effects that may result from construction of the substation and associated infrastructure at Lord Roberts Annex include: impediment of sight-lines, increased demand for lighting, potential increase in concealed, isolated, and entrapment areas (e.g., public washrooms and entrance to the substation), the timeline of construction and diminishment of maintenance and management of the park, greater demand for signage, and loss of positive aesthetics environment. During operations, potential effects may include, but are not limited to, public safety concerns in relation to the above-ground ventilation vents, building access and structures which will impede sight-lines.

Potential mitigation measures to support crime prevention during construction and design of the new school may include but are not limited to new designs that allow good visibility, the elimination of concealed or entrapment areas, natural or formal surveillance, or access to help through security features such as emergency telephones. With the implementation of appropriate mitigations and design, the new Lord Roberts Annex may result in some positive outcomes, including reducing the overall number of concealed, isolated, or entrapment areas, increasing the net area of green space (approximately 40% increase), adding new areas to support programming activities, and an overall improvement in the use and design of the school. It is recommended that a full CPTED site risk assessment be undertaken to provide specific CPTED design elements that can be incorporated into the future redesign of the new school.

Public Safety—Accidents and Malfunctions

A desktop study was undertaken to determine potential effects that could result from accidents or malfunctions that may occur during the construction and operation of the proposed Lord Roberts Annex Project. Potential accidents and malfunctions may include: failed equipment, spills of hazardous materials, traffic accidents, electrical hazards from unauthorized access or illegal activity, natural disasters (e.g., earthquakes, fires, and floods), and human caused error.

During construction, most risks to the public and workforce will be related to the movement of materials and people at the construction site. These risks can be reduced through applicable signage, fencing, and adherence to local, municipal, and provincial traffic and safety bylaws, policies and plans, and a project specific Traffic Management Plan.

During construction and post construction, potential risks that may result from the factors described above may be reduced as compared to an above ground substation design because the overall physical impact of effects (e.g., fire, release of hazardous materials, or explosions) will be confined and retained underground. However, the subsurface design may create additional risks to emergency response personnel, because the design creates limited access, confined spaces, and potential for increase in smoke from reduced airflow/ventilation. These effects increase the risks for emergency response providers should a potential operational outage or substation malfunction occur.

BC Hydro could undertake a number of initiatives to manage and reduce these risks, such as using a worst-case scenario approach when designing substations, working with the City of Vancouver in developing a substation specific emergency response plan, training, and applying the Best Available Technology Economically Achievable (BATEA) in the design of the substation (e.g., application of fire retardants, advanced ventilations systems and shut-offs).

Economic Studies

Real Estate Value

Stantec Consulting Ltd. contracted Altus Group to conduct a baseline and literature review of the impact of construction of the two underground substations on property values in the surrounding areas. The two potential impacts on property values as determined by baseline data collected include construction noise and health-related issues associated with electromagnetic fields (EMF) during operations. The two forms of literature reviewed to assess these impacts included questionnaires associated with electrical infrastructure and the analysis of transactional market data of real estate. No literature was found that directly studied the impact of an underground substation on property values; however, similar infrastructure was reviewed. Literature showed that the perception of proximity to a substation could affect property values but there was no technical grounds to confirm this or to determine to what extent.

Based on the BCH conceptual design, having the facility underground removes the risk of a visual intrusion on residents within the area. Having the visual presence of electrical infrastructure did show a decrease in value from similar studies looking at above ground substations however, these conclusions are subjective comparisons when looking at the impact of a below ground substation on local property values. Perceived health impacts of EMF also showed a decrease in value to surrounding property values; however, once again, the literature reviewed only looked at above ground electrical infrastructure and therefore, the conclusion has limitations when comparing to BCH's conceptual design. In conclusion, the BCH conceptual design does have the potential to lower property values for those residents in the surrounding area resulting from the perceived health risk of EMF, however this conclusion currently has no technical merit and is limited in comparison. It was also concluded that independent study of the effect of this uncertainty is likely impossible as it is only one set of factors which can impact property values in the vicinity of electrical works. Construction noise could cause an "annoyance" to residents but no literature showed a decrease in property value.

No mitigation measures were offered within the report, however one could conclude that lowering the perceived risk through public consultation, outreach, and education could be an effective mitigation for those that resided within the immediate surrounding area. One could also conclude that any perceived risk would diminish over time.

The comprehensive Value Impact Report can be found in Appendix F.

Nelson Park

Environmental Studies

Vegetation

As of 2014, the urban forest canopy cover in the West End neighbourhood was approximately 18.6% (City of Vancouver 2014a). Nelson Park has an existing canopy cover of approximately 49% of the park. Nelson Park is less than 1% of the total area of the West End neighbourhood. A total of 127 trees were recorded within Nelson Park, of this total, 98 trees are ≥20 cm. No invasive plants, noxious weeds, or rare plant species were observed during the survey.

Based on the conceptual design, five trees would need to be removed for construction of the proposed distribution and transmission ducts. Of these five trees, three are ≥ 20 cm DBH and two are < 20 cm DBH. Tree clearing for the proposed Project will result in a loss of approximately 2% of the existing canopy cover from the park, which is less than 0.1% of the West End neighbourhood. This temporary loss of urban canopy includes the loss of ecological functions provided by the urban forest within the park such as habitat for pollinators and urban wildlife, as well as values such as shade. The temporary loss of urban canopy can be replaced in the long-term.

Various mitigation measures are recommended for each phase of the Project. During the design phase, the layout and configuration of the Project has been adjusted to minimize the loss of trees. Mitigation measures during construction are intended to protect retained trees along the perimeter of the Project footprint and relocate smaller trees within Nelson Park or to nearby parks or streets. Recommended mitigation measures during construction also guide the handling and transportation of soils to reduce erosion and sedimentation, as well as reduce the risk of introduction of invasive plant species. The risk of flooding or drought to trees would be mitigated through surface run-off and groundwater management. Mitigation measures would be implemented to maintain pre-construction drainage patterns to reduce long-term adverse effects on vegetation.

Mitigation measures following construction include working with the VPB to replace the number of trees required by the City of Vancouver to achieve no net loss of trees or urban canopy due to the Project. Although large trees cannot be replanted on top of underground infrastructure, other vegetation such as grass, small shrubs, or possibly small trees (e.g., <5 m height, and <15 cm DBH, at maturity) could be replanted to restore the park following construction and partially offset temporary losses of the urban canopy. A detailed landscape design would be prepared that incorporates the design constraints presented by the completed Project, while aiming to replace as much of the tree canopy on-site and in-kind as is feasible. The post-construction landscape design for the park will be prepared as a future phase of work following this initial impact and mitigation report.

Final mitigations would be subject to approval by the VPB.

Electric and Magnetic Fields (EMF)

Stantec Consulting Ltd. contracted Aura Health and Safety Corporation to conduct a study to evaluate the impact of EMF that could result from the project. Available reports of baseline electric and magnetic field (EMF) measurements at the park and measurements taken at and above Cathedral Square underground substation (which is similar to the proposed substation) were reviewed. A search of the literature was conducted to find other studies on EMF levels at or near substations, particularly of underground substations. International guidelines and reports on EMF were reviewed to compare predicted exposures with guideline levels and to determine exposure risk to humans. From the exposure and health guideline information, risk categories were assigned. Categories were selected based on two criteria: predicted approximate exposures to human populations, and predicted perceived risk to human populations.

The proposed substation will have three 230 kV transmission underground cables near the south-east corner of the station and throughout the park. It is expected that the highest levels of magnetic fields will occur at this corner right above each of the 230 kV cables, but should be less than the levels measured at Cathedral Square where currently three 230 kV transmission cables enter the square. It is anticipated that the magnetic fields levels will be similar to those above the Cathedral Square transmission cables where the majority of the time, the levels immediately above the transmission lines would be expected to be less than 25 mG. A recent review of the literature (2012-2016) indicates there is no new evidence that changes the conclusion of both Health Canada and World Health Organization that there are no confirmed health consequences associated with exposure to low level electromagnetic fields (Exponent, 2017). The risk of impacts from EMF at Nelson Park is low.

Various engineering mitigation strategies to reduce the magnetic fields from underground transmission cables can be considered such as burying the cables deeper and optimizing the conductor spacing and phasing arrangement. These mitigation strategies have been modelled to decrease magnetic field levels substantially (e.g., potentially 75 to 90% reduction). These strategies will further reduce magnetic field levels well below the ICNIRP guideline value of 2000 mG. In addition, information sharing and communications in regard to the actual health risks related to EMF may relieve any public perception of risk.

When engineering designs for the proposed substation becomes available, the EMF levels should be modelled for the substation and surrounding areas, and this information should be shared with the public. See Appendix E for additional information on the EMF study completed by Aura Health and Safety Corporation.

Air Quality, Noise and Vibration

Due to the fact that construction impacts within the borders of Nelson Park will be limited to the installation of underground transmission and distribution lines (which will take place over one to two months), the primary air quality, noise and vibration impacts will result from the construction of the underground substation at Lord Roberts Annex on School Board lands. See the Lord Roberts Annex section for a summary of the air quality, noise and vibration studies that will also affect Nelson Park.

Subsurface Hydrology and Ground Conditions

Proposed activity at the Nelson Park site includes constructing electrical conduits into the substation, with trenches up to 3 m below existing ground level. Data from the Geological Survey of Canada map for Vancouver (Map 1486A), Google Earth imagery, and previous Stantec projects in close proximity to the Project site indicates that the Nelson Park site bedrock, comprised of interbedded sandstone and shale, is within 10 m or less of the surface. Glaciated till soils are likely to overlay the bedrock and are comprised of clay, silt and sand with gravel and cobbles with the occasional boulder. Top soil and fill materials likely comprise the upper 1 to 2 m above the till soils. Perched groundwater is expected at variable depths, depending on season and weather conditions.

It is expected that the conduit excavations will be within topsoil, fill materials, or till soils. Potential impacts for shallow excavations up to 3 m depth include: perched groundwater and/or surficial water runoff may enter the excavations requiring removal using standard sumps and pumps, groundwater seepage may cause instability to temporary excavation sides; and, temporary shoring may be required should construction workers require entry to excavations over 1.2 m depth.

Minimal mitigation measures are considered necessary for the temporary excavations required for the electrical conduits. Typical temporary construction techniques should include protecting excavation side slopes from exposure to precipitation and associated ground surface run-off, and should be regularly inspected by a professional geotechnical engineer for signs of instability. Geotechnical and groundwater investigations should be undertaken during detailed design to confirm all assumptions made during conceptual design.

Birds and Other Wildlife

Field surveys conducted by two qualified biologists were completed at Nelson Park on January 18 and 27, 2017, respectively to record observations and assess value for birds and other wildlife. The park supports 127 urban trees, which support nesting, foraging, and daytime roosting opportunities for urban birds and other wildlife. One mammal and eight bird species were detected during the field survey and one eastern grey squirrel nest and two northwestern crow nests were detected.

Permanent removal or alteration of trees and understory vegetation in Nelson Park will reduce nesting, foraging, and daytime roosting opportunities for migratory, resident, and overwintering birds as well as other urban wildlife (e.g., racoons, skunks). Tree removal and reduction in canopy cover will further reduce habitat connectivity for some species. Based on the current proposed Nelson Park Project conceptual design, installation of the underground cables will result in the removal of five trees. If construction activities at Nelson Park are scheduled to coincide with the nesting window for migratory birds, there may be increased potential for incidental take (i.e., mortality or destruction) of breeding individuals and nests located in sections of the park that are subject to vegetation clearing. Sensory disturbance due to noise and vibrations, can also result in avoidance behavior for birds and other wildlife at Nelson Park. Noise levels at 70 dB are expected to cause disturbance in the vicinity of the noise source for the duration of construction. Current evidence does not confirm that low levels of EMF exposure result in definitive health or behavioral consequences for birds and other wildlife. A recent review of the literature (2012-2016) indicates there is no new evidence that changes the conclusion of both Health Canada and World Health Organization that there are no confirmed health consequences associated with exposure to low level electromagnetic fields (Exponent, 2017).

Potential mitigation measures to reduce impacts to birds and other wildlife include, but are not limited to avoiding vegetation clearing during the breeding season for migratory birds (March 28 through August 8) and raptors (February 5 through August 31) to avoid incidental take, and implementing waste management practices to reduce potential wildlife attractants. It is recommended that a pre-construction survey be completed by a qualified biologist to re-assess the presence of wildlife habitat features of concern (e.g., raptor nests, wildlife trees) within the park limits prior to vegetation clearing.

Social

Park Use and Programming

A series of desktop and on-site studies were conducted to create an inventory of current park materials, amenities, and conditions, and to understand how Nelson Park is used. Additionally, the site was surveyed to record the current layout and location of major park components.

While the development of the substation is expected to occur on the Vancouver School Board property, it is anticipated that Nelson Park and its users will also be impacted. Construction impacts will include the underground routing of transmission and distribution ducts via trenching through portions of the park. The construction process is anticipated to take one to two months, and certain areas of the park will have restricted public access at that time. The school playground equipment will also be removed during construction, and will not be available to the public.

Should the proposed project move forward and BC Hydro advances their designs, additional engagement will take place with the VPB and the public to reassess the areas of the park that will be affected by the project. Mitigation measures should also include proper construction sequencing to minimize potential impacts on the surrounding community, BC Hydro working with VPB to reassess changes to programming of the park once construction is complete (as the park is older, consideration may be given to update designs, uses, and materials to reflect current uses of public space), and consideration for completing further studies such as a full condition assessment to understand the quality and longevity of each material, site furnishings, and play equipment, including providing recommendations for upgrades and/or replacement.

Public Safety—Crime Prevention

A desktop study was undertaken based on the design principles and strategies identified by the National Crime Prevention Council's *Crime Prevention Through Environmental Design (CPTED) Guidebook (2003).* Additional secondary sources were also consulted to reflect provincial and municipal approaches.

Potential public safety effects that may result from the installation of underground transmission cables during construction includes: impediment of sight-lines, increased demand for lighting, potential increase in concealed, isolated, and entrapment areas, the timeline of construction and diminishment of maintenance and management of the park, greater demand for signage, and loss of positive aesthetics environment. During post-construction, the potential impacts to park users will be few to none, based on the current plans to bury the cables underground.

Potential mitigation measures to support crime prevention during construction may include but are not limited to allowing good visibility through natural or formal surveillance, the elimination of concealed or entrapment areas, appropriate signage, or access to help through security features such as emergency telephones. It is recommended that a full CPTED site risk assessment be undertaken to provide specific CPTED design elements that can be incorporated into the future redesign of Nelson Park.

Public Safety—Accidents and Malfunctions

A desktop study was undertaken to determine potential effects that could result from accidents or malfunctions that may occur during the construction and operation of the proposed Nelson Park/Annex Project. For Nelson Park, this includes the laying of electric cables under the park and their operation. However, accident or malfunction of the substation adjacent to the park at Lord Roberts Annex will also result in adverse effects to park users and are summarized in the Lord Roberts Annex section.

Economic Studies

Real Estate Value

Stantec Consulting Ltd. contracted Altus Group to conduct a baseline and literature review of the impact of construction of the two underground substations on property values in the surrounding areas. The two potential impacts on property values as determined by baseline data collected includes construction noise and health-related issues associated with electromagnetic fields (EMF) during operations. The two forms of literature reviewed to assess these impacts included questionnaires associated with electrical infrastructure and the analysis of transactional market data of real estate. No literature was found that directly studied the impact of an underground substation on property values; however, similar infrastructure was reviewed. Literature showed that the perception of proximity to a substation could affect property values but there was no technical grounds to confirm this or to determine to what extent.

Based on the BCH conceptual design, having the facility underground removes the risk of a visual intrusion on residents within the area. Having the visual presence of electrical infrastructure did show a decrease in value from similar studies looking at above ground substations however, these conclusions are subjective comparisons when looking at the impact of a below ground substation on local property values. Perceived health impacts of EMF also showed a decrease in value to surrounding property values however, once again, the literature reviewed only looked at above ground electrical infrastructure and therefore, the conclusion has limitations when comparing to BCH's conceptual design. In conclusion, the BCH conceptual design does have the potential to lower property values for those residents in the surrounding area resulting from the perceived health risk of EMF; however, this conclusion currently has no technical merit and is limited in comparison. It was also concluded that independent study of the effect of this uncertainty is likely impossible as it is only one set of factors which can impact property values in the vicinity of electrical works. Construction noise could cause an "annoyance" to residents but no literature showed a decrease in property value.

No mitigation measures were offered within the report, however one could conclude that lowering the perceived risk through public consultation, outreach, and education could be an effective mitigation for those that resided within the immediate surrounding area. One could also conclude that any perceived risk would diminish over time.

The comprehensive Value Impact Report can be found in Appendix F.

Emery Barnes Park

The initial conceptual design for Emery Barnes Park used in BC Hydro's initial consultation materials was modified based on feedback from various stakeholders to improve sightlines and reduce shadow effects. The modified design is a mirror image of the initial concept and was used as the basis for Stantec's impact and mitigation study.

Environmental Studies

Vegetation

As of 2014, the urban forest canopy cover in the Downtown neighbourhood was approximately 8.3% (City of Vancouver 2014a). Emery Barnes Park has an existing canopy cover of 32%, which is approximately 1% of the canopy cover of the Downtown neighbourhood. During the tree inventory survey, 111 trees were measured, of which 33 are ≥ 20 cm DBH. No invasive plants, noxious weeds, or rare plant species were observed during the survey. A large portion of the Project footprint is open grassy field with paths throughout.

Based on the footprint of the conceptual design for the Project within Emery Barnes Park, 59 trees would need to be removed for construction. Of the 59 trees to be removed, 15 of which are ≥ 20 cm DBH. Their removal represents a temporary loss of approximately 33% of the existing canopy cover from the park, and less than 0.1% of the canopy of the Downtown neighbourhood. This temporary loss of urban canopy includes the loss of ecological functions provided by the urban forest within the park such as habitat for pollinators and urban wildlife, as well as values such as shade. However, the temporary loss of urban canopy can be replaced in the long-term.

Various mitigation measures are recommended for each phase of the Project. During the design phase, the layout and configuration of the Project has been adjusted to minimize the loss of trees. Mitigation measures during construction are intended to protect retained trees along the perimeter of the Project footprint and relocate smaller trees within Emery Barnes Park or to nearby parks or streets. Recommended mitigation measures during construction also guide the handling and transportation of soils to reduce erosion and sedimentation, as well as reduce the risk of introduction of invasive plant species. The risk of flooding or drought to trees would be mitigated through surface run-off and groundwater management plans. Mitigation measures would be implemented to maintain pre-construction drainage patterns to reduce long-term adverse effects on vegetation.

Mitigation measures following construction include working with the VPB to replace the number of trees required by the City of Vancouver to achieve no net loss of trees or urban canopy due to the Project. Although large trees cannot be replanted on top of the substation and underground infrastructure, other vegetation such as grass, small shrubs, or possibly small trees (e.g., < 5 m height and <15 cm DBH, at maturity) could be replanted to restore the park following construction and partially offset temporary losses of the urban canopy. The use of raised beds and planter boxes, as currently exhibited in Emery Barnes Park, could potentially support additional tree replacement on-site. A detailed landscape design would be prepared that incorporates the design constraints presented by the completed Project, while aiming to replace as much of the tree canopy on-site and in-kind as is feasible. The post-construction landscape design for the park would be prepared as a future phase of work following this initial impact and mitigation report.

Final mitigations would be subject to approval by the VPB.

Electric and Magnetic Fields (EMF)

Stantec Consulting Ltd. contracted Aura Health and Safety Corporation to conduct a study to evaluate the impact of EMF that could result from the project. Available reports of baseline electric and magnetic field (EMF) measurements at the park and measurements taken at and above Cathedral Square underground substation (which is similar to the proposed substation) were reviewed. A search of the literature was conducted to find other studies on EMF levels at or near substations, particularly of underground substations. International guidelines and reports on EMF were reviewed to compare predicted exposures with guideline levels and to determine exposure risk to humans. From the exposure and health guideline information, risk categories were assigned. Categories were selected based on two criteria: predicted approximate exposures to human populations, and predicted perceived risk to human populations.

The proposed substation will have three 230 kV transmission underground cables near the south-east corner of the station and throughout the park. It is expected that the highest levels of magnetic fields will occur at this corner right above each of the 230 kV cables, but should be less than the levels measured at Cathedral Square where currently three 230 kV transmission cables enter the square. It is anticipated that the magnetic fields levels will be similar to those above the Cathedral Square transmission cables where the majority of the time, the levels immediately above the transmission lines would be expected to be less than 25 mG. A recent review of the literature (2012-2016) indicates there is no new evidence that changes the conclusion of both Health Canada and World Health Organization that there are no confirmed health consequences associated with exposure to low level electromagnetic fields (Exponent, 2017). The risk of impacts from EMF at Nelson Park is low.

Various engineering mitigation strategies to reduce the magnetic fields from underground transmission cables can be considered such as burying the cables deeper and optimizing the conductor spacing and phasing arrangement. These mitigation strategies have been modelled to decrease magnetic field levels substantially (e.g., potentially 75 to 90% reduction). These strategies will further reduce magnetic field levels well below the ICNIRP guideline value of

2000 mG. In addition, information sharing and communications in regard to the actual health risks related to EMF may relieve any public perception of risk.

When engineering designs for the proposed substation become available, the EMF levels should be modelled for the substation and surrounding areas, and this information should be shared with the public. Refer to Appendix E for the full report regarding EMF. See Appendix E for additional information on the EMF study completed by Aura Health and Safety Corporation.

Air Quality

Baseline or existing air quality measurement was determined from the two nearest, most representative, continuous air monitoring station in proximity to the proposed Emery Barnes Project. Generally, the baseline ambient air quality in the vicinity of Emery Barnes Park is good. Expected sources of criteria air contaminants (CAC) near Emery Barnes Park include: vehicular traffic, space heating, and other dust sources.

Impacts to air quality were studied based on emission factors from estimated representative off-road excavation and construction equipment. Sources of particulate matter from wind erosion and dust from mobile equipment were not quantified in this study as these sources are difficult to quantify and are highly dependent on the activities/techniques used onsite.

Based on professional judgement and a qualitative assessment of the type, duration and frequency of construction activities, it is predicted that construction of the substation will increase CAC concentrations in the vicinity of Emery Barnes Park during construction. If best management practices to control CAC emissions are implemented, the degree of change to CAC concentrations is expected to be low. Activities will also be limited to daytime hours, temporary, and irregular in occurrence. As well, impacts would be reversible upon completion of the construction phase. During operations, no air quality impacts are expected as activities will be limited to the venting of air for equipment cooling and to maintaining indoor air quality.

Potential mitigation measures may include, but are not limited to the implementation of best management practices such as watering surfaces prone to wind to suppress fugitive dust, maintaining vehicles in good operating condition, using modern (Tier 3) construction equipment, and reducing idling. Investigating the cause of complaints (if any) may also help to yield continuous improvement during construction.

Noise

The acoustic baseline condition was determined by conducting continuous noise measurement within the Emery Barnes Park on January 20, 2017. During the daytime period, the existing acoustic environment around Emery Barnes Park is influenced by local activities within the park (e.g., people, dogs), commercial activities in nearby streets, natural environment (i.e., wind and birds), vehicle traffic, air traffic and noises associated with the off-leash dog area and children's playground. The noise measurements at Emery Barnes Park were also influenced by ongoing construction activities, occurring at the north end of the park, on Seymour Street.

Worst case noise predictions for the construction and operations phase were performed using Cadna/A acoustic modeling software (DataKustik 2015) and in accordance with the internationally accepted sound propagation algorithms (ISO 1993, 1996). During construction, heavy construction equipment such as excavators, and jack hammers will generate noise. During operations, noise will be primarily associated with the operation of the ventilation equipment for the substation.

During construction activities such as jack hammering, the noise level at the nearest point of reception are predicted to be as high as 109.1 dBA., exceeding the noise limit of 85 dBA prescribed in the City of Vancouver Noise By-Law. During operations, noise from the substation ventilation system is predicted to be below the continuous daytime and nighttime noise limits of 70 dBA and 65 dBA respectively.

Potential mitigation measure to reduce sound levels to allowable limits may include, but are not limited to constructing a 2 m high temporary barrier around the entire construction site to reduce the noise effect by 5 to 10 dBA, and using quieter equipment. Silencers could also be installed on ventilation air inlet and ventilation exhausts. Additional studies could also be implemented to monitor noise levels at night to support a better understanding of ambient conditions, and complete additional modelling once a detailed inventory of construction equipment is known.

Vibration

The vibration study focused on ground vibration effects from construction equipment, as ground-borne vibration has the potential to affect human health and structural integrity of building. The vibration study area extends 200 m out from the project boundary. Vibration effects are not expected during the operation phase of the Project.

There is no available construction vibration guidance for the City of Vancouver or any provincial vibration by-law for construction activities in BC. A such, the City of Toronto Construction Vibration Limit (By-Law No. 514-2008) was referenced for comparison, with a focus on structural damage thresholds. Vibration effect during construction include excavation, earthworks, construction of the facility and drilling activities. Blasting and pile driving activities are not planned for the construction of the Project.

At the Emery Barnes site, the predicted vibration effect due to excavation at the closest point of reception is above the recommended structural damage threshold level of 8 mm/s. The residential building located 7.5 m southeast of the Project is identified within the zone of influence, and the perceptibility of construction vibration could also result in annoyance.

Vibration can be mitigated by reducing the dynamic forces associated with construction equipment or by isolation. Potential mitigation measures to reduce the vibration effects in order to meet the recommended level of 8 mm/s (City of Toronto Construction Vibration Limit) during construction activities include, but are not limited to confining vibration-generating operations to the least vibration-sensitive part of the day, consulting with the community regarding proposed events, or using smaller equipment or alternative equipment when working close to residential buildings.

Subsurface Hydrology and Ground Conditions

The proposed Emery Barnes underground substation will require an excavation depth of approximately 36 m below existing ground level. Data from the Geological Survey of Canada map for Vancouver (Map 1486A), Google Earth imagery, and previous Stantec projects in close proximity to the Project site indicates that at the Emery Barnes Park site bedrock, comprised of interbedded sandstone and shale, is more than 10 m below the surface. Glaciated till soils are likely to overlay the bedrock, and contain clay, silt and sand with gravel and cobbles with the occasional boulder. Top soil and fill materials likely comprise the upper 1 to 2 m above the till soils. Perched groundwater is expected at variable depths, depending on season and weather conditions.

Excavation of soil and rock to construct the underground substation structures is likely to cause noise, vibrations, and dust, all of which are associated with normal construction activities. Excavation of bedrock may involve the use of heavier than normal construction equipment which will require consideration to limit potential impact to nearby structures or nuisance to the local public. Ground subsidence associated with temporary groundwater control is not considered to be a significant risk to the proposed Emery Barnes Project. The risk of ground movement associated with the excavation of soil and rock is also considered to be limited.

Suggested activities to mitigate impacts include, but are not limited to: avoiding potentially noisy construction activities (e.g., excavation) during nighttime hours, using noise barriers and protection blankets during excavation to reduce noise transmittal, limiting generation of dust by wetting surfaces during excavation and covering excavated material prior to and during transport. Geotechnical and groundwater investigations should be undertaken during detailed design to confirm the assumptions made in the conceptual design.

Birds and Other Wildlife

Field surveys conducted by two qualified biologists were completed at Emery Barnes Park on January 18 and 27, 2017, to record observations and assess value for birds and other wildlife. The park includes 111 urban trees, which support nesting, foraging, and daytime roosting opportunities for urban birds and other wildlife. One mammal and three bird species were detected during the field survey.

Permanent removal or alteration of trees and understory vegetation in Emery Barnes Park will reduce nesting, foraging, and daytime roosting opportunities for migratory, resident, and overwintering birds as well as other urban wildlife (e.g., racoons, skunks). Tree removal and reduction in canopy cover will further reduce habitat connectivity for some species. Based on the current proposed Emery Barnes Project conceptual design, construction of the underground substation (and supporting infrastructure) will result in the removal of 59 trees. If construction activities at Emery Barnes Park are scheduled to coincide with the nesting window for migratory birds, there may be increased potential for incidental take (i.e., mortality or destruction) of breeding individuals and nests located in sections of the park that are subject to vegetation clearing. Sensory disturbance due to noise and vibrations, can also result in avoidance behaviour for birds and other wildlife at Emery Barnes Park. Noise levels at 70 dB are expected to cause disturbance in the vicinity of the noise source for the duration of construction. Current evidence does not confirm that low levels of EMF exposure result in definitive health or behavioral consequences for birds and other wildlife. A recent review of the literature (2012-2016) indicates there is no new evidence that changes the conclusion of both Health Canada and World Health Organization that there are no confirmed health consequences associated with exposure to low level electromagnetic fields (Exponent, 2017). A recent review of the literature (2012-2016) indicates there is no new evidence that changes the conclusion of both Health Canada and World Health Organization that there are no confirmed health consequences associated with exposure to low level electromagnetic fields (Exponent, 2017).

Potential mitigation measures to reduce impacts to birds and other wildlife include, but are not limited to avoiding vegetation clearing during the breeding season for migratory birds (March 28 through August 8) and raptors (February 5 through August 31) to avoid incidental take, and implementing waste management practices to reduce potential wildlife attractants. It is recommended that a pre-construction survey be completed by a qualified biologist to re-assess the presence of wildlife habitat features of concern (e.g., raptor nests, wildlife trees) within the park limits prior to vegetation clearing, in order to comply with regulatory requirements.

Social Studies

Park Use and Programming

Much like Nelson Park, a series of desktop and on-site studies were conducted to create an inventory of current park materials, amenities, and conditions, and to understand how the park is used. The Emery Barnes site was also surveyed to record the current layout and location of major park components.

The development of the substation will occur on the VPB's property, therefore impacts to park programming and use will result in changes to the usable space due to substation structure requirements. Construction impacts will include the construction of the underground substation and routing of the underground transmission and distribution ducts via trenching through portions of Emery Barnes Park. The construction process is anticipated to take three years, and it is anticipated that most of the park will be affected though construction activities and a full re-construction of the park space will be necessary after the substation is constructed.

Should the proposed project move forward and BC Hydro advances their designs, additional engagement will take place with the VPB and other interested parties to collaboratively develop solutions for Emery Barnes Park. Mitigation measures should also include proper construction sequencing to minimize potential impacts on the surrounding community, redesign, and changes to programming of the park once construction is complete. Public input on park use may lead to re-programming opportunities to better meet new user needs. Further study should include detailed analysis of the design of the above-ground elements that can be incorporated into the future redesign of the park.

Public Safety—Crime Prevention

A desktop study was undertaken based on the design principles and strategies identified by the National Crime Prevention Council's *Crime Prevention Through Environmental Design (CPTED) Guidebook (2003).* Additional secondary sources were also consulted to reflect provincial and municipal approaches.

Potential public safety effects that may result from construction of the substation and associated infrastructure at Emery Barnes Park include: impediment of sight-lines, increased demand for lighting, potential increase in concealed, isolated, and entrapment areas (e.g., public washrooms and entrance to the substation), the timeline of construction and diminishment of maintenance and management of the park, greater demand for signage, and loss of positive aesthetics environment. During operations, potential effects may include, but are not limited to, public safety concerns in relation to the above-ground ventilation vents which may impede sight lines, and possible loss of activity generators which encourage natural surveillance.

Potential mitigation measures to support crime prevention during construction and design of the new park may include but are not limited to park designs that allow good visibility, the elimination of concealed or entrapment areas, and natural or formal surveillance. It is recommended that a full CPTED site risk assessment be undertaken to provide specific CPTED design elements that can be incorporated into the future redesign of Emery Barnes Park.

Public Safety—Accidents and Malfunctions

A desktop study was undertaken to determine potential effects that could result from accidents or malfunctions that may occur during the construction and operation of the proposed Emery Barnes Project. Potential accidents and malfunctions may include: failed equipment, spills of hazardous materials, traffic accidents, electrical hazards from unauthorized access or illegal activity, natural disasters (e.g., earthquakes, fire, and floods), and human caused error.

During construction, most risks to the public and workforce will be related to the movement of materials and people at the construction site. These risks can be reduced through applicable signage, fencing, and adherence to local, municipal, and provincial traffic and safety bylaws, policies and plans, and completion of a project-specific Traffic Management Plan.

During construction and post construction, potential risks that may result from the factors described above may be reduced as compared to an above ground substation design because the overall physical impact of effects (e.g., fire, release of hazardous materials, or explosions) will be confined and retained underground. However, the subsurface design may create additional risks to emergency response personnel, because the design creates limited access, confined spaces, and potential for increase in smoke from reduced airflow/ventilation. These effects increase the risks for emergency response providers should a potential operational outage or substation malfunction occur.

BC Hydro could undertake a number of initiatives to manage and reduce these risks, such as using a worst-case scenario approach when designing substations, working with the City of Vancouver in developing a substation specific emergency response plan, training, and applying the Best Available Technology Economically Achievable (BATEA) in the design of the substation (e.g., application of fire retardants, advanced ventilations systems and shut-offs).

Economic

Real Estate Value

Stantec Consulting Ltd. contracted Altus Group to conduct a baseline and literature review of the impact of construction of the two underground substations on property values in the surrounding areas. The two potential impacts on property values as determined by baseline data collected includes construction noise and health-related issues associated with electromagnetic fields (EMF) during operations. The two forms of literature reviewed to assess these impacts included questionnaires associated with electrical infrastructure and the analysis of transactional market data of real estate. No literature was found that directly studied the impact of an underground substation on property values however similar infrastructure was reviewed. Literature showed that the perception of proximity to a substation could affect property values but there was no technical grounds to confirm this or to determine to what extent.

Based on the BCH conceptual design, having the facility underground removes the risk of a visual intrusion on residents within the area. Having the visual presence of electrical infrastructure did show a decrease in value from similar studies looking at above ground substations however, these conclusions are subjective comparisons when looking at the impact of a below ground substation on local property values. Perceived health impacts of EMF also showed a decrease in value to surrounding property values however, once again, the literature reviewed only looked at above ground electrical infrastructure and therefore, the conclusion has limitations when comparing to BCH's conceptual design. In conclusion, the BCH conceptual design does have the potential to lower property values for those residents in the surrounding area resulting from the perceived health risk of EMF; however, this conclusion currently has no technical merit and is limited in comparison. It was also concluded that independent study of the effect of this uncertainty is likely impossible as it is only one set of factors which can impact property values in the vicinity of electrical works. Construction noise could cause an "annoyance" to residents but no literature showed a decrease in property value.

No mitigation measures were offered within the report, however one could conclude that lowering the perceived risk through public consultation, outreach, and education could be an effective mitigation for those that resided within the immediate surrounding area. One could also conclude that any perceived risk would diminish over time.

The comprehensive Value Impact Report can be found in Appendix F.

Abbreviations

BATEA	Best Available Technology Economically Achievable
BC	British Columbia
BC CDC	British Columbia Conservation Data Centre
BC MOE	British Columbia Ministry of Environment
CAC	criteria air contaminant
CEC	Corporate Emergency Center
cm	centimetre
CO	carbon monoxide
CPTED	Crime Prevention Through Environmental Design
dBA	A-weighted decibel level
DBH	diameter at breast height
DD	downtown district
dia.	diameter
ECCC	Environment and Climate Change Canada
EIA	Environmental Impact Assessment
EMF	electromagnetic field
FCI	facility condition index
G	ground absorption factor
GCAP	Greenest City 2020 Action Plan
GIS	Gas Insulated Switchgear
HCAP	A Health City for All Action Plan

Hz	hertz
ICNIRP	International Commission on Non-Ionizing Radiation Protection
kV	kilovolt
L90	statistical sound levels
Leq	equivalent sound levels
LFAP	Local Food Action Plan
m	metre
m/s	metres per second
m^2	square metres
m^3	cubic metres
MBCA	*Migratory Birds Convention Act*
mG	milligauss
mm	millimetre
mm/s	millimetres per second
MVA	megavolt amperes
NDG	New Del Grauer substation
NES	Neighbourhood Renewable Energy Systems
NO_2	nitrogen dioxide
NO_x	oxides of nitrogen
ºC	degrees Celsius
PM	particulate matter
$PM_{2.5}$	fine particulate matter
PPV	peak particle velocity

Proposed Emery Barnes Project	Proposed Emery Barnes Substation Project
Proposed Nelson Park/Annex Project	Proposed Nelson Park/Lord Roberts Annex Substation Project
Proposed Projects	Proposed Emery Barnes Substation Project and Proposed Nelson Park/Lord Roberts Annex Substation Project
RMS	root-mean-squared
SARA	*Species at Risk Act*
SF6	sulphur hexa-fluoride
SO_2	sulphur dioxide
The Annex	Lord Roberts Annex school
VPB	Vancouver Parks Board
VSB	Vancouver School Board
WTE	West End substation

1.0 INTRODUCTION

BC Hydro commissioned Stantec in January 2017 to complete a study of technical, environmental, and socio-economic considerations for developing two new underground substations located in Downtown Vancouver. The study includes a preliminary evaluation of potential impacts and mitigation measures based on the conceptual level of planning completed at this early stage of Project development. The proposed development includes building an underground substation on Vancouver Park Board (VPB) property under Emery Barnes Park in Downtown, and for the West End, building a new underground substation on Vancouver School Board (VSB) property next to Nelson Park.

The intent of this study is to allow the various stakeholders and the public to review the proposed concepts and provide input during the public consultation process. This input, along with the results of the study itself, will allow both the VSB and VPB to make an informed decision at the end of March as to whether BC Hydro can build the two proposed underground substations on their respective properties.

If the concept is not approved by all parties, it is Stantec's understanding that BC Hydro will advance its traditional approach of building two above-ground indoor substations, likely within a three block radius of the proposed project locations. Stantec recommends additional studies be undertaken to confirm that construction impacts for an above-ground indoor substation would be comparable, and that operational impacts regarding safety, visual impact and noise would be greater than an underground substation.

If the concept is approved by all parties at the end of March 2017, leasing agreements for the lands will be negotiated and finalized and BC Hydro would move forward with more detailed deigns in consultation with the public and other stakeholders. The British Columbia Utilities Commission, a regulatory agency of the Provincial Government, will also act as a decision maker through its administration of the *Utilities Commission Act*. Additional provincial and municipal permits and authorizations may also be required to advance the construction of the proposed projects.

This report presents a study of technical, environmental, and socio-economic considerations for the substation development concepts, including context on existing conditions at each potential site, a description of each proposed development, and a preliminary evaluation of potential impacts, potential mitigation measures, and Project benefits based on concept level details available at this early stage of Project development. The sites addressed in this report are: Emery Barnes Park, and Nelson Park/Lord Roberts Annex. Additional stand-alone reports focused on electronic and magnetic fields (EMF) and real estate evaluations can be found in Appendix E, F and G of this report.

1.1 PROJECT BACKGROUND

The following section describes the history of BC Hydro's electrical infrastructure in downtown Vancouver and the proposed process to build two new underground substations at Nelson Park/Lord Robert Annex (proposed Nelson Park/Annex Project) in the West End and Emery Barnes Park (proposed Emery Barnes Project) in Downtown.

To increase the reliability of existing electrical infrastructure and address growing demand for electricity in the downtown core, ageing existing substations, and seismic issues, BC Hydro is looking to expand their infrastructure in Downtown Vancouver. BC Hydro has analysed their load growth and condition of existing assets and has determined that they require two new substations in the Downtown and West End neighbourhoods. The majority of the substations constructed in North America are above-ground substations (also known as "outdoor") similar to BC Hydro's Murrin substation located at the corner of Quebec Street and Union Street in Downtown Vancouver. Recently many Gas Insulated Switchgear (GIS) substations have been built in urban centers similar to BC Hydro's Mount Pleasant Substation. These substations have a significantly smaller footprint than standard outdoor substations, but require land to build on in highly populated cities.

With the constrained land requirements in Downtown Vancouver, BC Hydro is proposing to construct two new underground substations, similar to the existing Cathedral Square Substation. Built in the mid-1980s, Cathedral Square is one of only two underground high voltage substations operating in North America, with one additional underground substation under construction in Toronto. Though the construction costs of underground substations are significantly higher than outdoor substations, BC Hydro believes that this is a viable option due to very high real estate values in downtown Vancouver and additional community benefits.

1.1.1 Proposed Underground Substations

The proposed locations for the new underground substations are under Emery Barnes Park in Yaletown and under the Lord Roberts School Annex (the Annex) adjacent to Nelson Park in the West End. Underground electrical cables would need to be routed through Nelson Park to connect to the substation.

The proposed Nelson Park/Annex Project is proposed to be built first with construction to commence in 2020 and an in-service date of 2024. The substation would be fed by 230 kV underground cables from the Cathedral Substation in Downtown Vancouver and from the Horne Payne substation in Burnaby. The substation would be used to transform the power from 230 kV down to 12.47 kV and 25 kV which will then be fed out through underground cables to feed power to sections of Downtown Vancouver.

Subsequent to construction of the proposed Nelson Park/Annex Project, BC Hydro proposes to construct the Emery Barnes Project, located under Emery Barnes Park, commencing in 2036 with an in-service date of 2041. This substation would be fed by three 230 kV underground cables:

one from the proposed Nelson Park/Annex Project, another from the Cathedral Substation and the other from Burrard. This substation would be used to transform the power from 230 kV down to 25 kV which will then be fed out through underground cables to feed power to additional sections of Downtown Vancouver.

1.2 STRATEGIES AND INITIATIVES

1.2.1 Introduction

The City of Vancouver, VPB, and VSB have published several strategies and initiatives that guide the decision-making, planning, and operations for each organization. This section provides an overview of the key City of Vancouver and VSB policies, strategies and/or plans that are relevant to both the proposed Emery Barnes Project and the proposed Nelson Park/Annex Projects (the proposed Projects).

Two overarching plans direct the City of Vancouver's strategic vision and approach for addressing its environmental and social challenges: the "*Greenest City 2020 Action Plan* (GCAP)" and "*A Healthy City for All Action Plan* (HCAP)". These plans are important to decisions and actions of the VPB, given its mission to "*provide, preserve and advocate for parks and recreation services to benefit all people, communities and the environment*" (City of Vancouver 2017a). The *Park Board Strategic Framework* supports the objectives of these plans through inclusion of the goal to be a "*leader in greening*", as well as objectives and actions related to green operations and healthy ecosystems (Park Board 2012).

1.2.2 Methods and Scope

Using the *Greenest City 2020 Action Plan (GCAP)* as the accepted framework for environmental sustainability in Vancouver, key plans, strategies, and initiatives which are relevant to the Projects and support progress toward achieving GCAP goals, were identified through a desktop literature review. A high-level summary of these documents is provided in Section 1.2.3 below.

Section 1.3 provides a summary of the VSB's sustainability framework, which will be considered in design, construction, and operation of the new school proposed to replace the Annex as part of the proposed Nelson Park/Annex Project.

1.2.3 Greenest City 2020 Action Plan and Supporting Strategies

In 2011, City Council approved the GCAP which details ten long-term goals that support the City of Vancouver in achieving its aspirational vision of becoming the greenest city in the world by the year 2020 (Greenest City Action Team 2009). A summary of these goals and a series of more detailed plans and strategies that support the implementation of GCAP are described in Appendix B, Table B.1.B (Greenest City Action Team 2009). The following section highlights the GCAP plans and strategies related to climate and renewables, green buildings and transportation which are addressed in this assessment.

1.2.3.1 Supporting Strategies Related to Climate and Renewables, Green Buildings, and Transportation

Renewable City Strategy: our future to 2050: The *Renewable City Strategy* is a continuation of the GCAP. It establishes the direction to stay focused on energy reduction and conservation measures required to address the longer-term targets for 2050 (City of Vancouver 2015a). The *Renewable City Strategy* is primarily focused on realizing improvements in the buildings and transportation sectors (City of Vancouver 2015a).

Several building-related priority actions are identified within the Renewable City Strategy which may have relevance for design of Project above-ground infrastructure, and park buildings. The *Renewable City Strategy* priorities which foster the development of zero-emission buildings are supplemented by additional plans that are summarized in Appendix B. Key building considerations which may be relevant to the Projects include, but are not limited to:

- Adherence to zero-emission standards for new buildings
- Design to facilitate integration with existing or new Neighbourhood Renewable Energy Systems (NES)
- Substation operation in a manner that supports Vancouver's priority to ensure that grid supplied electricity is 100% renewable
- Applicable priorities for renewably-powered transportation that are described in the Renewable City Strategy, and may be related to BC Hydro's proposed Projects include:
  - Use of land-use policies that enhance the pedestrian network and cycling infrastructure
  - Support for increased car-sharing
  - Development of supporting infrastructure that meets the needs of renewably-powered vehicles (City of Vancouver 2015a)

Further vision and direction for Vancouver's Transportation Initiatives are established in the *Transportation 2040 Plan* which is summarized in Appendix B.

Climate Adaptation Strategy: In addition to mitigation efforts that focus on reducing greenhouse gas emissions to limit or prevent climate change, the City of Vancouver recognizes the need for strategic response and adaptation to the potential impacts of climate change. The Climate Adaptation Strategy details the actions required to take advantage of potential opportunities, and avoid or manage adverse effects related to climate change (City of Vancouver 2012). Key strategies identified by the City to adapt to the effects of climate change which may have implications to the Projects include, but are not limited to:

- Completion of defined urban forestry initiatives to help offset potential urban heat island effects from solar energy absorption from asphalt and buildings. Parks and greenspace also have a role in decreasing the impacts or occurrence of flooding from heavy rainfall or storm surge. Parks can be used for detention and infiltration of storm water or as containment areas for heavy storm surge.
- Implementation of standards for more resiliently-built infrastructure and buildings to help reduce potential impacts on trees, buildings, and human safety from the anticipated increase in the frequency of severe wind.

- Appropriate storm water management planning to address storm water sewer overflows because of overland flooding from increased frequency and intensity of precipitation (City of Vancouver 2012).
- Operation of the proposed Projects will contribute to the City's priority action for climate adaptation related to appropriate planning for and supply of dependable power from renewable sources (City of Vancouver 2012).

1.2.4 Strategies Related to Access to Nature

The Parks Board has substantial responsibility for supporting the City of Vancouver in achieving its targets related to the GCAP Access to Nature goal. This goal addresses the need to incorporate nature into the urban environment, and has prompted the development of various related strategies that build upon this vision. The Park Board Strategic Framework has similarly established a goal to be a "*leader in greening*", and has established priority actions to manage operations in a sustainable manner; preserve, restore and expand green space; and, use VPB expertise, programs, facilities, and partnerships to increase awareness and knowledge of sustainable living (Park Board 2012).

Urban Forest Strategy: The total area of urban forest canopy has been on a steady decline over the past 20 years (City of Vancouver 2014a). In response, The City of Vancouver and VPB identified the need for a dedicated, long term approach to sustain Vancouver's urban forest. In April 2014, Vancouver City Council endorsed the Urban Forest Strategy, which requires the protection of existing trees, the planting of 150,000 trees by 2020 in a strategic manner, and the management of a healthy, resilient urban forest for future generations (City of Vancouver 2014a).

Construction of both proposed Projects will require clearing of surface vegetation for installation of below-ground and above-ground infrastructure. Clearing will also be required for development of the new school proposed to replace the Annex. It is anticipated that approximately 101 trees will need to be removed to support construction of both Projects. Project-related clearing activities may influence VPB's ability to implement their commitments related to the Urban Forest Strategy.

Vancouver Protection of Trees Bylaw: To further support attainment of the GCAP Urban Forest targets, the ability for property owners or builders to remove one healthy tree per year was eliminated from Section 4.5 of the Vancouver Protection of Trees Bylaw (City of Vancouver 2014b).

Vancouver Bird Strategy: The GCAP Access to Nature goal includes the need to create conditions within the urban environment that support a diversity of bird life. In 2013, City Council and the Park Board mandated the creation of a strategy to support Vancouver's vision "*to be a world leader in supporting a year-round rich and diverse assemblage of native birds, accessible to Vancouver residents in every neighborhood and park in the city, by 2020*" (Vancouver Bird Advisory Committee 2015).

Strategic actions have been assigned to the City, VPB, Tourism Vancouver, and other partners. The VPB is responsible for implementation of the Bird Strategy, given its role in managing trees and natural areas that contribute to bird habitat (Vancouver Bird Advisory Committee 2015). Design of above-ground Project infrastructure, the new school, and re-developed parks, may be influenced by certain objectives of the Bird Strategy and the responsibility of the VPB to:

- Protect, enhance, and create habitats for diversity of native birds
- Reduce threats to birds in the urban environment
- Enhance access to nature for Vancouver residents and visitors to the city (Vancouver Bird Advisory Committee 2015)

Rewilding Vancouver: An Environmental Education and Stewardship Action Plan: The Environmental Education and Stewardship Action Plan was developed to help Vancouver residents improve and enhance their experiences with urban nature, and to increase their understanding and awareness of the natural environment within the urban setting (Park Board 2014). The Plan identifies 49 actions to achieve three priority objectives over a five-year period. Of the three objectives stated in the Action Plan, the commitment to "*Integrate nature into the daily experiences of Vancouverites, by allowing it back into public spaces and places*", appears to be most connected with planning, construction, and operation of the BC Hydro Projects.

Biodiversity Strategy: The Biodiversity Strategy was developed by the VPB in 2016, with a goal to '*increase the amount and ecological quality of Vancouver's natural areas to support biodiversity and enhance access to nature"* (Park Board 2016a). The Strategy defines natural areas as both large and small patches of the urban landscape, which support nature. In addition to forests, wetlands, and shorelines, these areas include green roofs, constructed wetlands, and rain gardens (Park Board 2016a).

Strategy objectives which require the Park Board to: support biodiversity within parks, streets, and other City-owned lands; and, protect and enhance biodiversity during development (Park Board 2016a), are of direct relevance to construction and site restoration activities included within the scope of the proposed Projects. Priority strategy actions that are attributed to the VPB, and are likely to have an influence on the Projects include:

- Continued implementation of the Urban Forest Strategy
- Control of invasive species in parks
- Incorporation of smaller natural features such as pollinator meadows into new and redeveloping parks and other city-owned lands (Park Board 2016a)

1.2.5 Supporting Strategies Related to a Local Food and a Healthy City

Healthy City Strategy and Healthy City for All Action Plan

The *Healthy City Strategy* was approved in 2014, and is guided by the vision of "*a city where together we are creating, and continually improving the conditions that enable all of us to enjoy the highest level of health and well-being"* (City of Vancouver 2015b*).* The Strategy outlines thirteen long-term goals, and provides the social component of Vancouver's three-pillared approach to sustainability, which includes the GCAP (environment), and the *Vancouver Economic Action Strategy* (economy) (City of Vancouver 2015b). The first four-year *Healthy City for All Action Plan* (HCAP) identifies nineteen high priority actions to support implementation of the goals defined in the *Healthy City Strategy*.

Four of the thirteen goals are of direct relevance to the VPB, and will influence the post-construction park redevelopment phase of the proposed Projects:

- Feeding Ourselves Well—Vancouver has a healthy, just, and sustainable food system
- By 2020: Increase city-wide and neighbourhood food assets by a minimum of 50% of 2010 levels
- Being and Feeling Safe and Included—Vancouver is a safe city in which residents feel secure
- Increase Vancouver residents' sense of safety by 10%
- Make Vancouver the safest major city in Canada by reducing violent and property crime every year, including sexual assault and domestic violence
- Active Living and Getting Outside—Vancouverites are engaged in active living and have incomparable access to nature
- By 2020: All Vancouver residents live within a five-minute walk of a park, greenway, or other green space (City of Vancouver 2015b)

The Park Board Strategic Framework includes an action to "support community-based food production by contributing to the development of neighbourhood and city-wide food infrastructure programs and assets" (Parks Board 2012).

The following initiatives align with, and support implementation of the Healthy City Strategy— "Feeding Ourselves Well", goal:

Vancouver Food Strategy: The Vancouver Food Strategy was developed to provide a coordinated approach to meet the City's environmental and social targets to increase the city's food assets by 50% by 2020 (City of Vancouver 2013). These food assets include community gardens, urban farms, farmers' markets, food processing infrastructure, community composting facilities, and neighbourhood food networks (City of Vancouver 2013). The Strategy aims to improve the existing food system by addressing issues around the production, processing, distribution, access, consumption, and waste management of food (City of Vancouver 2013). The Food Strategy recommends priority actions which should be reflected in plans for redevelopment of the parks and school following Project construction.

Park Board Local Food Action Plan: The VPB acknowledges that creating healthy, active, and connected communities requires a broad perspective, which includes the potential for integrating food assets into the existing parks and recreation system (Park Board 2013). The VPB Local Food Action Plan (LFAP), builds upon on pre-existing City policy, but recognizes the unique position of the Park-Board in its ability to provide food assets including land (community gardens, food trees); facilities (concessions, farmers' markets, and community food markets); capacity building; and programs (staff horticultural expertise, community education and outreach programs) (Park Board 2013). The LFAP helps guide the work of the VPB to enable development of the local sustainable local food movement in Vancouver.

Park Board Urban Agricultural Policy: The VPB has adopted a policy for urban agriculture that better reflects agricultural activities which currently take place in urban parks (Park Board 2015). The policy replaces the Park Board's Community Gardens Policy, and applies to both existing and new food-related projects including, but not limited to, community. The Policy provides Park Board support for the development of urban agriculture in the Vancouver park system. It establishes an expanded definition for agricultural projects, defines operating requirements for urban agricultural projects, and provides the criteria for public consultation required by the VPB as part of the approval process for new projects (Park Board 2015).

Given the VPB's responsibility for contributing food assets to the City's goal to develop or further enhance food production from local and sustainable sources, it is anticipated that park re-development plans associated with the Projects will need to consider potential siting for community gardens, markets, and/or other creative contributions to advance the City and VPB's goals and objectives.

1.2.6 Vancouver School Board Strategies

VSB policies and strategies that guide planning and operational activities will provide direction for design and construction of the proposed new school building and grounds to replace the Lord Roberts Annex. These policies and strategies include, but are not limited to the following:

VSB Sustainability Framework: The Vancouver School Board Sustainability Framework was developed in 2010, and provides a guide to VSB planning and coordination of sustainability efforts. The vision of this framework is to support VSB in becoming the greenest, most sustainable school district in North America. The framework details environmental processes and solutions, and embeds sustainability as a core element of the school system. Principles of the framework include being a sustainability leader, setting targets in key result areas and integrating with complimentary sustainability plans (VSB 2010).

FNA-R-2: Use of Facilities and Grounds for K–12: Use of School Grounds for Creative Play Areas: The VSB supports, in principle, the establishment of creative play areas or the upgrading of existing ones on school grounds. As capital funding for these projects is not available through the Ministry of Education, all associated costs for these projects must be borne by schools. Guidelines for planning creative play areas, obtaining approval, and procedures for project scheduling and development are outlined in the VSB Policy Manual (VSB 1996a).

FNA-R-3 Use of Facilities and Grounds for K-12: Use of School Grounds for Garden Plots: The VSB supports, in principle, the establishment of locally-initiated garden plots on school grounds. These garden projects may be established in the interests of providing an educational opportunity for the students and staff, and a focus of community activity. In general, the VSB does not provide funding for the development and maintenance of garden plots. Garden plots should be designed in accordance with the regulations prescribed in the VSB Policy Manual (VSB 1996b)

VSB 2021 Strategic Plan: The Strategic Plan establishes a clear and shared vision for the future of public education in the Vancouver School District (VSB 2016). It focuses on the District's core goals of teaching and learning to support student achievement and well-being. Key actions that align with Vancouver's GCAP and HCAP include the need to:

- Encourage and enhance practices that support cultural, social-emotional, physical, and mental well-being
- Increase knowledge, awareness, appreciation of and respect for Aboriginal histories, traditions, cultures, and contributions
- Respect and celebrate all forms of diversity
- Support collaborative relationships with community partners that enhance student learning and well-being
- Develop a Sustainability Action Plan enabling the school district to be the greenest school district in North America
- Provide increased opportunities to connect students to their learning (VSB 2016)

1.2.7 Recommendations for Further Work

The information presented in the preceding sections provides an overview of the City of Vancouver, VPB, and VSB strategies and initiatives that could potentially influence proposed Project design, construction, and post-construction activities. Recommendations for further work if the seed concept is approved include:

- Detailed analysis of strategic requirements in relation to the proposed Project descriptions, to identify potential:
  - Project constraints
  - Challenges or issues related to short-term and long-term implementation of strategic commitments resulting from proposed project developments
  - Opportunities for the proposed Projects to contribute to, or enhance strategic initiatives through incorporation of innovative design elements
- Public and stakeholder engagement to confirm that potential issues and opportunities, with respect to the proposed Projects and the various strategies, have been appropriately identified
- Incorporation of the data, mitigations, and conclusions from the technical studies into a more quantitative or qualitative assessment of potential project effects on measurable objectives contained within the strategies and initiatives
- Collaboration with the Landscape Architecture and Parks Planning Disciplines to incorporate creative visioning into the design of proposed Project siting, infrastructure, and restoration plans
- Development of proposed Project-specific objectives and metrics relative to the various strategies, to measure actual effects, including contributions. Proposed Project performance data can be used to implement corrective actions if needed, as well as to provide reference data that can be used as a benchmark for future projects.

2.0 PROPOSED EMERY BARNES PARK PROJECT

2.1 EMERY BARNES PARK CONTEXT STATEMENT

The following context statement was provided by the VPB and provides a description of Emery Barnes Park, including its size, location, history, and service area/catchment.

Emery Barnes Park, located at 1170 Richards Street, Vancouver is approximately 0.85 hectares (ha; 8,500 m^2 approx.) in size and provides a multifunctional space for passive recreation. The landscaping includes turf space, colourful planting, seating areas, a stream, pergolas, and mosaics.

Emery Barnes Park was built in three phases. Phase 1, facing Richards Street, featuring a fountain, stream, benches, and plantings was completed in 2003. Phase 2 features an off-leash dog park, a children's playground, seating areas, and an open lawn space surrounded by an oval pedestrian path, and was completed in summer 2010. Phase 3, constructed in April 2012, completed the park with an entry plaza at Davie and Seymour Streets. This portion of the park is defined by a pedestrian gateway framed by trees, shrubs, benches, trellises, and chess board tables.

Emery Barnes Park officially opened on September 27, 2003 and was named after Emery Barnes; a long-time community activist and member of the British Columbia (BC) Legislature.

Planning Context

- Downtown South—Yaletown Neighbourhood
- Downtown South Guidelines (excluding Granville Street) adopted by City Council July 30, 1991 Amended September 29, 1994, October 7, 1997 and June 10, 2004

Acquisition History

Land for Emery Barnes Park was acquired via Community Amenity Contributions from site development in the area.

Service Area/Catchment

Population within an eight-minute walk:

- Daytime population 2011—60,909
- Nighttime population 2011—13,229
- Projected nighttime population 2041—17,136
- Increase in population within an eight-minute walk, predicted by 2041 = 23%

The Downtown neighbourhood area has limited park space; 0.63 ha per 1,000 person. This is considerably lower than the Park Board minimum provision target of 1.1 ha per 1,000 persons. Given projected population growth, and without the addition of new park space, the provision of park space is likely to be 0.50 ha per 1,000 persons by 2041. Optimum service levels, incorporating a more qualitative approach, are currently under review by VPB as a part of the Parks and Recreation Services Master Planning process (Park Board 2016b).

Other Site History

In 2011 the Community Association of New Yaletown undertook legal action in dispute of the rezoning and development of a city-owned lot adjoining Emery Barnes Park at 508 Helmcken Street. 508 Helmcken Street was social housing, known as Jubilee House, and had been planned as a future extension of Emery Barnes Park. The developer proposed to build a new social housing building at 1099 Richards to replace the Jubilee House and, in exchange, the City of Vancouver would give the developer its property at 508 Helmcken Street and rezone it to permit a 36-storey mixed-use residential building.

A legal petition against the City of Vancouver was submitted to the BC Supreme Court, and was successful; however, the decision was later overturned after an appeal process by the City and Brenhill Developments.

The basis of the Community Association's legal petition was;

- Lack of transparent and open information during the rezoning and land-swap negotiations
- Insufficient public engagement and communication on the issue
- Impact of the dramatic increase in new residents accessing an already very busy park

2.2 PROPOSED DEVELOPMENT—EMERY BARNES PROJECT

2.2.1 Design of Substation and Underground Infrastructure

Conceptual design concepts for the proposed underground substation and infrastructure at Emery Barnes Park is shown in the 3D rendering below. The rendering is the mirror image of the preliminary design used in BC Hydro's initial consultation materials, and was modified based on feedback from various stakeholders to improve sightlines and reduce shadow effects. The modified design was used as the basis for Stantec's impact and mitigation study.

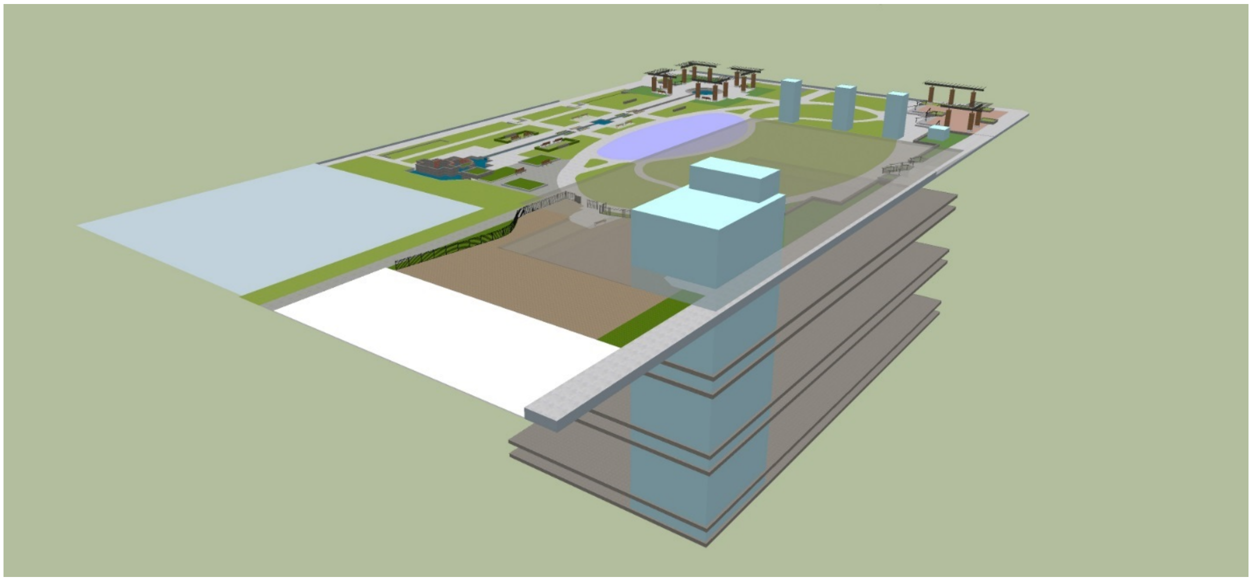


Figure 2-1 3D Rendering Image showing above Ground and Below Ground Infrastructure—Emery Barnes Park

Emery Barnes Park is centrally located in Downtown Vancouver in between the business districts, Yaletown and Gastown. Emery Barnes Park is bound on three sides by city streets (Seymour Street, Davie Street and Richards Street), as well as one existing building at (1170 Richards St, Vancouver BC V6B 3M7), and one lot under construction to build “8x On the Park” to the east. The total gross area of the project site is 10,084 m^2 (road curb to road curb to eastern edge of development. The total net park area is 9,394 m^2 (inside sidewalk to inside sidewalk). The site is Vancouver Parks Board property, and the parks board is the governing authority on park programming, design, public consultation, and construction for the site.

The proposed Emery Barnes Project is a facility where electricity is transformed from a high voltage to a lower voltage for distribution to the customers, and is a critical link between BC Hydro’s transmission network and residents’ light switches.

The proposed substation would be a large concrete structure 88 m long, 45 m wide, and 33 m deep. The top of the structure would be buried approximately 3 m under the surface. The substation is now in the conceptual design phase so configurations have not been finalized, but currently it is designed to have three floors with the 230 kV GIS switchgear and Gas Insulated transformers in the bottom floor, 25 kV GIS switchgear in the middle floor and control panels located on the first floor. Each floor would be approximately 8 m in height with 3 m spaces between the floors to allow for the installation of the cables.

Power transformers are typically immersed in oil for better cooling, where the oil serves as both a coolant and an insulating medium. In a gas insulated transformer, gas is used as an insulating and cooling agent. SF6 is an important gas used in these types of transformers. The main advantage of gas-insulated transformers is the elimination of oil and the reduced risk of fire or spills. These gases are non-flammable in nature and reduce the need for firefighting equipment in the transformer room. No liquid or oil purifying process is required, the gas can be recycled. While the transformers are larger, the overall substation space requirements are reduced.

Fully gas-insulated substations, adopting a combination of these transformers and switchgear, offer extra ease for safety assurance, accident prevention, and inspection/ maintenance. GIS is a compact metal-encapsulated switchgear consisting of high-voltage components such as circuit-breakers and disconnectors, which can be safely operated. GIS is commonly used where space is limited, for example, in underground substations, in city buildings, on roofs, on offshore platforms, in industrial plants, and in hydro power plants.

Each of the substations are proposed to have a large elevator that will move workers, tools and equipment into and out of the substation during construction and maintenance. All of the equipment inside the substation could be moved through this elevator except for the large power transformers. These transformers would be installed through a large hatch in the roof of the structure that would be closed and buried after construction, and would only be reopened if there is a need to install an additional transformer, or if one of the existing transformers must be removed for maintenance, it is anticipated that this hatch will only be required to be opened once every 30 years. There are external ventilation structures required along with an emergency exit structure.

Approximately 97% of the substation infrastructure will be located underground. The above-ground infrastructure of the substation will include three vent structures on the southwest end of the substation (near the intersection of Davie Street and Seymour Street), and vehicle access and intake structure located on the northwest side (accessible via Seymour Street). It is anticipated that the Canada Line tunnels may conflict with the current conceptual design of the substation.

2.2.2 Summary of Construction

The proposed Emery Barnes Project as currently proposed is a concept that may evolve, pending Project approval and input from all future stakeholders. This section of the report outlines a proposed timeline of events if construction were to proceed based on the concept presented here.

2.2.2.1 Construction Sequencing

Construction of the proposed Emery Barnes Project, as conceptually proposed, is expected to take approximately five years with the construction commencing early in 2036 and an expected in-service date near the end of 2041.

The first phase of construction is expected to require fencing-off portions of Emery Barnes Park to allow for the start of the excavation. BC Hydro will maximize the amount of park left for public use, while providing a safe environment for those interacting near the construction zone.

The excavation will start with the removal of the existing topsoil which will be stored, as required, for future use. Dewatering wells are expected to be installed to control local water table. Perched groundwater is expected to be encountered at variable depths, depending on the season and weather conditions during the construction period. Based on Stantec past experience, other local projects in close proximity to Emery Barnes Park encountered groundwater during investigations at up to 18 m below ground level; however, groundwater can be expected at shallow depths during wet weather periods.

Excavation will commence for the 88 m x 45 m x 37 m underground substation, using a staged excavation process. It is expected that three large excavators would be used for the excavation process. Based on the expected size of the excavation, over 150,000 m^3 of material will be removed. This material will be removed from site via tandem trucks; based on the current schedule this will require 35–50 trucks per day, 3–4 days a week for approximately 14 months.

Excavation of the soil and soft bedrock is expected to be possible using normal construction equipment such as excavators with buckets, ripping, and hydraulic breaker attachments. Rock saw cutting could be used instead of blasting to limit the impact to the surrounding buildings. Ripping may be suitable for excavating weak to medium strong rock, with hydraulic breaking required to excavate harder materials.

Excessive vibrations, noise, and dust may occur due to the excavation of soil and rock. Alternative methods or mitigation measures would be planned to avoid exceeding permissible or nuisance levels. Excavation work will need to adhere to the City of Vancouver bylaws.

Seepage from the walls of the excavation is to be expected due to perched water within the soils. This can be controlled using weep holes and horizontal drains to dewater and depressurize the excavation face. Drainage panels between the soil/rock face and the shotcrete panels would be installed for the full height of the excavated face covered with shotcrete. Weep holes would be installed through the shotcrete panels connected to the drainage panels and perimeter drains.

Excavation dewatering will largely be limited to perimeter drains connected to collection sumps. The collected water should be retained in the sumps for a sufficient length of time to allow precipitation of sediment before the water is pumped to the City storm sewer system. Alternatively, a sediment collection system should be used prior to water disposal. The requirements for sediment collection should be evaluated during the subsurface investigation stage.

There is potential for the excavation to intercept the groundwater table within the bedrock. The groundwater table could potentially be impacted by tidal fluctuations from False Creek, located approximately 500 m distance from Emery Barnes Park. Groundwater monitoring wells should be installed into the bedrock in advance of any excavation design works to determine whether the excavation is likely to intercept the groundwater table or an aquifer.

Support of the excavation sides should be possible using conventional shotcrete and tie-back anchors (soil nailing); however, depending on the performance of the native sand with the till deposit, hollow anchor bars may be needed to allow for adequate grout/soil bond. Excavation supports using shotcrete and tie-back anchors are common practice in Vancouver and several local contractors are very familiar with this construction technique. Photo 2-1 shows a typical shotcrete and tie-back anchor retention system used in a Downtown Vancouver temporary excavation.

Photo 2-1 Shotcrete and Tie-Back Anchor Retention System—Downtown Vancouver

A search and survey of all local utilities and underground structures should be conducted to allow ground anchors, or nails, to be located outside these areas. This information will be used by the retention system designer to avoid intercepting utilities and underground structures during anchor drilling. It may be necessary to protect or move underground utilities during construction to avoid damage associated with vibrations and/or ground movements. Encroachment agreements will need to be established with adjacent property owners where anchors, or soil nails, encroach into their property boundaries.

It is recommended that a series of monitoring points be established on the excavation face and selected points on adjacent structures and/or on the ground set back from the excavation. Regular surveying of the monitoring points in all three directions should be undertaken during excavation and construction of the permanent foundation walls. The frequency of the required surveying at site would be established by the engineer, based on the actual soil, bedrock and groundwater encountered during bulk excavation work.

The Canada Line SkyTrain passes within approximately 20 m of the proposed Emery Barnes Project location. TransLink will be consulted to establish the precise location of the SkyTrain tunnels and the permissible distance that the excavation can occur adjacent to the tunnels. Should the excavation be within influencing distance of the SkyTrain tunnels, analysis of the potential for excessive ground movements around the tunnels will be conducted with special construction techniques possibly required to mitigate potential ground movements.

A tower crane will typically be installed once part of the excavation reaches the lowest excavation level, to permit the movement of construction material and equipment. Conveying equipment may also be used to permit movement of construction materials and excavated soil and rock.

The first stage of construction will require an under-slab drainage system. The under-slab drainage system will most likely consist of a network of slotted or perforated rigid-wall pipe embedded within a layer of drain rock. The under-slab drainage system will then discharge through non-perforated pipe to a sump-pump system to prevent the build-up of any water pressure under the slab.

The construction of the substation will then commence like much of the large commercial construction currently occurring in Downtown Vancouver. The first stage would be the installation of the foundations. The underground substation would then be constructed similar to a large underground parkade, with the concrete base slab poured first and the external concrete retaining walls surrounding the structure installed. The internal walls and slab floors should be installed in sequence until the final roof structure is completed. A section of the roof structure will contain a large hatch that will be designed so that it can be removed for the initial installation of the large transformers that cannot be moved through the elevator, and in the future when maintenance may be required.

Once construction is completed an elevator will be installed in the shaft on the west corner of the substation. This elevator will be used to install all other major equipment in the substation, and it will also be used to move construction staff and future maintenance staff in and out of the substation.

Cable trenching will also be required for both the 230 kV lines and the 25 kV lines coming in from the street. There will be three major 230 kV transmission lines installed into the substation at Emery Barnes Park. These cables will be installed in conduit buried approximately 1.5 to 2.0 m below the surface. The trenches will be excavated with a standard excavator and the conduits will be installed in sand at the bottom of the trench. The trench will then be backfilled with special concrete mixture and the trench will then be backfilled with native fill. These trenches can be installed at any time, and the cables will be pulled in once all construction of the substation has been completed.

Following construction of the substation, Emery Barnes Park will be reconstructed and the fencing removed to allow the public access to the facilities. The Park Board would determine the new park design of Emery Barnes Park through a comprehensive community engagement process funded by BC Hydro prior to the substation construction.

2.2.2.2 Lay Down Areas

The current dog park will possibly be used as a laydown area for storage of construction equipment and materials.

A logistics delivery plan can be implemented so that materials and equipment will not need to be stored onsite longer than required, therefore reducing the required laydown area.

Materials will be stored in the excavation pit, once constructed.

2.2.2.3 Access/Egress

Approximately 55% of Emery Barnes Park will remain open to the public during construction and will be accessed via Richards and Davie streets. An additional 4% will be fenced off for approximately one to two months for installation of the underground duct work.

Construction access will be provided from Seymour Street, adjacent to the current dog park.

During construction, full time traffic control will be provided on Seymour Street to facilitate all construction equipment into and out of site. A detailed traffic impact assessment would be undertaken and a Traffic Management Plan would be implemented during construction to reduce impacts in the project area.

2.2.2.4 Construction Schedule and Areas Impacted

Total construction is anticipated to take approximately 5 years, with some overlapping construction activities as listed below:

- Mobilization and removal of existing facilities (1 month)
- Excavation of substation (12 months)
- Construction of Substation substructure (17 months)
- Fit-out of substation including all electrical and mechanical equipment (18 months)
- Reconstruction of the park (6–12 months). This activity will overlap with the fit out of the substation.
- Final commissioning of substation (6 months)

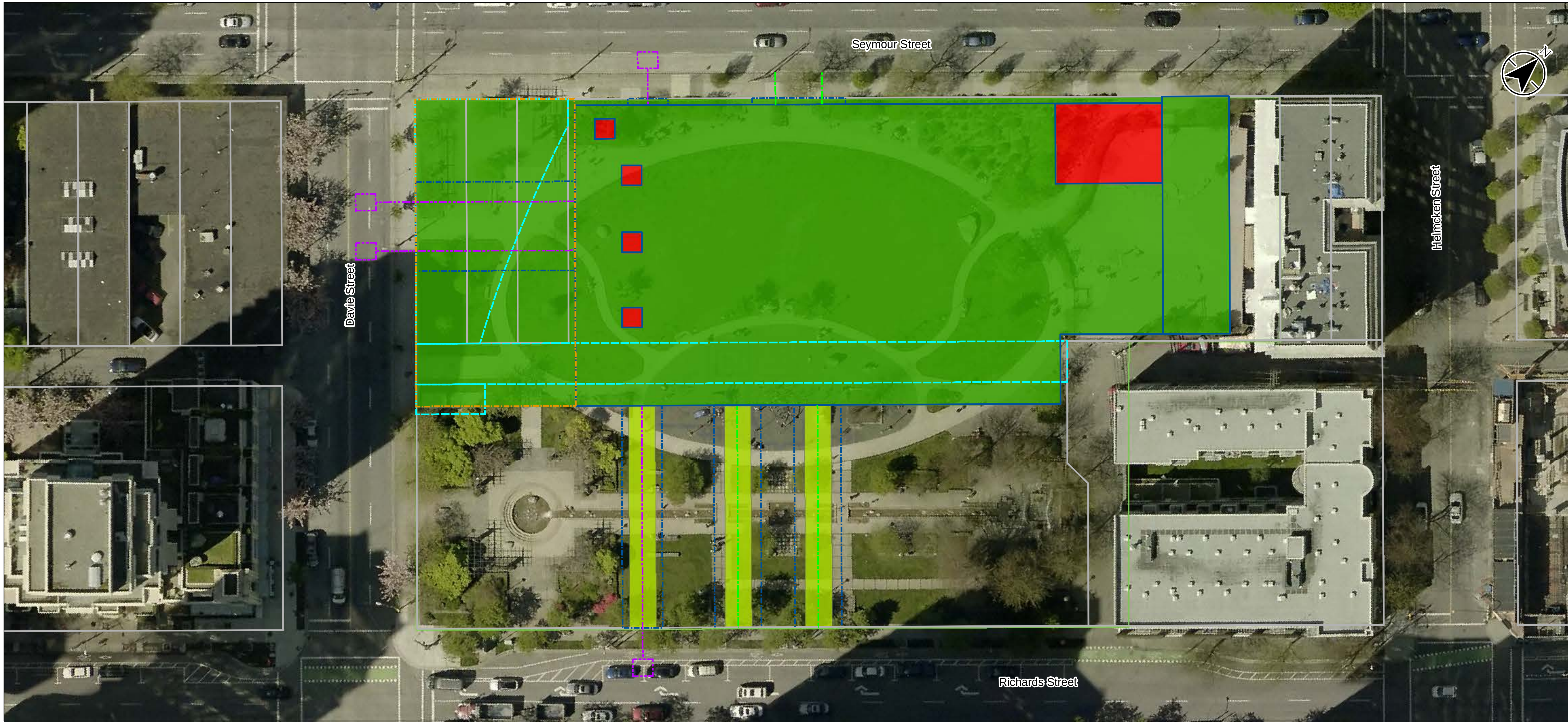
A summary of the permanent and temporary areas impacted by the proposed project is described in Table 2-1 below and presented in Figure 2-1 for Emery Barnes Park.

Table 2-1 Construction Impact and Duration

Site	Construction Impact and Duration	Area (m^2)	Percent
Emery Barnes Park	Permanently Lost: BC Hydro Infrastructure	228	3%
	Temporary Lost: Substation Construction (min. 3 years)	4,014	45%
	Temporary Lost: Cable Installation (1-2 months)	400	4%
	Not impacted	4,326	48%
	Total Area	**8,967**	

At Emery Barnes Park, construction of the underground substation will temporarily impact 4,014 m^2, or 45% of the park for approximately three years. Installation of the underground cables will also temporarily impact 400 m^2, or 4% of the park for approximately one to two months. Once construction is complete, 228 m^2 or 3% of the VPB lands at Emery Barnes Park will be permanently lost due to the space required for BC Hydro infrastructure, including the vehicle access/intake structure, emergency exit stairwell, and exhaust shafts. The remaining 97% of the Emery Barnes Park will be permanently available to park users.

Options to incorporate the vent shafts into the design of the park, or allocate them to the perimeter of the property may further reduce the amount of permanently lost space.



Road segment
Statutory Right Of Way
Proposed Statutory Right Of Way
Temporary Work Area
Proposed Distribution Duct
Proposed Transmission Duct
Proposed Substation
Property Boundary

Construction Impact and Duration
Permanent
Temporary, min. 3 years
Temporary, 1-2 months

0 10 20 metres
1:600 (At original document size of 11x17)

Stantec

Project Location
Vancouver, BC

123220737
Prepared by L. Trudell 2017-02-15
Reviewed by L. Thompson 2017-02-15

Client/Project
Emery Barnes Park

BC Hydro SEED Program Study

Figure No.
2-2

Title
Emery Barnes Park
Construction Impact and Timelines

Notes
1. Coordinate System: NAD 1983 UTM Zone 10N
2. Base features: DataBC, Government of British Columbia (GovBC); Surrey History National Topographic System, GovBC; CanVec v12,Government of Canada (GC)
3. Orthoimagery: City of Vancouver Open Data catalogue 2015

\\CD1183-F03\Workgroup\1232\projects\123220785\analysis\Vegetation\20170214_percent_area_lost\fig_123220785_ti_001_Emery_Barnes_Park_Construction_Impact_and_Timelines.mxd Revised: 2017-02-15 By: ltrudell

2.3 EXISTING CONDITIONS, IMPACTS AND MITIGATION

The following section describes the existing environmental and social values that currently exist at Emery Barnes Park, how those values could be impacted by BC Hydro's proposed project, and recommendations to avoid, mitigate or compensate for potential impacts. For addition information related to EMF and real estate, please see the stand alone reports in Appendices E, F and G.

2.3.1 Park Inventory and Conditions

2.3.1.1 Baseline Data and Findings

A survey was completed for Emery Barnes Park, picking up a variety of elements including but not limited to:

- Edges of pavement (delineation between hard and soft surfaces)
- Park features—outlines of planters, walls, custom seat walls/benches, water fountains)
- Park structures—trellis, shelters, playground equipment etc.)
- Park buildings (washroom buildings, storage buildings, etc.)
- Utility boxes, lids, and equipment
- Trees—locations and diameter at breast height (DBH)
- Furnishing and lighting—lights posts, bollards, benches
- Legal property lines
- Edge of curb between the road and the municipal sidewalks that bound each park

NOTE: bench placements and other minor paving details were field verified and photos of existing site furniture were taken to capture their condition at the time of this report. A photo capture of various views into the park have also been recorded to document Emery Barnes Park current condition.

This survey was completed to create a "record drawing" that identifies the current layout and location of major elements within Emery Barnes park. This survey was used to develop a digital base plan for the park site that included all property lines and right of ways. The prepared base plan was used to calculate existing project metrics such as; amount of concrete, amount of tuff, number of benches, number and size of trees, etc. This information provides a baseline of data on the existing park that will be used should the project move forward to the detailed design phase.

Table 2-2 Inventory of Current Park Features and Amenities

Item	Description	Quantity	Unit
Materials			
1.1	Open Grassed Area	3,896	m^2
1.2	Planting Bed	1,208	m^2
1.3	Water Feature	199	m^2
1.4	Rubber Tiling (playground area)	567	m^2
1.5	Dirt/gravel (dog park)	850	m^2
1.6	Concrete Paving (internal park)	2,660	m^2
1.7	Concrete Paving (perimeter City sidewalk)	690	m^2
Total Gross Area		**10,070**	**m^2**
Amenities and Furnishings			
2.1	Metal Fence (dog park)	94	Linear metre
2.2	Trellis Structure Above	281	m^2
2.3	Benches	33	each
2.4	Lamp Standards	28	each
2.5	Playground Feature	1	each
2.6	Swing Set	1	each
2.7	Picnic Tables	6	

Figure 2-2 indicates the composition breakdown of the total 9,380 m^2 of park surface area. Note that "paved" areas comprising of 43% of the park surface area includes all concrete paving, dog park sand, and the rubber surface for the playground.

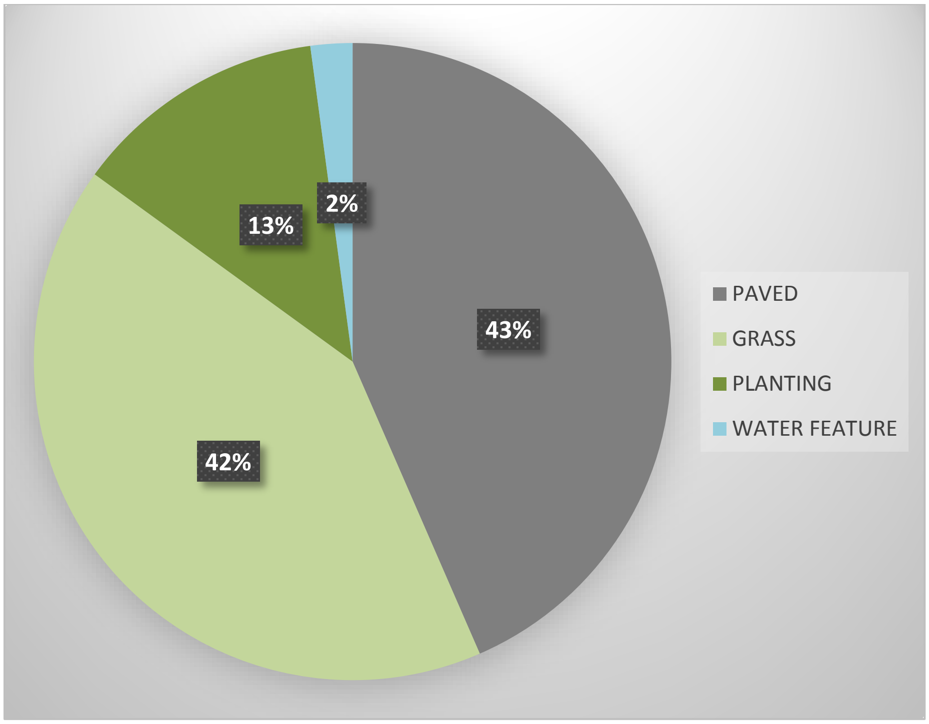


Figure 2-3 Percent Composition of Various Substrate Comprising the Surface Area at Emery Barnes Park

2.3.1.1.1 Desktop Study—Online Reviews

YELP.com rates Emery Barnes Park at 4 out of 5 stars (based on 18 reviews). Google Reviews rates it at 4.3 out of 5 stars (based on 56 reviews). And tripadvisor.com rates Emery Barnes Park at 3.5 starts out of 5 (based on 8 reviews). Figure 2-4 is a wordle which summarizes all the comments from all three online review sources into a wordle generator, which depicts the words mentioned more often as larger in the graphic below.

Figure 2-4 Wordle Diagram that Depicts Park Uses Identified through Desktop Review

2.3.2 Park Use and Programming

2.3.2.1 Baseline Data and Findings

Being centrally located in Downtown Vancouver in between the business districts, Yaletown and Gastown, Emery Barnes Park Due has a very high population of people within an 8-minute walk to the park. In addition to being used as a commuter pathway, the park is well-used by children playing on the playground or in the water feature, dogs in the off-leash area, and people sitting on the benches.

The following desktop and on-site studies were completed in January of 2017:

1. Three on-site studies of the park were conducted in 2 hour durations each, in late January 2017 at three key time frames:
    a. Study Type 1—weekday rush hour (8:00 AM to 10:00 AM)
    b. Study Type 2—weekend review (2:00 PM to 4:00 PM)—Saturday afternoon
    c. Study Type 3—weekday mid-morning (10:00 AM to 12:00 PM)

2. Desktop study (study type 4) of the summer use was conducted by reviewing Emery Barnes Park through Google Earth, Orthophotos, as well as Google street view to observe both frequency of users and the types of activities those users were engaged in.

3. Desktop review of online reviews of Emery Barnes Park were studied including:
   a. Google reviews
   b. YELP reviews
   c. Trip Advisor reviews
   d. Foursquare reviews

2.3.2.2 PARK PROGRAMMING

The programming for the park consists of both structured and non-structured uses. Structured uses refer to the park being used for specific purposes for community events, groups or city-wide events typically planned in advance. Non-structured uses refer to informal activities (active or passive) by visitors at any given time at their discretion.

Structured Uses

Table 2-3 provides a summary of the various events and other group activities that have used the park in the past five years and when they occurred (please note this is not a conclusive list but a sampling of the types of events that typically happen).

Table 2-3 Partial Summary of the Events and Group Activities Held in Emery Barnes Park over the Past 5 Years

Season	Event/ Festival	Description	Open to Public/ Group Event	Dates
Summer	Gathering Festival	Community art workshops, amateur and professional music performances, film screenings at Vancity Theatre, Summer Solstice parades, and celebrations	Open to Public	June 18 and 19 annually
Spring	Vancouver Urban Sketchers Meetup	Organized gathering for local sketch artists	Open to Public	Annually, April
Spring	Filming "Beijing Meets Seattle"	Ocean Bridge Pictures production	Closed event	6/1/2016
Summer	Filming "Lucifer"	Television production	Closed event	9/16/2016
Winter	Winter Solstice Procession	Processions originating at Emery Barns Park, Cooper's Park, and Vancouver Aquatic Centre head towards David Lam Park	Open to Public	Annually, December 21
Spring	Cricket Solos for Clarinet, Piccolo, Percussion, and Violin	Performance in partnership between Vancouver New Music and Contemporary Art Gallery	Open to Public	7/10/2015

2.3.2.2.1 Non-Structured Uses

The variety of amenities at the park, as well as the physical layout of these amenities, contributes to a variety of informal uses and experiences at the park. Uses mainly include:

- Casual strolling
- Bench dwelling
- Grass sitting/laying/sunbathing
- Dining
- Active play at the playground
- Active play (e.g., ball sports) in the open grass area
- Playing with the fountain at the south end of the park
- Dog walking as well as off-leash playing at the dog park

All of these above non-structured uses take place across the park site based on amenity locations. Please refer to Appendix A.1, Emery Barnes Park Programming, and Use Figures for a graphic depiction of where these non-structure uses take place at any given time.

The dog "off leash" park is open from 6:00 AM to 10:00 PM.

2.3.2.3 Park Use

As noted, landscape field technicians visited the site at three key time frames:

- Study 1—weekday rush hour (8:00 AM to 10:00 AM)
- Study 2—weekend review (2:00 PM to 4:00 PM)—Saturday afternoon
- Study 3—weekday mid-morning (10:00 AM to 12:00 PM)

Study 1—Weekday Rush Hour

Overall, there was a high frequency of weekday commuters that use the park to "cut-through" on their way to work. Given the grid-like fabric of the surrounding Downtown neighbourhood, Emery Barnes Park is estimated to cut off approximately 3 minutes from the walking commute (based on measuring the length and frequency of commuters compared with the length of the direct "cut-across" routes. There were some users of the playground, but that did not pick up until 9:00 AM, when the temperature increased. There were many dog-walkers observed that were either walking casually through the park, or slowly walking over to the dog-park. It was observed that most dog walkers who frequent this park have small dogs. At all three study times, only owners with small dogs were observed in the park.

Table 2-4 summarizes the types of users observed at this study timeframe.

Emery Barnes Park Study #1
Date: Tuesday, January 24, timeframe: 8:00 AM to 10:00 AM
Weather: overcast, 3ºC

Table 2-4 Summary of the Types of Users Observed on Tuesday, January 24

User Type	8:00 AM	8:15 AM	8:30 AM	8:45 AM	9:00 AM	9:15 AM	9:30 AM	9:45 AM	total
Commuters: Primary Route: from the north corner of Seymour towards the south corner at Davie and Richards	8	11	8	6	6	9	4	5	**57**
Commuters: Second Priority Route: From the west corner at Seymour and Davie to the east corner at Richards	8	7	12	8	12	6	3	11	**67**
Commuters: Third Priority Route: From the middle of the park entrance off Davie towards to the east corner at Richards	3	1		4	4	6	2		**20**
Commuters (Total)	**19**	**19**	**20**	**18**	**22**	**21**	**9**	**16**	**144**
Families (at the playground)			2	1	1	1	2	3	10
Dog Walkers	8	7	13	10	11	9	10	6	74
Strollers			2	2	2		1	1	8
School Walkers			2		2				4
Bench Dwellers	1					2	3	4	10
Dog Park Users	2	3	1	1	2	3	4	3	19
Total All Users	**30**	**30**	**44**	**36**	**41**	**38**	**30**	**38**	**287**

Study 2—Weekday Mid-Morning

The park was the least busy during this time frame. The dog park was the most frequented spot in the park at this time. There were mostly families (typically consisting of one adult with one or two young children [estimated at under four years old, as the study was conducted during school hours]). Consistently, weekday use of benches was by adult individuals for extended periods of time.

Table 2-5 following table summarizes the types of users observed at this study timeframe.

Emery Barnes Park Study #2

Date: Thursday, January 19, timeframe: 10:00 AM to 12:00 PM
Weather: sunny, 6ºC

Table 2-5 Summary of the Types of Users Observed on Thursday, January 19

User Type	10:00 AM	10:15 AM	10:30 AM	10:45 AM	11:00 AM	11:15 AM	11:30 AM	11:45 AM	Total
Commuters: Primary Route: from the north corner off Seymour towards the south corner at Davie and Richards	6	6	4	4	2	4	3	2	**31**
Commuters: Second Priority Route: From the west corner at Seymour and Davie to the east corner at Richards	4	3	3	4	3	2	1	2	**22**
Commuters: Third Priority Route: From the middle of the park entrance off Davie towards to the east corner at Richards	2			2		1	1		**6**
Commuters: Fourth Priority Route: from the north corner at Seymour down to the southeast entrance off Richards		1		1	1		1	1	**5**
Commuters (Total)	**12**	**9**	**7**	**10**	**5**	**7**	**5**	**4**	**64**
Families (at the playground)	2	3	2	2	1	3	1	3	**17**
Dog Walkers	8	7	13	10	11	9	10	6	**74**
Strollers			2	2	2		1	1	**8**
School Walkers			1						**1**
Bench Dwellers	1					2	3	4	**10**
Dog Park Users	3		1	1		3			**8**
Total All Users	**26**	**20**	**26**	**26**	**20**	**24**	**21**	**19**	**182**

Study 3—Weekend Afternoon

The weather was mostly sunny, however it had rained between 1:00 PM and 2:00 PM. The majority of park users at this time were at the playground, which typically included adults with one or two children (with two families of three children). The other most frequented spot in the park was the dog park.

Table 2-5 summarizes the types of users observed at this study timeframe.

Emery Barnes Park Study #3

Date: Saturday, January 21, 2017, timeframe: 2:00 PM to 4:00 PM
Weather: overcast, 7ºC

Table 2-6 Summary of the Types of Users Observed on Saturday, January 21

User Type	2:00 PM	2:15 PM	2:30 PM	2:45 PM	3:00 PM	3:15 PM	3:30 PM	3:45 PM	Total
Casual Walkers	4	6	4	2	2	3	2	1	**24**
Commuters		1	1	1		3			**6**
Families (at the playground)	2	3	4	2	1	3	4	5	**24**
Dog Walkers	2	3	1		1	2	2	3	**14**
Strollers		1		2			1	1	**5**
School Walkers									**0**
Bench Dwellers	3	6	8	7	6	6	4	5	**45**
Dog Park Users	3	4	5	3	2	5	6	4	**32**
TOTAL ALL USERS	**14**	**24**	**23**	**17**	**12**	**22**	**19**	**19**	**150**

It should be noted that overall number of users decreased on the Saturday observation (Study #3) which is likely due to the overcast weather, and earlier rain, which may have deterred people from venturing outside that afternoon. It would be expected that the Saturday numbers would likely be higher during peak summer seasons, however, it does indicate how significantly this park is used for commuting and/or people cutting through the park, particularly during the work week.

Study 4—Desktop Study (Summer Use)

A desktop study of Google street view and available air photos was conducted, depicting high park use in the warm summer months (May-September). Most park benches and seating areas were occupied on a sunny day. Park users were observed sun bathing on grassy areas, children playing in the water feature and on the playground, walking their dogs, and groups playing Frisbee in the open grassy areas of the park.

Google reviews has an application that allows cell phones, when located within the park, to communicate with satellites, allowing Google to track users throughout the year. The peak times according to Google's data on an average Saturday indicates that people typically spend about 45 minutes here.

A series of desktop and on-site studies were employed to understand how the park is used. It is recognized that the on-site studies were conducted in January of 2017, which is not an ideal time of year to observe the maximum potential of users and activities taking place in the park. While the initial site studies offered in this report were completed in January, ,they should provide a good indication of frequency of use in winter months as a sample, as well as the routes of travel of local pedestrians (such as walking commuters) and how they use the park. Because of the timing of the site observations, we recommend that an ongoing review of the park be undertaken to ensure all user preferences are captured.

Types of Users

During all the observations (both on site and desktop research), predominant and typical types of users are during the winter season at Emery Barnes Park. Table 2-7 depicts these types of users along with a description and an image capture of these users in action at the park.

Table 2-7 Summary of Emery Barnes Park User Groups

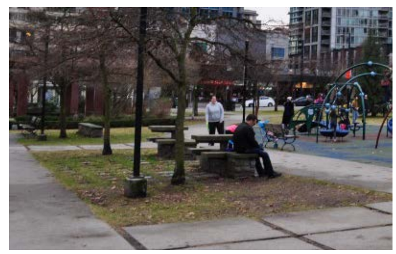
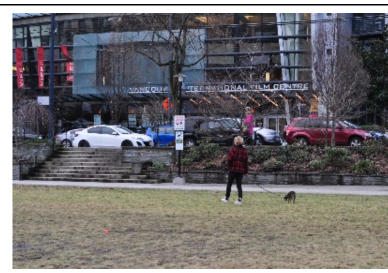
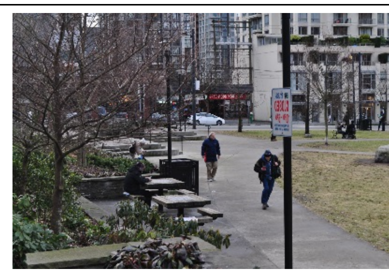
Icon	Type	Description	Image Example
	Strollers	Adult with stroller and baby/toddler walking along the paths through the park.	
	Families	Mostly two-adult families with multiple children, typically observed at the park, or on grassed areas in a social setting.	
	Commuters	People walking fast with very direct routes through the park. They use the shortcut paths most often.	
	Dog Walkers	Typically consists of one person with their dog on a leash, walking slowly around the circular path while the dog sniffs things.	

Table 2-7 Summary of Emery Barnes Park User Groups

Icon	Type	Description	Image Example
	Bench Dwellers	People sitting on benches. Typically benches in the sun are most frequented.	
	Dog Park Users	Dog owners with their dogs off leash in the dog park. Almost all dog owners congregate in the middle of the dog park to socialize while their dog plays.	
	Joggers	Joggers running through the park. These users are mostly observed on the weekend or in the early weekday morning (although less frequent).	
	Casual Walkers	Couples or small groups of adults walking through the park.	

Frequency of Use of Amenities

The types of users vary depending upon the time of day and the day of the week. For a graphic depiction of these types of users, refer to Appendix A.1, Types of Users (weekend) and Types of Users (weekday). The overall frequency of users in the park and the areas and amenities that are frequented most at any given time, have been graphically depicted in Appendix A.1, Frequency of Park Uses.

2.3.2.4 Discussion of Impacts

Based on the information gathered about the amenities and users of the park, as well as the proposal for the substation below ground, the impacts to the Park Programming and Use are anticipated to be as follows:

2.3.2.4.1 Impacts to Park During Construction

The primary route of travel for commuters (and local community groups) is directly across the park starting from the north end of Seymour Street, and cutting south over to Davie Street. This route will not be accessible during the construction of the substation.

Being a small park space it is anticipated that the combination of Project site construction activities and required laydown space will disturb a significant portion of the existing park. Much of the park spaces will be unusable due to construction activity during the entire substation construction schedule. This will affect both the programmed uses to the site as well as frequently used pathways and travel routes. However, at time of Project detailed design, phasing opportunities will be reviewed to minimize the amount of park space shut-down at any one time.

2.3.2.4.2 Potential Changes to Park Design and Programming Post-Construction

While the park area will be put back in place once the underground work is completed, there will be a loss of usable park space during the construction phase of the project and post-construction due elements such as venting and surface access. While the substation requires approximately 228 m^2 of above-ground surface area which will be temporally unavailable for park users during construction. Approximately 24.7 m^2 of this is in open grassed area used by many park users and for park programming events.

Depending upon the final design of the substation, and the technical requirements of bringing power lines into and out of the station, some of the existing park layout may need to change. The existing water course will be affected due to bringing distribution lines into the substation. The initial concept design for the substation also shows that the new venting and entrance structure for the substation may impact the layout and use of the dog park and a small portion of the lawn area.

The vehicle access building as located in primary designs will impact the current travel route of walkers shortcutting though the park.

The most notable interference to park amenities result from the vehicle access garage located at the north end of the park. This is currently proposed within the dog park and takes up approximately 850 m^2 of space. The dog park would not be able to stay where it is, as vehicle access to the vehicle elevator shaft will also be required. Therefore, the dog park would have to be relocated, further taking up other park space, and having a ripple effect on park programming.

The location of three large ventilation stacks in the open grassed area would impact the use of this open grassed area for active uses such as Frisbee, soccer, baseball, etc. Further to this, assuming these elements could possibly be converted into an architectural feature or "public art" that may vary use and celebrate infrastructure, it does changes the nature of the space. With these features, the surrounding area would likely need to be paved, which therefore would change this space from an open green space to a more urban-focused area or paved plaza.

2.3.2.5 Mitigation Measures

Potential mitigation measures for the impacts discussed above could include, but are not limited to:

- A loss of parkland and net area for park use
  - Change the shape/size and form of the above ground structures so that they are more conducive to use by park visitors. For example, if the vehicle access elevator could be shaped to have a sloped side with a grassed roof that users could walk on and use as a "look out" point, that would allow park space to be maximized while also allowing for access into the elevator shaft
  - Elevate the design of above ground structures to incorporate architectural detailing. For example, a living green wall could be placed over the exposed sides of a structure.
  - Use above ground structures to incorporate opportunities for artistic expression within the park space.
  - Change park programing to meet technical requirements of what can be utilized over the substation.
  - Due to the impact of the substation, a complete redesign and reconstruction of the entire park would be required concurrently with the substation design and construction. This park design process would be led by the Park Board though a comprehensive community engagement process and the Park Board would work in conjunction with BC Hydro to implement the reconstruction.
- Interference to park amenities and programming:
  - Prior to construction, further review and public input on park use could be completed which might lead to an opportunity to re-program park to better meet new user needs.
  - If programmed/active uses are needed more than passive ones, uses can be relocated within the park space. For example, the "off leash" dog park could be relocated west taking up more of the planting area.
  - Elevate the dog "off leash" park to be on the structure above the elevator shaft and vehicle access, with access into the dog park located through grade change and elevation up to elevated dog park feature
- Change the park design to provide dog park near the venting structures (which may provide a more suitable park amenity to accommodate such structures) and place the open green space towards or above the vehicle elevator shaft
- Blockage/disruption of most frequently used pathways and routes of travel
  - Largely occurring during the construction process, it is not anticipated that any restrictions to foot traffic within the park would be present after the substation is built.
  - Explore opportunities to share uses.
  - Shift the venting structures to be away from pathways, realigning them, or changing the shape

- Provide a pedestrian bridge or other park feature to bring users up and over the vehicle access
- Provide a more enhanced "gateway" feature to north access into park, signifying the new entrance (with art/lighting/paving change, and other amenities as part of a new design vision)

- Restrictions on planting of large trees on top of substation facilities and limitations on permanent amenity construction in future park upgrades

2.3.2.6 Recommendations for Future Study

It is recommended that a detailed analysis of the design of the above-ground elements that interfere with park programming be completed to creatively determine how the engineering and structure of the elements could be modified to work with park spaces and uses. This may include a case study of past examples of infrastructure (not limited to substations) and how they have been modified to allow park uses on top or complementary to them.

2.3.3 Park Experience and Aesthetics

2.3.3.1 Baseline Data and Findings

A shadow study was completed to help understand how the vehicle elevator shaft and ventilation stacks would affect the parks' sun and shade throughout the day. See Appendix A.1. A positive park experience is tied to the amount of sun exposed to the park which is also tied to a positive aesthetic experience. Therefore, the shadow study reveals changes in sun exposure and the potential change in park user experience and aesthetics.

2.3.3.2 Discussion of Impacts

Understanding the high level impacts the substation would have on the overall experience of the park include considering how the location of the vehicle elevator at the north corner would block the "arrival" experience at the north corner of the park, how the ventilation stacks may affect park aesthetics, and understanding the types of trees and vegetation that can safely be planted on top of the substation.

2.3.3.3 Mitigation Measures

The mitigation measures proposed to deal with the above impacts could include creative ways to incorporate the design of the vehicle elevator at the north corner of the park to minimize the loss of usable park space and interruption to the north entrance. Consider how to utilize the roof of this vehicle elevator as usable park space by creating a focal feature point within the park. Ways to mitigate the visual impact of the required ventilation stacks could include designing them to work with other proposed park upgrades, consider different heights, materials and commissioned public art.

2.3.3.4 Recommendations for Future Study

Some recommended future studies could include the following:

- Visual impact assessment
- Further detail on what the vent stacks can handle in terms of public art, or other structures on top that integrate them more with the overall experience of the park
- Further exploration of the design of the substation would be undertaken so that the renewed park on the roof can be sustained for the long term, i.e., so that the membrane on the substation below the park can support a mature tree canopy and so that during the initial 50–75-year life span of the substation, it can be upgraded without impacting surface features, especially mature trees.

2.3.4 Vegetation

2.3.4.1 Baseline Data/Findings

An arborist study was conducted to inventory and document the location, species, DBH, and general condition of each tree within Emery Barnes Park (Appendix C; Emery Barnes Arborist Report). The Vancouver Street Tree Inventory (City of Vancouver 2017b) and as-built landscape plan designs supplemented the field survey (Appendix A.3) The Project footprint is defined as the location of the underground substation, above-ground substation entrance structure and public washrooms, above-ground vents, and underground transmission and distribution ducts.

Urban forest canopy cover is an important part of the Urban Forest Strategy and Greenest City Action Plans (City of Vancouver 2014a, City of Vancouver 2015). To determine the canopy cover of the parks, aerial photos were used to digitize the tree canopy. The area of tree canopy cover was determined and divided by the total area of the park (0.85 ha for Emery Barnes Park; City of Vancouver 2017c).

As of 2014, the urban forest canopy cover in the Downtown neighbourhood was approximately 8.3% (City of Vancouver 2014a). Emery Barnes Park has an existing canopy cover of 32%, which is approximately 1% of the canopy cover of the Downtown neighbourhood. Emery Barnes Park is approximately 0.2% of the total area of the entire Downtown neighbourhood.

Landscaping in Emery Barnes Park was installed over three phases, with the most recent phases completed in 2010 and 2012 (City of Vancouver 2017c). The trees planted during the most recent phase are quite small (i.e., the majority are < 20 cm DBH; Table 2-8). The park has a large open field in the middle, including a formal garden with trees and a water feature along Richards Street. The west side of the park, along Seymour Street has raised planter boxes with ornamental shrubs and ground covers. Small trees are planted throughout these planter boxes.

Table 2-8 provides a summary of the tree species, DBH and count of trees within Emery Barnes Park. A total of 111 trees were recorded within Emery Barnes Park (Appendix C), of this total, 33 are ≥20 cm DBH (see Appendix C).

Table 2-8 Summary of Trees within Emery Barnes Park

Common Name	Scientific Name	Minimum DBH (cm)	Average DBH (cm)	Maximum DBH (cm)	Number of Trees	Number of Trees ≥20 cm DBH
paperbark maple	*Acer griseum*	11	14	16	3	0
Japanese maple	*Acer palmatum*	19	32.5	50	6	5
eastern redbud	*Cercis canadensis*	8	10	13	3	0
dogwood	*Cornus* sp.	2	7	11	4	0
beech	*Fagus* sp.	14	24	33	5	4
American sweetgum	*Liquidambar styraciflua*	12	20	26	8	6
apple	*Malus* sp.	7	10	12	4	0
dawn redwood	*Metasequoia glyptostroboides*	16	17	19	3	0
cherry	*Prunus* sp.	7	19	27	8	4
Callery pear	*Pyrus calleryana*	13	15	18	5	0
Japanese snowbell	*Styrax japonicus*	6	13	19	10	0
little-leaf linden	*Tilia cordata*	21	29	37	5	5
red maple	*Acer rubrum*	28	33	37	4	4
katsura	*Cercidiphyllum japonicum*	11	15	22	3	1
black pine	*Pinus nigra*	13	13	13	1	0
pine	*Pinus* sp.	16	16	16	1	0
unknown	*Unknown*	8	11	14	2	0
oak	*Quercus* sp.	16	16	16	1	0
pin oak	*Quercus palustris*	35	35	35	1	1
giant sequoia	*Sequoiadendron gigantium*	24	24	24	1	1
Persian ironwood	*Parrotia persica*	7	10	12	2	0
unknown[a]	*Unknown*	-	-	-	1	-
Total					**111**	**33**

NOTE:
[a] This is a small, weeping tree on the top of the water feature. It was unsafe to measure the DBH.

No invasive plants, noxious weeds, or rare plant species were observed during the survey.

A large portion of the proposed Emery Barnes Project footprint is open grassy field with paths throughout (Figure 1, Appendix C).

The condition of most trees was good. One American sweetgum had a damaged trunk (tree no. 34), and another was topped (tree no. 19; see Appendix C for their location). Some of the smaller trees had damage from lawn maintenance equipment and scratches on the bark. Additional information on the trees in Emery Barnes Park can be found in Appendix C (Emery Barnes Park Arborist Report).

2.3.4.2 Discussion of Impacts

Based on the conceptual design, the clearing for the proposed Emery Barnes Project and infrastructure will result in a temporary loss of approximately 33% of the existing canopy cover from the park, and less than 0.1% of the canopy of the Downtown neighbourhood.

Fifty-nine (59) trees will be removed during Project construction within Emery Barnes Park, 15 of which are ≥ 20 cm DBH.

Excavation of soil and rock to construct the underground substation structures has the potential to affect subsurface hydrology, which may in-turn adversely affect vegetation remaining outside the excavation footprint

The anticipated schedule for the completion of construction at Emery Barnes Park is 2041. Within that time, existing trees will continue to mature and increase in size, though the rate and extent depends upon individual species' growth rates and size at maturity. The canopy cover will also increase proportionately, though precise quantitative predictions of the degree of increase are technically challenging to estimate.

2.3.4.3 Mitigation Measures

The following mitigation measures are recommended to reduce effects of construction on the urban forest in the Downtown neighborhood. These are preliminary and will be finalized prior to construction, in consultation with the VPB.

- Pre-Construction
  - The subsurface hydrology section of this report recommends conducting groundwater monitoring for one year to generate a better understanding of groundwater fluctuations during the seasons. This information would help assess the risk of effects on vegetation due to changes in subsurface hydrology and inform accompanying mitigation measures.
- Construction
  - Where possible, the location of the transmission ducts will be placed under existing hardscape infrastructure, such as gravel or concrete pathways, to reduce the number of trees that may be affected.
  - Tree protection barriers for remaining trees should be installed prior to the start of construction. The tree protection barriers should follow the Tree Protection standard 32 01 56 in the Park Development Standards (PWL Partnership Landscape Architects Inc. 2015).

- Smaller trees currently located within the Project footprint could be moved to existing parks within the Downtown neighbourhood. If this occurs, relocation should follow the Tree Digging and Relocation standards 32 96 43.05 in the Park Development Standards (PWL Partnership Landscape Architects Inc. 2015).
- An Erosion and Sediment Control Plan will need to be submitted as part of the permit application to the City of Vancouver. This plan will include elements to protect storm drain inlets; to remove mud and debris from City property; to reduce sediment run-off; to schedule construction to limit vegetation clearing until necessary; to provide minimum-impact access; and provide a monitoring plan to sample discharge water (City of Vancouver 2017e).
- Where possible, construction staging areas should be placed to avoid removing trees.
- Construction activities involving movement of soil should follow best management practices to reduce the spread of invasive plants by arriving on-site with clean vehicles, and ensuring that any soil transported is clean and free of invasive species seeds or vegetative propagules.

- Post-Construction
  - BC Hydro will work with the VBP to replace the number of trees required by the City of Vancouver to achieve no net loss of trees or urban canopy due to the Project.
  - The landscaping of Emery Barnes Park will be restored following Project construction.
  - The aim of the Project is to achieve no-net-loss of the urban canopy in the long-term. Trees will be replaced following Schedule D of the Protection of Trees Bylaw (City of Vancouver 2017d).
  - Replacement trees should be planted on-site; if this is not possible, then they should be planted off-site but within Downtown to maintain canopy cover within the neighbourhood. Opportunities and constraints pertaining to tree replacement on-site and within the Downtown Neighbourhood will be determined during the design phase of the Project, which will include the detailed landscape design of the park for the post-construction timeframe.
  - Although large trees will not be replanted on top of the underground substation, other vegetation, such as grass, shrubs, and small trees (e.g., <5 m mature height and <15 cm DBH at mature height) may be planted on top of the underground substation.
  - To reduce the temporal loss of canopy cover during construction, replacement trees should be planted prior to the removal of trees, where feasible.
  - Trees, shrubs, and herbaceous plants should be installed following the Plants and Planting standard 32 93 10 in the Park Development Standards (PWL Partnership Landscape Architects Inc. 2015).
  - Soil placement should follow the Growing Medium standard 32 91 13 in the Park Development Standards (PWL Partnership Landscape Architects Inc. 2015).
  - Surface and groundwater management should maintain pre-construction conditions following construction to reduce long-term adverse effects on vegetation (see details in sections 2.3.9 and 2.3.10).

2.3.4.4 Recommendations for Future Study

Future study at Emery Barnes Park should include an additional arborist survey prior to construction to determine the total number of trees at that time (given the timeframe of construction). This survey will allow an update of the number of trees and species, since it is possible that trees will be removed (i.e., because of death or failure) or planted in the intervening years.

Future study should also identify the opportunities and constraints for reducing the temporal loss of the urban canopy during Project construction by identifying suitable locations and amounts of trees to be replaced, along with the schedule for replacement. This process would proceed in conjunction with the parks design process for the post-construction condition to identify on-site tree replacement options, and would extend to off-site options within the Downtown neighborhood, or city-wide, if necessary.

2.3.5 Air Quality

Air quality is the state of the atmosphere with respect to the presence of substances that are potential contaminants. Air quality is assessed because of its intrinsic importance to the health and well-being of humans, wildlife, vegetation, and other biota. Criteria air contaminants (CACs) are nationally recognized air contaminants. They have been regulated and used as measurable parameters for air quality. Understanding the amount of CACs released and the ambient concentrations in the atmosphere are crucial in assessing the air quality and the potential to affect the receiving environment. The CACs considered include: oxides of nitrogen (NOx) presented as nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), and fine particulate matter ($PM_{2.5}$).

2.3.5.1 Baseline Data and Findings

Metro Vancouver's air quality objectives for CACs were used for this air quality study and are summarized in Table 2-9.

Table 2-9 Metro Vancouver's Ambient Air Quality Objectives for CACs

Substance	Averaging Period	Objectives (µg/m^3) [1]
NO_2	1-hour	200
	Annual	40
SO_2	1-hour	196 [2]
	24-hour	125
	Annual	30
CO	1-hour	30,000
	8-hour	10,000
$PM_{2.5}$	24-hour	25
	Annual	8 (6) [3]

NOTES:

1 Metro Vancouver's 8-hour and 24-hour objectives are intended to be compared against concentrations calculated as a rolling average. Metro Vancouver objectives are "not to be exceeded", meaning the objective is achieved if 100% of the validated measurements are at or below the objective level.

Table 2-9 Metro Vancouver's Ambient Air Quality Objectives for CACs

Substance	Averaging Period	Objectives (µg/m³) [1]
[2] This 1-hour SO_2 objective is interim and is intended to apply to all applications for new or significantly modified discharge authorizations under Greater Vancouver Regional District Air Quality Management Bylaw No. 1082 made on or after May 15, 2015 but not intended to apply to existing facilities. "Significantly modified" refers to an increase in authorized quantity of emission of greater than 10%. The interim SO_2 objective will be revisited after the Canadian Council of Ministers of the Environment adopts a new Canadian Ambient Air Quality Standard, likely in 2016. [3] Metro Vancouver's Annual $PM_{2.5}$ Planning Goal of 6 µg/m³ is a longer term aspirational target to support continuous improvement.		
SOURCE: Metro Vancouver, 2016		

The potential impacts of the proposed Emery Barnes Project include the change in CAC concentrations during construction. During operations, no air quality impacts are expected as activities will be limited to the venting of air for equipment cooling and to maintaining indoor air quality. The operations phase will; therefore, not be further evaluated in this air quality study.

Project impacts on air quality are based on professional judgment and a qualitative evaluation of the relationship between the proposed Emery Barnes Project construction emissions and baseline air quality.

The baseline or existing air quality is determined from the nearest, most representative, continuous air monitoring station in proximity to the proposed Emery Barnes Project. No one station measures all CACs considered in this study, therefore data from two stations are evaluated, as presented in Table 2-10. Data from the Vancouver Downtown station is used for the evaluation of NO_2, SO_2 and CO baseline concentrations. This station is located in the Robson Square Complex which is approximately 720 m northeast of Emery Barnes Park. For context, $PM_{2.5}$ concentrations from Vancouver Kitsilano station is used because $PM_{2.5}$ is not monitored at the Vancouver Downtown station. This station is located at the Kitsilano Secondary School, approximately 3,300 m southwest of Emery Barnes Park.

Table 2-10 Continuous Ambient Air Quality Monitoring Stations Used in the Baseline Air Quality Analysis

Station Name	Latitude	Longitude	Elevation (m asl)	Location (UTM NAD83)			Substances Monitored			
				mE	mN	Zone	SO_2	NO_2	CO	$PM_{2.5}$
Vancouver Downtown [1]	49.2823°N	123.1219°W	32	491134	5458846	10	x	x	x	-
Vancouver Kitsilano [1]	49.2617°N	123.1635°W	34	488104	5456562	10	-	-	-	x
NOTES: x = continuous monitoring data available for the baseline air quality analysis - = monitoring data not available										
SOURCE: [1] Metro Vancouver 2014 Lower Fraser Valley Air Quality Monitoring Report (Metro Vancouver, 2014)										

The results of a baseline air quality analysis from 2008 to 2015 are presented in Table 2-11.

Table 2-11 Summary of Continuous Ambient Air Quality Monitoring Data at Stations Used in the Baseline Air Quality Analysis

Substance	Averaging Period	Objectives ($\mu g/m^3$)	Vancouver Downtown ($\mu g/m^3$)	Vancouver Kitsilano ($\mu g/m^3$)
NO_2 [1]	1-hour	200	84.1	
	Annual	40	37.7	
SO_2 [2]	1-hour	196	82.4	
	24-hour	125	19.0	
	Annual	30	7.50	
CO [2]	1-hour	30,000	768	
	8-hour	10,000	699	
$PM_{2.5}$ [4]	24-hour	25	-	12.5
	Annual	8(6)	-	4.92

NOTES:

[1] BC MOE summary database for NO_2 observations at Vancouver Downtown are for 2008, 2009 and 2012, 2013, and 2014. The 1-hour background NO_2 concentration was determined based on the daily 1-hour maximum concentrations, followed by the calculation of the 98th percentile for each year, then averaged over the BC MOE database period. Annual NO_2 background concentration was based on the average of annual mean values.

[2] BC MOE summary database for SO_2 observations at Vancouver Downtown are for 2008, 2009 and 2012, 2013, and 2014. The 1-hour background SO_2 concentration was determined based on the daily 1-hour maximum concentrations, followed by the calculation of the 99th percentile for each year, then averaged over the BC MOE database period. The 24-hour background SO_2 concentrations were determined based on the 98th percentile of 24-hour SO_2 concentrations for each year, then averaged over the period of record. Annual SO_2 background concentration was based on the average of annual mean values.

[3] BC MOE summary database for CO observations at Vancouver Downtown for 2009, 2012, 2013, 2014, and 2015. The 1-hour and 8-hour background CO concentrations were determined based on the 98th percentile of 1-hour and 8-hour CO concentrations for each year, then averaged over the period of record.

[4] BC MOE summary database for $PM_{2.5}$ observations at Vancouver Kitsilano are for 2009, 2010, 2011, 2012, and 2013, The 24-hour $PM_{2.5}$ background was determined based on average of the 98th percentile values for the 24-hour averaging interval. For the annual averaging interval, it is the average of the annual mean values.

SOURCE: BC MOE 2016b

BC Ministry of Environment (BC MOE) monitored concentrations of NO_2, SO_2, CO and $PM_{2.5}$ are demonstrated to be below the applicable Metro Vancouver Air Quality Objectives (Table 2-9). Baseline air quality of NO_2, CO, and SO_2 in Downtown Vancouver is influenced primarily by dense traffic close to a busy street (Vancouver Downtown station) (Metro Vancouver 2012). Baseline air quality of $PM_{2.5}$ in the vicinity of the Kitsilano monitoring station, is influenced primarily by a sandy beach volleyball court a few metres away from the monitoring station (Metro Vancouver 2012).

Generally, the baseline ambient air quality in the vicinity of Emery Barnes Park is good. Expected sources of CACs near Emery Barnes Park include: vehicular traffic, space heating, and other dust sources.

Estimated substation construction activities are separated into off-road excavation and construction equipment. US EPA NONROAD emission factors were used in conjunction with a list of representative off-road excavation and construction equipment. For this study, it is assumed that all equipment has Tier 3 engines (ECCC 2012). The sulphur content for off-road diesel is assumed to be 15 ppm based on ultra-low sulphur diesel limit (ECCC 2002). Following the EPA NONROAD model, all particulate matter (PM) emissions are assumed to be less than 2.5 µm in aerodynamic diameter ($PM_{2.5}$) (USEPA 2004) for this study.

Sources of PM from wind erosion and dust from mobile equipment are not quantified in this study. These sources are difficult to quantify as they are highly dependent on the activities/techniques used onsite. These emissions will be managed through the proposed mitigations for the Project as well as recommendations for future study, discussed below.

Table 2-12 presents the estimated annual CAC emissions related to fuel combustion during excavation and construction activities at Emery Barnes Park. It is predicted that the annual emissions from construction will be more than the annual emissions from excavation. Construction emissions exceeded excavation emissions mainly due to the equipment count and operating time required to complete these activities.

Table 2-12 Annual CAC Emissions from Excavation and Construction Activities at Emery Barnes Park

Activity	Emissions (tonnes/year)			
	NO_2	SO_2	CO	$PM_{2.5}$
Off-road excavation equipment	15.0	0.01	15.0	0.9
Off-road construction equipment	16.4	0.02	17.8	1.1

Excavation and construction activities are each estimated to last more than one year; therefore, Table 2-12 presents the total emissions from these activities. The CAC emissions in Table 2-13 include those emitted from fuel combustion only.

Table 2-13 Total CAC Emissions for Excavation and Construction of the Substation at Emery Barnes Park

Activity	Emissions (tonnes)			
	NO_2	SO_2	CO	$PM_{2.5}$
Off-road excavation equipment	16.9	0.02	16.9	1.0
Off-road construction equipment	20.9	0.02	22.3	1.4
Total	**37.8**	**0.04**	**39.2**	**2.4**

2.3.5.2 Discussion of Impacts

Professional judgement was used to qualitatively assess the potential impacts of the Project on air quality. This study is based on the types of construction activities, as well as the duration and frequency of construction activities. Activities associated with the construction of the substation will increase CAC concentrations in the vicinity of Emery Barnes Park. However, if best management practices to control CAC emissions are implemented, the degree of change to CAC concentrations is expected to be low. Activities will also be limited to daytime hours, temporary, and irregular in occurrence. As well, impacts would be reversible upon completion of the construction phase.

Baseline conditions are good, with all CACs measuring less than the ambient air quality objectives. The Project's impact on air quality are qualitatively assessed to remain within the ambient air quality objectives if construction best management practices are implemented.

2.3.5.3 Mitigation Measures

Mitigation measures applicable to air quality are limited to construction best management practices. These include:

- Water road surfaces and exposed surfaces prone to wind erosion to suppress fugitive dust
- Operate vehicles within the posted maximum speed limits to limit fugitive dust and fuel combustion emissions
- Implement wheel-cleaning for vehicles leaving site to prevent dust "track-out" onto the surfaces of public roads
- Maintain vehicles in good operating condition to meet emission standards (such as catalytic converters and particulate filters for diesel engines)
- Use appropriate size and modern (Tier 3) fleet of construction equipment to reduce fuel consumption
- Reduce vehicle idling and limit rapid starts and stops
- Use low-sulphur diesel fuel

2.3.5.4 Recommendations for Future Study

Emissions from sources other than fuel combustion have not been included in this study. Due to the type of the Project, PM (dust) from wind erosion and mobile equipment are difficult to quantify as they are highly dependent on the activities/techniques used onsite. It's recommended that impacts be evaluated during construction. This can be accomplished with the investigation of the cause for complaints (if any) related to PM emissions. Results of these investigations can yield continuous improvements to the best management practices over the duration of construction.

2.3.6 Noise

2.3.6.1 Baseline Data and Findings

Noise was selected as an environmental effect because activities during construction and operations of the Project will generate noise at Emery Barnes Park. Noise has been identified as a topic of concern to BC Hydro, VPB, stakeholders, and the public. For the purpose of this study, noise is defined as unwanted sound that has the potential to affect the health and well-being of humans.

The City of Vancouver Noise Control By-Law No. 6555, November 15, 2016 (Noise By-Law) regulates noise or sound within the City of Vancouver. The Noise By-Law prescribes different noise threshold for the quiet zone, intermediate zone, event zone, and activity zone. Quiet zone means any portion of the City not defined as an activity zone, intermediate zone, or event zone. Emery Barnes Park is located in the DD (Downtown) District, which is classified as an activity zone.

In an activity zone, the continuous daytime noise limit is 70 dBA and nighttime noise limit is 65 dBA. Continuous noise is defined as any sound occurring for duration of more than three minutes, or occurring continually, sporadically or erratically but totalling more than three minutes in any 15 minute period of time. The zone limits do not apply to construction related activities. During construction, the noise effect should not exceed 85 dBA for an activity zone, when measured at the property line, of the parcel of land where the construction is taking place, which is nearest to the point of reception of the sound or noise. The Noise By-Law restricts the construction activities hours as follows:

- Construction on private property must be carried out between 7:30 AM and 8:00 PM on any weekday that is not a holiday, and between 10:00 AM to 8:00 PM on any Saturday that is not a holiday. Construction is not permitted on Sundays.
- Street construction must be carried out between 7:00 AM and 8:00 PM on any weekday or Saturday, and between 10 AM and 8 PM on any Sunday or holiday.

The noise limit is applicable at points of reception, which is defined and follows the definition in the By-Law. The noise study area extends 200 m outward from the Project boundary. This study area includes the most affected points of receptions near the Project.

Emery Barnes Park is in a residential area. The residential buildings are mainly multi-storey apartment complexes with commercial premises (restaurants, cafes, clinics) on the ground level. The closest point of reception is located directly along the Emery Barnes Park site east boundary.

The acoustic baseline condition was determined by conducting continuous noise measurement within the Emery Barnes Park on January 20, 2017. The measurement was conducted during two daytime periods within the same day. The measurements results provided preliminary information on the existing acoustic environment for the Project during the two daytime periods. A baseline field program with longer monitoring period (including nighttime) is recommended as an additional study.

The sound level meters used for the measurements were Brüel and Kjær 2250 (B&K 2250) Type 1 Sound Level Meter with a Type 4952 outdoor microphone. The meter met the American National Standards Institute (ANSI) S1.11-2004 (R2009) instrumentation requirement. The meter was calibrated with a Larson Davis Type CAL200 calibrator. This calibrator meets the ANSI S1.40-2006 Class 1 calibrator requirement. The sound level meter microphone was set up on a tripod at a height of approximately 1.5 m. During the measurement, there was no precipitation, the ambient temperature ranged between 6°C to 8°C, and the wind speed was between 0 m/s and 1.5 m/s.

The measured sound levels at Emery Barnes Park were analyzed using the Brüel and Kjær BZ5503 Measurement Partner Suite® software. The daytime equivalent sound levels (L_{eq}) and statistical sound levels (L_{90}) for the measurement periods were calculated and the results summarized in Table 2-14.

Table 2-14 Baseline Noise Measurement Results

Location	UTM Locations (m)	Date	Time Period	Time Duration	L_{eq} (dBA)	L_{90} (dBA)
Emery Barnes Park	Easting: 490956 Northing: 5458216 Zone 10	01/20/2017	12:32 PM to 1:35 PM	1 hr 3 min	61.8	57.7
			5:52 PM to 6:57 PM	1 hr 5 min	58.3	55.0

During the daytime period, the existing acoustic environment around Emery Barnes Park is influenced by local activities within the park (e.g., people, dogs), commercial activities in nearby streets, natural environment (i.e., wind and birds), and vehicle traffic on the surrounding roads. Air traffic and noises associated with the off-leash dog area and children's playground were also contributors to the area's acoustic environment. Additionally, the noise measurements at Emery Barnes Park were influenced by ongoing construction activities, occurring at the north end of the park, on Seymour Street.

In addition to the measurements at Emery Barnes Park, a short reconnaissance visit to the existing underground substation at Cathedral Square Park (Dunsmuir Street and Richards Street) was also conducted. The objective is to assess the noise emission from the ventilation shafts of the operating substation. The observation from the field specialist indicated that there was no audible noise effect from the existing ventilation air supply and exhaust shafts.

2.3.6.2 Methods

2.3.6.2.1 Environmental Noise Descriptors

Environmental noise typically varies over time. To account for this variation, a single number descriptor known as the energy equivalent sound level (L_{eq}) is used. It is defined as the steady, continuous sound level that has the same acoustic energy as the actual time-varying sound level over the same time interval. The unit for L_{eq} is the A-weighted decibel level (dBA), which reflects the response of the human ear to different sound frequencies. The percentile noise level L_{90} is the sound level exceeded for 90% of the time. For 90% of the measurement period, the sound level is above this level. L_{90} is generally considered to be representing the background level of an acoustic environment.

2.3.6.2.2 Approach

The approach used to assess the potential noise effects during the construction and operation of the Project is summarized as follows:

- Conduct noise measurement during daytime within the Emery Barnes Park on January 20, 2017 to determine the preliminary daytime baseline condition
- Determine the potential “worst case” for noise emissions from project activities during the construction phase
- Determine noise emissions from project activities during the operation phase
- Predict project noise levels at different point of receptions by performing noise modelling within the study area
- Compare the prediction results to the Noise By-Law limits

2.3.6.2.3 Noise Modelling

Noise predictions were performed using Cadna/A acoustic modeling software (DataKustik 2015) and in accordance with the internationally accepted sound propagation algorithms (ISO 1993, 1996). The modelling parameters used in the study are summarized in Table 2-15.

Table 2-15 Noise Modelling Setting

Item	Model Parameters	Model Setting
1	Temperature	20°C
2	Relative humidity	75%
3	Wind speed	Downwind condition, as per ISO 9613-2 standard downwind setting (wind speed of 1 to 5 m/s)
4	Noise propagation software	Cadna/A (DataKustik 2016)
5	Noise propagation calculation standard	ISO 9613

Table 2-15 Noise Modelling Setting

Item	Model Parameters	Model Setting
6	Ground conditions and attenuation factor	Ground absorption (G) of 0.3
7	Terrain topography	No terrain data incorporated

Values of 20°C (temperature) and 75% relative humidity are used in the model settings to represent average summer daytime condition. The wind speed is based on ISO 9613-2 standard, which assumes 1 to 5 m/s downwind condition from the source to the receptor in the sound propagation calculation. Ground absorption factor (G) of 0.3 (i.e., reflective) is used in the model to represent the Project surrounding area. G is an index with value ranges from 0 to 1 where 0 represents reflective ground and 1 represent absorptive ground condition. Ground topography is not incorporated in the noise model as the Project area is relatively flat; as well, it represents a conservative approach to the modeling.

2.3.6.3 Noise Emission Sources

2.3.6.3.1 Construction

Proposed construction at the Emery Barnes Park site is expected to last 3 years. During construction, various phases of excavation, foundation works, civil work, and equipment installation will take place. Heavy construction equipment such as excavators, jack hammers, and trucks will generate noise. This study focuses on several scenarios at the Emery Barnes Park site during jack hammering when operating at closest to the point of reception.

The noise emission of jack-hammering activities is summarized in Table 2-16.

Table 2-16 Construction Activities Noise Emission

Activities	Sound Power Level (dBA)	Reference
Jack hammering	120	FTA and Defra

2.3.6.3.2 Operation

Noise emission sources during the operation phase are associated with the ventilation system (air intake and outlet) for the substation.

The conceptual design of the ventilation system for the substation includes an air intake structure, three exhaust shafts, and the ventilation fans. The ventilation fans are the main noise sources. The noise transmits through the ventilation ducting to the ventilation openings (i.e., intake structure or exhaust shaft). The ducting leading to and from the ventilation fans is expected to be equipped with silencers. The detailed specifications of the ventilation fans are not available at the current design phase. The ventilation system will be mitigated so that the noise level at "closest" point of reception is below the noise limits prescribed in the Noise By-Law. The mitigated sound power level of each ventilation opening is summarized in Table 2-17.

Table 2-17 Operation Noise Emission

Noise Source	Sound Power Level (dBA)
	Emery Barnes Park
Air Intake Opening	97
Exhaust Opening	97

2.3.6.3.3 Results for Construction

The predicted noise levels at the point of reception during jack hammering near Emery Barnes Park site are summarized in Table 2-18. Figure 2-5 presents the noise contour results for the jack hammering activities (i.e., sound power level of 120 dBA) within the Emery Barnes Park site. The point of reception (i.e., PR1) is shown in the figures.

Table 2-18 Noise Level during Jack Hammering

Project	Activities	Point of Reception	Distance from Closest Noise Source (m)	Predicted L_{eq} (dBA)
Emery Barnes Park	Jack hammering	PR1	3	101.2

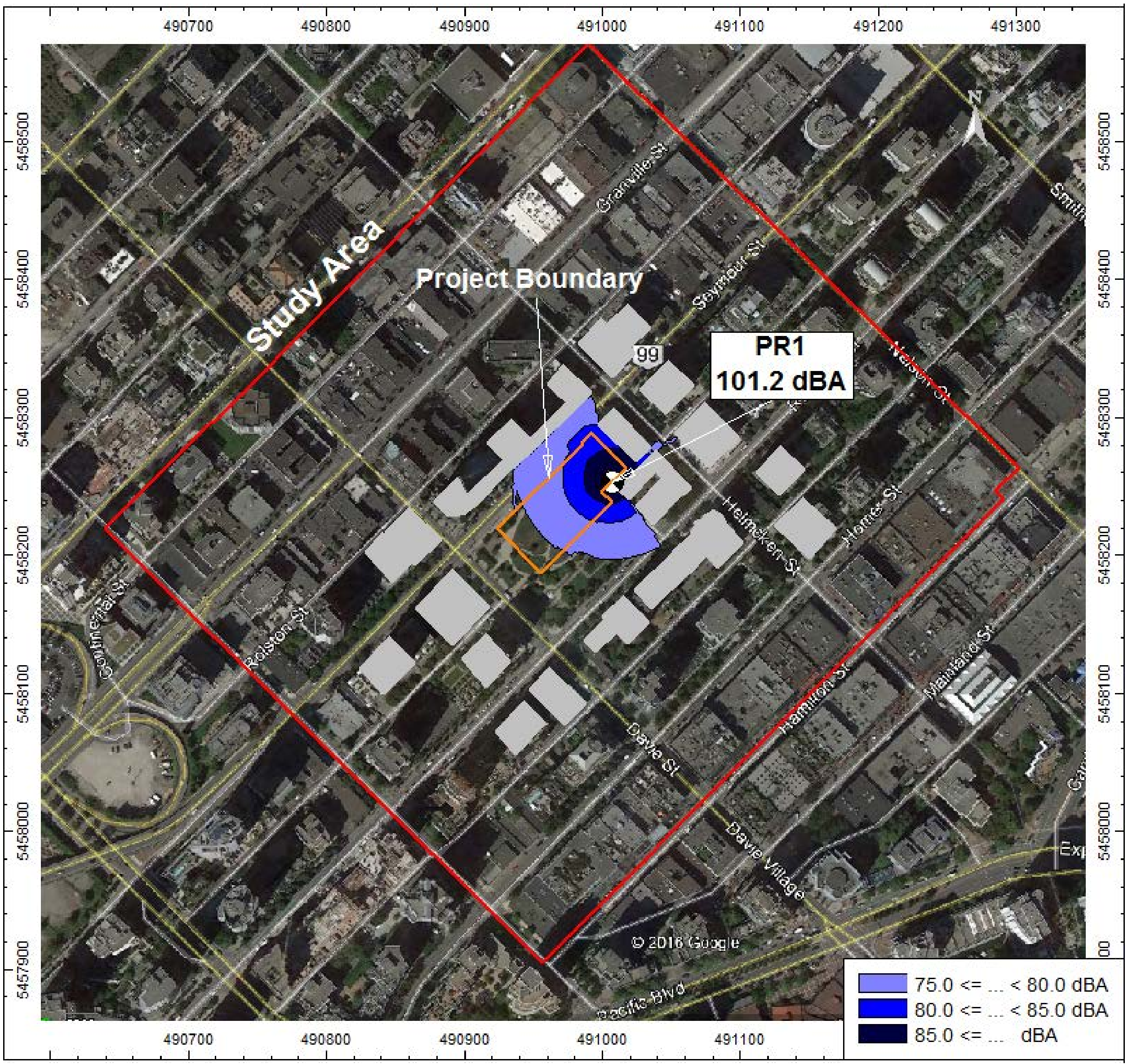


Figure 2-5 Predicted Jack Hammering Noise Contour at Emery Barnes Park

During jack hammering activities, the predicted noise level at the nearest point of reception PR1 can be as high as 101.2 dBA, which exceeds the noise limit of 85 dBA.

The construction noise effect predicted in previous section exceed the noise limit of 85 dBA prescribed in the Noise By-Law for the "worst" case. The noise effect will be restricted to the daytime period. The predicted levels at all point of receptions are outdoor noise levels. The indoor noise effects from the Project will be lower due to the sound transmission losses though the walls and windows of a building. However, the noise effects are expected to be noticeable for indoor occupants during certain activities (i.e., jack hammering, excavation). The perceptibility of construction noise could result in annoyance. Mitigation measures will be required to reduce the annoyance effects during construction.

2.3.6.3.4 Results for Operation

The dominant noise effect from the Project during operation will result from the ventilation air inlet and exhaust openings. The predicted noise levels from these openings are presented in Table 2-19 at two different points of reception, which are the closet points to the openings based on the Noise By-Law. Figure 2-6 presents the proposed Emery Barnes Project only noise contours within the study area for Emery Barnes Park site. The points of reception are also shown in the figure.

The results indicate that the predicted sound levels are below the continuous daytime and nighttime noise limits of 70 dBA and 65 dBA, respectively for Emery Barnes Park. The noise model assumes that all noise sources are operating continuously during both the daytime and nighttime period; therefore, prediction results are the same for both periods. Locations along the northwest boundary of Emery Barnes Park are most affected.

Table 2-19 Predicted Project Operation Noise Level at Different Point of Receptions

Project	Point of Reception	Distance from Closest Noise Source (m)	Predicted L_{eq} (dBA)
Emery Barnes Park	PR1	10	64.8
	PR2	22	63.7

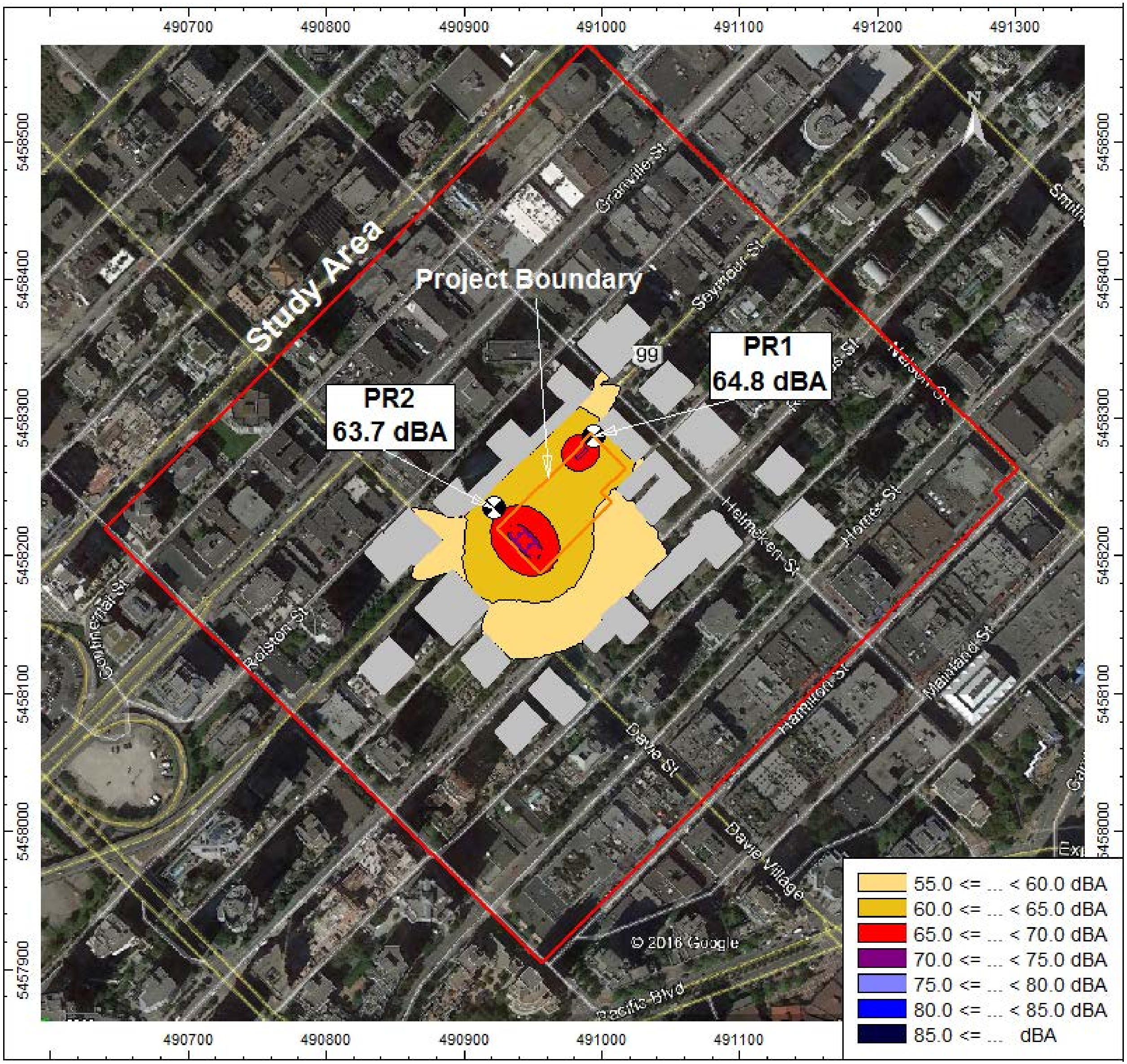


Figure 2-6 Predicted Operation Noise Contour at Emery Barnes Park

2.3.6.4 Mitigation Measures

The following potential mitigation measures referenced by the Australia Department of Environment and Climate Change Construction Guideline New South Wales (NSW 2009) could be considered during the construction phase:

- Teach workers and contractors to use equipment in ways to minimize noise

- Require that site managers periodically check the site, nearby residences, and other sensitive land uses for noise problems so that solutions can be quickly applied
- Include in tenders, employment contracts, subcontractor agreements, and work method statements clauses that require minimization of noise and compliance with directions from management to minimize noise
- Avoid the use of radios or stereos outdoors where neighbours can be affected
- Avoid the use of public address systems
- Avoid shouting, and minimize talking loudly and slamming vehicle doors
- Keep truck drivers informed of designated vehicle routes, parking locations, acceptable delivery hours or other relevant practices (for example, minimizing the use of engine brakes, and no extended periods of engine idling)
- Develop a one-page summary of approval or consent conditions that relate to relevant work practices, and pin it to a noticeboard so that all site operators can quickly reference noise information
- Minimize the need for reversing or movement alarms
- Avoid dropping materials from a height
- Avoid metal-to-metal contact on equipment
- Provide periods of respite are in the case of unavoidable maximum noise level events

In addition, mitigation measures for the proposed Emery Barnes Project during the construction phase include the following:

- A 2 m high temporary barrier around the entire site could reduce the noise effect by up to 10 dBA at the point of receptions
- Immediate barrier around the noise emission source
- Quieter equipment for construction activities can be used in combination with noise barrier to further reduce the noise effect.
- Figure 2-7 presents the mitigated noise contour for jack hammering at Emery Barnes park when a 2 m higher barrier is used in combination with jack hammer of lower noise emission level (i.e., 114 dBA instead of 120 dBA).

If mitigation measures are employed, noise contours are expect to be as shown on Figure 2-7. Mitigation measures during the Project operation phase include silencers for the ventilation air inlet and exhaust. The silencers will be designed to meet the noise emission requirements specified in Table 2-15.

2.3.6.5 Recommendations for Future Study

There is no baseline information collected during the nighttime period. Also, the ambient sound levels vary from time to time due to the changes in local activities. Therefore, a longer baseline measurement program will provide a complete baseline sound level for comparison to the Project operation noise effect.

Noise modelling for construction activities is recommended when a detailed construction equipment list and estimated equipment operating schedule is available.

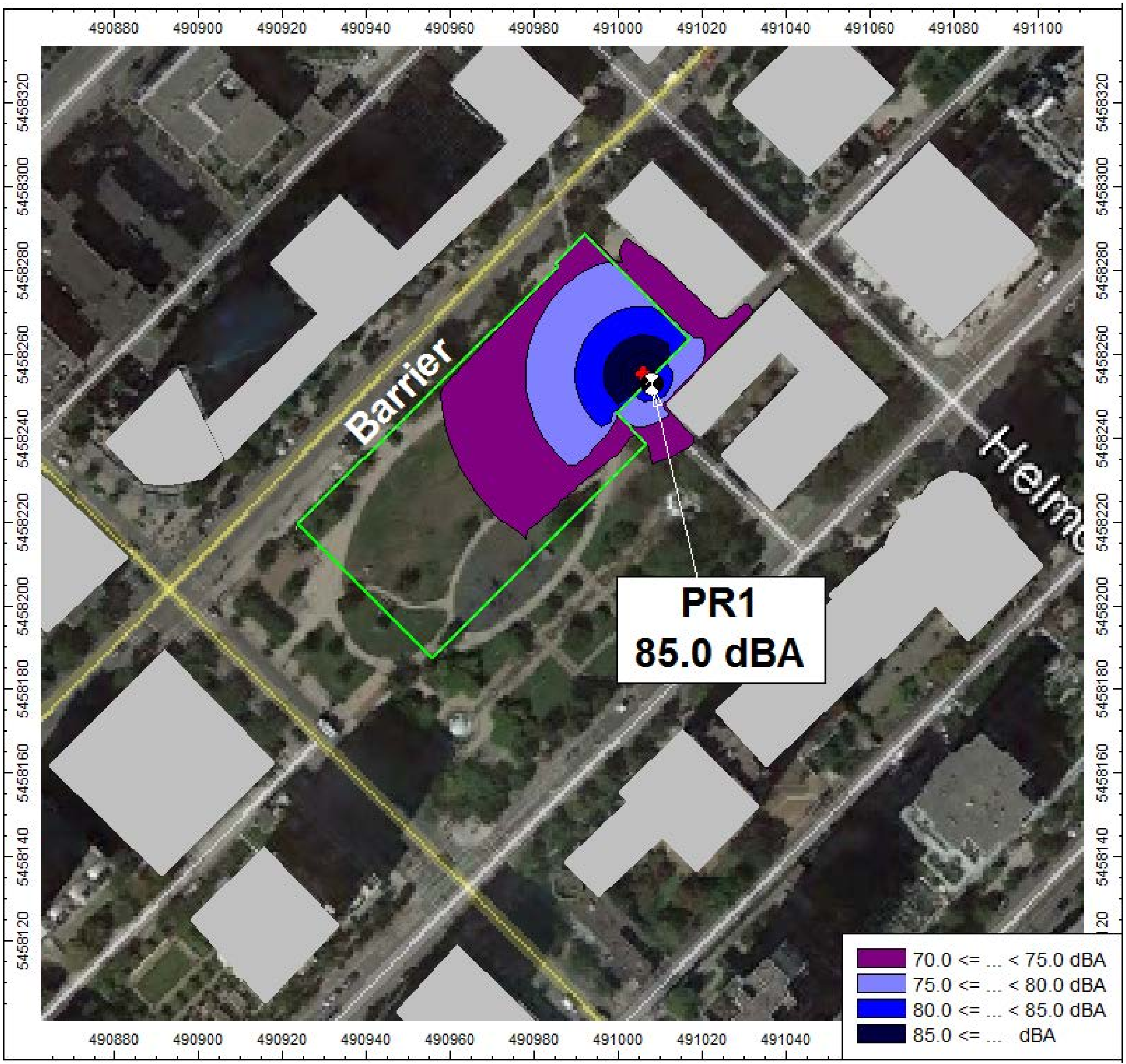


Figure 2-7 Mitigated Noise Contour for Jack Hammering at Emery Barnes Park

2.3.7 Vibration

2.3.7.1 Baseline Data and Findings

Vibration was selected as an environmental effect because activities during construction will generate vibration at Emery Barnes Park. Vibration has been identified as a topic of concern to BC Hydro, VPB, stakeholders, and the public. For the purpose of this study, vibration is defined as ground-borne vibration and has the potential to affect human health and structural integrity of building.

The vibration study quantifies the potential vibration effect during the construction of the Project and results are compared to the applicable vibration limit to assess compliance. High level mitigation measures are provided to reduce the vibration effect. The vibration study focuses on ground vibration effects from construction equipment. Vibration effects are not expected during the operation phase of the Project.

There is no available construction vibration guidance for the City of Vancouver or provincial vibration By-Law for construction activities in British Columbia. In the absence of national or Provincial guidance, the City of Toronto Construction Vibration Limit (By-Law No. 514-2008) is therefore referenced for comparison. The vibration threshold is frequency dependent as shown in Table 2-20.

Table 2-20 City of Toronto Construction Vibration Limit

Frequency of Vibration (Hz)	Vibration PPV (mm/s)
Less than 4	8
4 to 10	15
More than 10	25

In addition to the vibration limit, the City of Toronto By-Law requires that the study identify the zone of influence of vibrations and whether such zone of influence extends beyond the legal boundaries of the construction site that is the subject of the permit application. The zone of influence is the area of land within or adjacent to a construction site, including any buildings or structures, that potentially may be impacted by vibrations emanating from a construction activity, where the peak particle velocity as measured at a point of reception is equal to or greater than 5 mm/sec at any frequency.

The City of Toronto By-Law focuses on the structural damage thresholds with no guidance on annoyance thresholds for ground vibration. The Australian Department of Environment and Conservation New South Wales (NSW)—Assessing Vibration: A Technical Guideline, 2006 (NSW 2006) provides guidance for human annoyance thresholds due to ground vibration.

The NSW vibration guideline is based on guidelines contained in the British Standard (BS) 6472-1992, Evaluation of Human Exposure to Vibration in Buildings. The NSW guideline recommends different exposure criteria for residences, offices, and workshops during the daytime period. These guidelines are summarized in Table 2-21.

The criteria presented in Table 2-21 for impulsive vibration relate to vibration that builds up rapidly to a peak followed by a damped decay, with up to three occurrences in a study period, e.g., occasional loading and unloading, or dropping of heavy equipment.

Table 2-21 Indoor Vibration Exposure Criteria

Location	Continuous Vibration		Impulsive Vibration	
	RMS (mm/s)	PPV (mm/s)	RMS (mm/s)	PPV (mm/s)
Residences	0.4	0.56	12	17
Offices	0.8	1.1	26	36
Workshops	1.6	2.2	26	36

The vibration study area extends 200 m out from the project boundary. This study area will include the "most affected" points of receptions near the Project. This study area is expected to cover the zone of influence described in the previous section.

Baseline ground vibration level at receptors has not been quantified. Under most guidelines, the vibration assessment is based on comparing the Project only effects to the applicable guidance or thresholds, without consideration for the baseline levels.

2.3.7.2 Discussion of Impacts

Ground vibration is an oscillatory particle motion which can be measured in terms of displacement, velocity, or acceleration. Vibration effect for structures is commonly assessed using particle velocity measure. Vibration level can be quantified using a root-mean-square (RMS) level or peak level. The ground vibration level in this study is defined in terms of peak particle velocity (PPV) and is measured in millimetres per second (mm/s), representing the maximum instantaneous positive or negative peak of the vibration signal. Vibration frequency is defined as the number of oscillations-per-second and is specified in Hertz (Hz).

Vibration effect during construction includes excavation, earthworks, construction of the facility, and drilling activities. Blasting activities are not planned for the construction of the Project.

This study used published references such as the United States Federal Transit Administration (FTA) to estimated typical vibration levels for various types of construction activities. The FTA reference vibration level for different activities was extrapolated to appropriate distances to predict the vibration effect within the study area.

The vibration levels from different construction activities (i.e., excavation, drilling) are compared to the City of Toronto construction vibration limit of 8 mm/s. These activities are expected to occur at different times and locations; vibrations from multiple concurrent sources are not expected to interact cumulatively for the same point of reception.

The heavy construction equipment associated with excavation during construction is expected to generate ground vibration up to 1 mm/s at a distance of 25 m (FTA 1995 and ASCE 2000). The predicted vibration level at the nearest point of reception (residential building located at southeast of Emery Barnes Park) due to excavation is 6.01 mm/s.

Drilling typically generates a ground vibration level of up to 0.4 mm/s at a distance of 25 m (FTA 1995). The predicted vibration level at the nearest point of reception (residential building located at southeast of Emery Barnes Park) due to drilling is 2.3 mm/s.

The ground vibration effects from different construction activities (i.e., drilling and excavation) are below 8 mm/s at the nearest point of reception, which is located 7.5 m from southeast of Emery Barnes Park site boundary. The zone of influence is the area where the peak particle velocity measured at the point of reception is equal to or greater than 5 mm/s at any frequency. The Project construction activities zones of influence are summarized in Table 2-22. The residential building located 7.5 m northeast of the Project is identified within the zone of influence for Emery Barnes Park.

Table 2-22 Zone of Influence of the Project

Activity	Distance from Source (m)
Excavation	9
Drilling	5

Prediction of ground borne vibration from a vibration source to a point of reception is a function of source, ground conditions, building foundations, building material, and building construction techniques. Ground vibration propagation is affected by the soil type, density, and profile. Accurate prediction of ground vibration propagation is difficult and requires a detailed knowledge of soil property. In this study, the predicted vibration levels based on reference vibration source data represents an approximate method.

The City of Toronto By-Law focuses on structural damage threshold with no guidance on annoyance threshold for ground vibration. The typical threshold of human perception of ground vibration is 0.5 mm/s peak particle velocity (Blasters' Handbook 2011); however, the perceptibility threshold varies from person to person. In an urban and suburban environment, a person may be subjected to a wide range of vibration effects, depending on the location, time of the day, proximity to day-to-day vibration sources (e.g., vehicle, train). The vibration effects due to certain construction activities (e.g., drilling, excavation) may be noticeable for indoor occupants. The perceptibility of construction vibration could result in annoyance. Mitigation measures should be considered to reduce the annoyance effects during construction activities.

2.3.7.3 Mitigation Measures

Vibration can be mitigated by reducing the dynamic forces associated with construction equipment or by isolation. The following potential strategies for managing construction vibration are referenced from the NSW vibration guideline (NSW 2006):

- Use the "Best Available Technology Economically Achievable" concept to select equipment that incorporates the most advanced and affordable technology to reduce vibration output
- Inform neighbours about the nature of the construction stages and the vibration generating activities (e.g., excavation and rock-breaking)
- Restriction of use of heavy vehicles on particular roads, limiting speed and reducing the occurrence of surface irregularities such as potholes and speed humps
- Organize demolition, earthmoving, and ground impacting operations so as not to occur in the same time period
- Avoid night-time activities wherever possible to limit impact on residential receivers
- Place as much distance as possible between the equipment and the receivers
- Select demolition methods not involving impact where possible (e.g., hydraulic rock splitters rather than rock breakers)
- A vibration management plan is recommended that include the following components
  - A vibration monitoring program during the construction phase
  - Use alternative, lower-impact equipment or methods
  - Scheduling the use of vibration-causing event during the least sensitive time of day
  - Schedule operations to avoid overlapping of different activities that have vibration effects
  - Maintain equipment in good operating conditions

Managing vibration effect may require a short-term increase in vibration level beyond the applicable limits. Such situations may include drilling, excavation, and abnormal construction situations (e.g., breakdown of equipment). Mitigation strategies may be impractical for such short-term events. The construction manager should demonstrate that alternatives have been considered before seeking an accommodation from the consent authority to operate above the vibration limit values. The following options could be considered:

- Confining vibration-generating operations to the least vibration-sensitive part of the day—which could be when the background disturbance is highest
- Determining an upper level for vibration impact and considering what is achievable using feasible and reasonable mitigation
- Consulting with the community regarding the proposed events
- When operating in the zone of influence, especially in close proximity to the buildings located to the northeast of the Project, smaller equipment or alternative equipment may be required

2.3.7.4 Recommendations for Future Study

Baseline vibration level monitoring is recommended at specific vibration-sensitive receptors (i.e., most impacted location or locations with high existing vibration level). The vibration baseline study for the proposed Emery Barnes Project may be considered during subsequent studies.

When the detailed construction equipment list and estimated equipment operating location are available, further vibration analysis for construction activities is recommended.

2.3.8 Public Safety—Crime Prevention

2.3.8.1 Baseline Data and Findings

A desktop study was undertaken to determine the potential project effects related to park accessibility, safety, and mitigations that could result from the construction and operation of the proposed substation and associated infrastructure under Emery Barnes Park. The study was based on the design principles and strategies identified by the National Crime Prevention Council's *Crime Prevention Through Environmental Design Guidebook (2003).* Additional secondary sources were also consulted to reflect provincial and municipal approaches in the use of crime prevention through environmental design principles. These include, BC Housing's *Crime Prevention through Environmental Design (Section 7)* in *BC Housings Design and Construction Standards* (2014), and the City of New Westminster's *Crime Prevention Through Environmental Design, Guidelines for Safe Urban Design* (1999).

Using project concept plans and Google Earth 2017 imagery, the study included consideration of how the placement of the proposed substations and applicable infrastructure would affect the current and future safety of the park users.

Crime Prevention Through Environmental Design (CPTED) is a multi-disciplinary approach to deterring criminal behaviour and nuisance activity through environmental design (BC Housing 2014). Although, there are several different related design principles available, the general theory of CPTED is based on the following design concepts:

- **Territoriality**—a design concept that clearly delineates private space from semi-public and public spaces, and creates a sense of ownership. Ownership thereby creates an environment where appearances of such strangers and intruders stand out and are more easily identified.
- **Natural Surveillance**—is based on the "eyes on the street" principle, where surveillance or legitimate intent to observe decreases the potential for criminal behaviour.
- **Access Control**—is aimed at limiting the number of entry points to discourage or deny entry to intruders.
- **Maintenance and Management**—is related to the 'pride of place' and territorial reinforcement. Essentially, the more dilapidated an area, the more likely it is to attract unwanted activities (BC Housing 2014; City of New Westminster 1999; NCPC 2003).

2.3.8.2 Discussion of Impacts

Potential public safety effects that may result from construction of the substation and associated infrastructure at Emery Barnes Park include: impediment of sight-lines, increased demand for lighting, potential increase in concealed, isolated, and entrapment areas (e.g., public washrooms and entrance to the substation), the timeline of construction and diminishment of maintenance and management of the park, greater demand for signage, and loss of positive aesthetics environment.

During operations, impacts include, but are not limited to, public safety concerns in relation to the above-ground ventilation vents, access ramps and service buildings which may impede sight lines, and possible loss of activity generators which encourage natural surveillance (e.g., loss of the playground, dog park, and stream). Overall, the incorporation of CPTED design principles in the park redesign may result in several positive effects, such as: efficiencies in lighting, reduction of entrapment areas, potential increase in activity generators (e.g., community garden, nearby parklets), new areas to support programming activities, and an overall improvement in the use and design of the park.

2.3.8.3 Mitigation Measures

The following mitigations should be implemented during design, construction, and post-construction to improve the use of CPTED principles, which will increase the safety of future park users:

- Design
  - Walkways should be designed to allow good visibility around sharp corners
  - In park redesign, incorporate principles of CPTED that limit and reduce concealed or isolated areas, such as:
    - Eliminating entrapment areas (travelled routes that are shielded by three sides) located within 50–100 m
    - Uniformly light concealed or isolated routes
    - Provide opportunities for natural and formal surveillance
    - Provide access to help (e.g., security alarms, emergency telephones, and signage information)
  - With BC Hydro assuming costs, the VPB will lead a comprehensive engagement process to consult with the public to identify opportunities to improve overall redesign of the park, and consider including the following CPTED principles:
    - Plan areas for a range of activities, even if they are intended for passive use
    - Parks and open spaces should be improved to provide access to and from populated areas in order to increase the use of the park system
    - Integrate park and open spaces with the sidewalk system to develop an open space and pedestrian network that attracts more people
    - Take into account the possibility of night time activities, for example adding tennis courts that are lit up in the evening
    - Include new park amenities such as benches, fitness trails, tennis or basketball courts, and bicycle paths in parks to reduce the sense of isolation
    - Locate washrooms near children's playgrounds

- Implement CPTED lighting principles in park redesign, such as:
  - Uniformly spread lighting to reduce contrast between shadows and illuminated areas
  - Consider night time uses of outdoor spaces in the type, placement, and intensity of lighting colour finishes to be used in underground car parks, around washrooms, and isolated walkways
- Construction
  - Where practical, temporary and permanent walkways should have clear sight lines, especially when they curve or change grade.
  - Provide highly visible signage of park closure area(s), expected time-line of closure(s), and temporary pedestrian access points utilizing visual maps, where applicable.
  - Conduct a site risk assessment using CPTED principles to identify areas where lighting may be affected during construction and provide temporary lighting fixtures where applicable. As part of the site risk assessment, identify concealed and isolated areas, and plan to reduce or eliminate them in park redesign.
- Post-Construction
  - Provide follow-up assessment on the incorporation and application of CPTED principles

2.3.8.4 Recommendations for Future Study

The findings noted above were limited to a CPTED qualitative analysis of the substation proposed to be constructed under Emery Barnes Park using concept plans and Google Earth 2017 imagery. It is recommended that a full CPTED site risk assessment be undertaken to provide specific CPTED design elements that can be incorporated into the future redesign of Emery Barnes Park.

2.3.9 Public Safety—Accidents and Malfunctions

2.3.9.1 Baseline Data and Findings

A desktop study was undertaken to determine potential effects that could result from accidents or malfunctions that may occur during the construction and operation of the proposed Emery Barnes Project. This included a review of environmental impact assessments (EIAs) that addressed potential accidents and malfunctions at substations (e.g., BCTC 2010; Manitoba Hydro 2015) and information interviews with the City of Vancouver Fire Department to identify potential risks, emergency response measures and approaches used to respond to electrical-related emergencies. A number of initiatives/mitigations were also identified by the Vancouver Fire Department that BC Hydro could undertake to reduce risks posed from the construction and operation of the substation. Mitigation measures were also identified from a review of applicable EIAs, BC Hydro's internal policies and procedures, and studies that reflect learning outcomes from past events (e.g., *BC Hydro Report: Downtown Vancouver Outage: July 14, 2008 [BC Hydro 2008]*). This information, along with feedback directly from BC Hydro's lead safety engineer, can be used to reduce specific risks posed by substation accidents or malfunctions.

Potential accidents and malfunctions include: potential hazards to the public; to the substation's construction, maintenance, and operating workforce; and to emergency response personnel. The following potential effects were identified that could result from an accident or malfunction of the proposed substation infrastructure:

- Use of energized equipment and hazardous test energy may result in failed equipment causing electrocution, electrical burns, ventricle fibrillation hazards, and fire.
- Working with hazardous substances (e.g., fuel and lubricants, oils, solvents, and greases), may result in spills or human contact causing harmful exposure or burns to workforce personnel during construction.
- Public interactions with the Project may result in potential risk of traffic accidents involving vehicles and equipment travelling to and from the construction site(s), and accidents involving local motorists, other commercial operations, pedestrians, and cyclists. Such traffic hazards could result in damage to personal or commercial property, and injury or death to the public or workforce.
- The potential for electrical hazards to residents, communities, or other individuals conducting activities near substations is primarily related to unauthorized entry into restricted areas (e.g., a substation compound), or other forms of illegal activity involved with tampering or attempts to destroy or dismantle circuit components.
- Natural disasters such as an earthquake, flood, storm, fire, or explosion may result in substation malfunctions and power outages. Such events have the potential to affect community and emergency response services, commercial and industrial operators, and residential tenants.
- Human-caused error during operations of the substations may result in component failures causing fires, or explosions.

2.3.9.2 Discussion of Impacts

During construction, most risks to the public and workforce will be related to the movement of materials and people at the construction site. These risks will be reduced through applicable signage, fencing, and adherence to local, municipal, and provincial traffic and safety bylaws, policies and plans, and a project-specific Traffic Management Plan.

The subsurface design of the substation may reduce some risks while increasing others. Potential risks that may result from human error, use/operation of energized equipment, working with hazardous materials, maintenance of infrastructure, or from natural disasters may be reduced because the overall physical impact of effects (e.g., fire, release of hazardous materials, or explosions) will be confined and retained underground. However, the subsurface design may create additional risks to emergency response personnel, because the design creates limited access, confined spaces, and potential for increase in smoke from reduced airflow/ventilation (Foster A., City of Vancouver Assistant Fire Chief. *Personal communications*. January 26, 2017). These effects increase the risks for emergency response providers should a potential operational outage or substation malfunction occur. BC Hydro can undertake a number of initiatives to manage and reduce these risks, such as using a worst-case scenario approach when designing substations, working with the City of Vancouver in developing a substation specific emergency response plan, training, and applying the Best Available Technology Economically Achievable

(BATEA) in the design of the substation (e.g., application of fire retardants, advanced ventilations systems and shut-offs) (Foster, *Personal comm*. January 26, 2017).

2.3.9.3 Mitigation Measures

Several mitigations have been identified that may manage and reduce potential effects from accidents or malfunctions during the design, construction, and operations phases. Most mitigations identified are based on:

1. Avoiding risks through effective design
2. Managing potential risks through engineering controls and emergency response procedures
3. Protecting the health and safety of the public and workforce

These measures include:

- Design
  - Apply engineering controls designed to limit the potential for release of hazardous materials, such as secondary containment systems and the use of oil detection sensors
  - Use a worst-case scenario approach when designing substations—consider who could be impacted and how underground incidents related to electrical hazards are heightened (e.g., more smoke, confided spaces, limited access, limited ventilation = increased risks to emergency response personnel)
  - Design substation and associated infrastructure to reduce the potential for the release of spills or hazardous material in the event of an accident or malfunction by using:
    - Spill response and containment systems
    - Fast-acting protection and control equipment
    - Fire walls and barriers
    - Explosion and blast protection barriers
    - Security surveillance systems
    - Vents and exhaust assessment systems (e.g., detention for location of exhaust, nature of exhaust, etc.)
    - Encased cables to ensure no negative impacts on tree roots
  - Implement BC Hydro's plans and policies for emergency situations, including:
    - Fire safety and response plan
    - Hazmat safety and response plan
    - Emergency response plan (include initial entry to investigate and assess by first responders and BCH workers, and re-entry for clean-up/switching, etc.) which can vary depending on the event
    - Spill response plan
  - During construction, maintenance, and repair activities, use fences, signs, and surveillance systems or other measures to prevent public access
  - Develop an emergency response plan with the City of Vancouver's Fire Department. The plan should include policies and ensure applicable training (where appropriate) is provided to the City of Vancouver's Fire Department to support fire suppression, inspection, communication, and liaison activities (Foster, pers. comm. January 26, 2017 and BC Hydro 2008)

- BC Hydro will use gas insulated switchgear (GIS) for the substation. GIS uses SF6 as an insulating medium for high and medium voltage switchgear systems. Unlike conventional oil insulated switchgears, GIS does not pose a fire risk, so the overall risk of substation fire will be reduced.

- Construction
  - Prepare and maintain a local inventory of all hazardous materials handled, stored, or used at the substation sites (see BC Hydro's Stationary Form #80420 –Toxic/Hazardous Product Inventory form)
  - During construction adhere to all applicable municipal, provincial, and federal regulatory requirements relating to traffic management including, but not limited to:
    - Street and Traffic By-Law No. 2849 (City of Vancouver 2016)
    - WorkSafeBC OHS Regulation, Traffic Control (WorkSafeBC 2009)
    - Ministry of Transportation and Highways Engineering Branch, 1999 – Traffic Control Manual for Work on Roadways (BC Ministry of Transportation and Highways 1999)
  - Require that all work undertaken during construction and operating activities comply with BC Hydro's Occupation Health and Safety Standards Guidelines (BC Hydro 2016)
- Post-Construction
  - In the event of an accident or malfunction, BC Hydro should activate its Corporate Emergency Center (CEC) until power is restored to all customers and all damaged circuits were repaired (BC Hydro 2008)
  - Within the event of an accident or malfunction, the following priorities identified by BC Hydro's Incident Action Plan should be addressed:
    1. Ensure public and employee safety
    2. Identify impacted critical infrastructure, customer key accounts, and feeder prioritization for a Restoration Plan
    3. Facilitate effective and timely communication
    4. Establish the impacts based on the damage assessment and receive situation updates from site (BC Hydro 2008)

  - In the event of an outage, BC Hydro should implement its priority sequence restoration of services in the following order:
    1. Generation and transmission facilities to supply distribution customers
    2. Communications facilities for civil authorities
    3. Hospitals
    4. Critical customers which include police stations, fire stations, ambulance stations, municipal emergency centres
    5. Facilities as directed by Municipal, Provincial, and Federal authorities
    6. Utility facilities which include gas, sewer, water, telephone, and cellular
    7. Emergency reception centres (schools, civil centres)
    8. General commercial, industrial, and residential customers (BC Hydro 2008)

  - In the event of an outage, BC Hydro will coordinate with the City of Vancouver's Fire Department and Emergency Management Department who will lead the initial response of an electrical or fire related emergency, which includes:
    1. Establish command (i.e., determine who is in charge)
    2. Undertake hazard identification and risk assessment (HIRA) or "size up"
    3. Isolate incident
    4. Test for toxins
    5. Apply 2 in 2 out rule
    6. Ensure full personal protective equipment is used

7. Apply touch approach to external/unobserved risks
8. Wait for confirmation from BC Hydro that power has been shut off (Foster A., City of Vancouver Assistant Fire Chief. *Personal communications*. January 26, 2017)

2.3.9.4 Recommendations for Future Study

The preceding identification of risks and mitigation measures is based on a review of the proposed Emery Barnes Project conceptual plan. It is recommended that a project-specific assessment of potential accidents and malfunctions be undertaken once more detailed design and engineering information has been developed. Additionally, given the number of agencies that are involved in maintaining public safety (e.g., BC Hydro, VPB, City of Vancouver Emergency Management Department and Fire Department, and Emergency Management BC) it is recommended that additional research and consultation be undertaken to develop an up-to-date, integrated emergency response plan for responding to potential substation accidents or malfunctions in Vancouver.

2.3.10 Storm Water Management

2.3.10.1 Baseline Data and Findings

2.3.10.1.1 Desktop Review

A desktop study was undertaken to determine potential effects that could result from the construction and operation of BC Hydro's proposed Emery Barnes Project. This included a review of impacts of the addition of various services to the substation. Information was obtained from the Vancouver parks website and the City of Vancouver's VanMap for existing service locations and pipe sizes.

2.3.10.2 Discussion of Impacts

Emery Barnes Park existing utilities include an underground 200 mm diameter (dia.) sanitary main and 450 mm dia. storm main traversing the park in the southwest direction, parallel to Seymour Street, near the center of the park.

Offsite services include: a 900 mm dia. storm main, a 300 mm dia. sanitary main, and a 200 mm dia. water main along Seymour Street; a 200 mm dia. water main along Davie Street; and 600 mm dia. storm main, 250 mm dia. sanitary main along Richards Street.

The Canada Line alignment travels under the west corner of the park site. The rail elevation is approximately 17.2 m below the park ground surface.

For a plan of the site and section details see the figures in Appendix A.9.

During construction, it is anticipated that seepage will be encountered from the walls of the excavation. During construction, specifically the excavation of the substation, weep holes and/or horizontal drains about 3 m long should be installed to dewater and depressurize the face. The majority of excavation dewatering will likely be limited to perimeter ditches connected to collection sumps. The collected water should be retained in the sumps for a sufficient length of time to allow precipitation of sediment before the water is pumped to the City storm sewer system.

The goal of storm water management is primarily to limit the post-development runoff flow such that it will not exceed the pre-development runoff flow entering the existing system. The existing park surface is mostly grass surfacing with a small portion of impervious surfaces such as walkways and playground areas. Since final park surface layout and proportions are not yet finalized, it is assumed that the proportion of post-development impervious surface would be the equivalent to the current park site.

The installation of the electrical cable will cause some traffic disruption on the previously mentioned streets. The cables from Richards Street should consider horizontal directional drilling or manual excavations in specific areas to install the 230 kV and 25 kV cables to avoid the existing fountain, water feature and tree roots.

2.3.10.3 Mitigation Measures

The following mitigation measures are recommended to reduce effects of construction and operation of the proposed Emery Barnes Project on the storm water management and site services. These measures are conceptual only, and will be finalized prior to construction in consultation with the VPB.

- Construction
  - To achieve the flows with minimal increase in the discharge, a network of subsurface drainage system should be installed. The system should consist of 150 mm dia. perforated or slotted rigid wall pipe above the substation vault. The drainage pipe should be surrounded by a minimum of 150 mm of 19 mm drain rock or 19 mm clear crushed gravel encased in a permeable geotextile fabric. The invert elevation of the drain pipe should be at least 150 mm below any structure or base. The pipes of the system should be configured such that lengths of pipe are spaced 3 m to 4 m apart, placed longitudinally, parallel to the length of the substation. The slope of the pipes may be -0.3% or even flat. The system should discharge into a rock pit where the infiltrated surface flow will permeate in the surrounding area. In extreme rainfall events, excess flow will discharge to the existing drainage system. This drainage system should be constructed to consider the depth of soil above required to support mature tree growth (if appropriate), and opportunities to renovate it from below, so as not to impact the park above.
  - The Canada Line tunnel appears to be in close proximity to the southwestern corner of the substation floor. It is currently unknown what the right of way or easement requirements are for the TransLink tunnel. To mitigate the conflict with the tunnel, the substation’s second and third floor may be reduced and constructed farther away from the tunnel. This will give the structure a stepped appearance and provide adequate clearance from the tunnel.
  - An Erosion and Sediment Control Plan should be developed prior to construction (as per the City of Vancouver requirement) and during construction, a sediment collection system should be used prior to water disposal.

- Any stormwater runoff entering the excavated site should be directed to a pump and discharged to surface tanks and a sediment flocculation system to remove sediments prior to discharge to the existing municipal drainage system.
- The existing sanitary main and storm main that traverse the site (through the planned substation footprint) should be relocated south, outside the excavation of the substation.
- Finished surface drainage from lawn basins and surface swales should be discharged to the relocated 450 mm dia. storm main.
- Post-construction:
  - Within the underground substation, a sump with pump should be situated on the bottom floor to remove any water spills or inadvertent flooding.

2.3.10.4 Recommendations for Future Study

It is recommended that BC Hydro contact TransLink to determine how close the substation can be from the tunnel, and modify the substation design as required. Further investigation of the soil infiltration rates will be required to determine the required volume of the rock pits.

2.3.11 Subsurface Hydrology and Ground Conditions

2.3.11.1 Baseline Data and Findings

It is understood that the proposed Emery Barnes underground substation will require an excavation depth of approximately 36 m below the existing ground level. Based upon Google Earth imagery, Emery Barnes Park is at an approximate Geodetic elevation of 20 m.

The Geological Survey of Canada map for Vancouver (Map 1486A) indicates that at the Emery Barned Park site bedrock is more than 10 m below the surface. Glaciated till soils are likely to overlay the bedrock and comprise clay, silt and sand with gravel and cobbles with the occasional boulder. Topsoil and fill material are likely to overlay the till soils in the upper 1 to 2 m. The bedrock is likely to comprise interbedded Sandstone and Shale initially soft becoming harder with depth. Cementitious hard rock (“Floaters”) is commonly encountered within the sandstone bedrock.

Photo 2-2 Boulder encountered in local downtown Vancouver project

Perched groundwater is expected to be encountered at variable depths depending on the season and weather conditions during the construction period. On previous Stantec projects in close proximity to Emery Barnes Park, groundwater was encountered during investigations at up to 18 m below ground level; however, groundwater can be expected at shallow depths during wet weather periods. Water levels measured during these investigations are not considered to be a true representation of the regional groundwater table, but rather perched water flowing within the glaciated sand interlayers within the glacial till deposit.

2.3.11.2 Discussion of Impacts

Excavation of soil and rock to construct the underground substation structures is likely to cause noise, vibrations, and dust associated with normal construction activities. Excavation of bedrock may involve the use of heavier than normal construction equipment which will require consideration to limit potential impact to nearby structures or nuisance to the local population.

Excavation of soil and rock to construct the underground substation structures will cause significant disturbance to existing subsurface hydrology which may impact some trees and other vegetation.

Groundwater control during the excavation will be required which will involve the use of pumps and sediment collection systems either within the excavation or at the surface near the excavation. Ground subsidence associated with temporary groundwater control is not considered to be a significant risk to the proposed Emery Barnes Project as fines loss from the soils is likely to be limited. The risk of ground movement associated with the excavation of soil and rock is also considered to be limited.

A retention system, such as ground anchors and shotcrete panels, is likely to be used during the temporary construction of the excavation. Ground anchors will penetrate through the soil and/or rock, providing temporary stability of the excavation faces. Consideration should be given to the proximity of adjacent underground structures and utilities when designing the location and drill length of anchors.

2.3.11.3 Mitigation Measures

The negative effects of construction noise can be reduced by undertaking the following actions:

- Avoid undertaking potentially noisy construction activities during unsociable hours
- Use noise barriers around the excavation to reduce noise transmittal
- Use protection blankets during bedrock excavation

The generation of dust can be limited by the following actions:

- Use of wetting during excavation, particularly during dry periods
- Covering excavated material prior to, and during, transport away from the excavation work site
- A retention system, such as ground anchors and shotcrete panels, will be used during the temporary construction of the excavation to provide stability
- Undertake an assessment of underground and overground utility locations should be completed to ensure potential ground movements do not adversely affect utilities
- Undertake a condition survey of nearby structures should to check for defects or potential structural weakness
- A review of adjacent underground structures and their foundation/basement construction will be undertaken to assess the potential risk of damage
- Special measures will be carried out, if necessary, to ensure temporary and permanent stability of nearby structures and utilities during and after construction, such as temporary shoring and underpinning

2.3.11.4 Recommendations for Future Study

Stantec recommends that a comprehensive geotechnical investigation be conducted to determine the subsoil and bedrock conditions and to characterize the soil and rock materials. The investigation should include the installation of piezometer groundwater monitoring wells installed in the soils and the bedrock materials to measure groundwater levels in the various soil and rock layers. Groundwater monitoring should be undertaken regularly for at least a full calendar year to understand the potential groundwater level fluctuations during the seasons. The geotechnical and groundwater investigations should include the preparation of a factual report available to engineers during subsequent design and engineering stages.

More investigations will be required prior to construction to ensure adjacent park and street trees are not impacted by potential hydrological changes created by the new substation.

2.3.12 Birds and Other Wildlife

2.3.12.1 Baseline Data and Findings

2.3.12.1.1 Desktop Review

Over 600 resident, migratory, and overwintering birds and other wildlife occur regularly in Metro Vancouver (City of Vancouver 2014c, 2017f). Emery Barnes Park supports a variety of urban birds and mammals that are tolerant of highly manicured landscaping and human disturbance (e.g., vehicle and pedestrian traffic). A review of wildlife information sources (e.g., BC Conservation Data Centre [BC CDC], eBird, City of Vancouver, Species at Risk Public Registry, published literature) was undertaken to understand existing conditions of birds and other wildlife, and their habitats within the park, and to characterize potential effects of the Project on birds and other wildlife. The review included identifying occurrence records of birds and other wildlife, including provincial (i.e., Red or Blue-listed) or federal (i.e., Threatened, Endangered, or Special Concern) species at risk.

Emery Barnes Park is generally manicured landscaping comprised of lawn areas interspersed with a combination of native and ornamental trees. Native and other wildlife are commonly observed in Metro Vancouver parks, including glaucous-winged gull (*Larus glaucescens*), northwestern crown (*Corvus caurinus*), American robin (*Turdus migratorius*), song sparrow (*Melospiza melodia*), black-capped chickadee (*Poecile atricapillus*), raccoon (*Procyon lotor*), and striped skunk (*Mephitis mephitis*) (City of Vancouver 2014c, 2017f; Cornell Lab of Ornithology 2017). Emery Barnes Park also supports invasive or exotic birds and mammals, including eastern grey squirrel (*Sciurus carolinensis*), rock pigeon (*Columba livia*), European starling (*Sturnus vulgaris*), and house sparrow (*Passer domesticus*) (City of Vancouver 2014d, 2017f). Feral or free-ranging domestic cats can also interact with birds and other wildlife in park settings. Species at risk have not been recorded in the park and are not expected to use the park for breeding, foraging, or roosting primarily due to lack of habitat and high level of disturbance.

2.3.12.1.2 Field Survey

Field surveys were completed at Emery Barnes Park on January 18 and 27, 2017, to record observations and assess value for birds and other wildlife in conjunction with surveys for urban forestry. The survey team included two qualified biologists. The survey team documented observations of birds and other wildlife (e.g., visual detections) and evidence of use (e.g., nests, tree cavities), the availability and condition of habitat for birds and other wildlife, and presence of wildlife habitat features (e.g., raptor stick nests) that may require mitigation.

The field surveys also provided site-specific information to support the characterization of habitat availability for birds and other wildlife that potentially occur in Emery Barnes Park. The park supports 111 urban trees, 33 of which had a measured DBH ≥ 20 cm. Most park trees were either Japanese snowbell (*Styrax japonicus*) or Callery pear (*Pyrus calleryana*). A detailed summary of trees located in Emery Barnes Park is found in Appendix C.

Trees in the park support nesting, foraging, and daytime roosting opportunities for urban birds and other wildlife. One mammal and three bird species were detected during the field survey. A summary of bird and other wildlife detections are provided in Table 2-23.

Table 2-23 Birds and other Wildlife Species Detected at Emery Barnes Park during the January 18 and 27, 2017 Field Survey

Common Name	Scientific Name	Detection Type
Mammals		
Raccoon	*Procyon lotor*	Visual
Birds		
Bushtit	*Psaltriparus minimus*	Nest
Rock pigeon [1]	*Columba livia*	Visual
Song sparrow	*Melospiza melodia*	Visual
NOTE: [1] Species listed as Exotic by the BC CDC (2017)		

2.3.12.2 Discussion of Impacts

2.3.12.2.1 Vegetation Clearing, Noise, and Vibrations at Emery Barnes Park

As part of the *Greenest City Action Plan*, the City of Vancouver developed the *Vancouver Bird Strategy* to improve methods for incorporating nature into the urban environment. The strategy outlines five action areas to support improving or maintaining healthy urban environments for birds (City of Vancouver 2014c). Permanent removal or alteration of trees and understory vegetation in Emery Barnes Park will reduce nesting, foraging, and daytime roosting opportunities for migratory, resident, and overwintering birds as well as other urban wildlife (e.g., racoons, skunks). Tree removal and reduction in canopy cover will further reduce habitat connectivity for some species. Based on the current proposed Emery Barnes Project design, construction of the underground substation (and supporting infrastructure) at this location will result in the removal of 59 trees.

Mitigation measures (below) and are developed in accordance with objectives and actions outlined in the City of Vancouver's *Urban Forest Strategy*, *Vancouver Bird Strategy*, and *Bird Friendly Design Guidelines* reports (City of Vancouver 2014a, 2014c, 2014d).

In BC, the *Migratory Birds Convention Act* (MBCA) and the BC *Wildlife Act* manage migratory and resident breeding bird populations by prohibiting the destruction of individuals, eggs, and occupied nests. In Metro Vancouver, nests of bald eagle (*Haliaeetus leucocephalus*) and great blue heron (*Ardea herodias fannini*) are protected from disturbance or destruction throughout the year. Both Environment and Climate Change Canada (ECCC) and the BC MOE provide recommendations on habitat disturbance to support compliance with applicable regulations. If construction activities at Emery Barnes Park are scheduled to coincide with the nesting window for migratory birds, there may be increased potential for incidental take (i.e., mortality or destruction) of breeding individuals and nests located in sections of the park that are subject to vegetation clearing. Non-native (i.e., invasive or exotic species) are not protected under the MBCA or the BC *Wildlife Act*.

Sensory disturbance due to noise and vibrations, caused by vegetation clearing and grubbing, excavation, construction, and start-up and testing can result in avoidance behaviour for birds and other wildlife at Emery Barnes Park. Some forest songbirds show avoidance of habitats subjected to noise disturbances (Bayne et al. 2008; McClure et al. 2013), while other species (e.g., crows, gulls) are likely habituated or more tolerant of regular human disturbance during periods of foraging or roosting (Verbeek and Butler 1999).

Poor waste management can also lead to human-wildlife conflict (e.g., garbage serving as an attractant for crows, racoons, skunks). Contemporary practices can be effective in reducing conflicts resulting in animal removal or the destruction of nuisance animals (BC MOE 2016).

Adherence to applicable legislation and regulations, and implementation of mitigation measures (see below) are expected to reduce residual effects of these activities on birds and other wildlife.

2.3.12.2.2 Electromagnetic Fields at Emery Barnes Park

Electromagnetic fields (EMFs) are produced during the production and transmission of electricity and can alter body currents in exposed individuals. A great deal of uncertainty exists in the literature on the nature and extent of effects of EMFs on wildlife under natural conditions. Most epidemiological and experimental studies completed to-date have focused on effects to livestock, bats, and insect population and have not identified adverse effects of EMFs on fertility, navigation, immune system health, or foraging behaviour (Dell'Omo et al. 2009; BC Hydro 2017b,c; EMFS 2017a).

To assess baseline EMF levels at Emery Barnes Park, BC Hydro measured magnetic field levels at several locations within the park during non-peak hours on January 21, 2017. The highest magnetic field level at Emery Barnes Park was measured at 4.6 mG, and is influenced by an existing distribution transformer (see Appendix E). Operational EMF levels for Emery Barnes Park were predicted based on measurements in and above the existing underground substation at Cathedral Square. The highest magnetic field level of 100 mG occurred where three 230 kV transmission cables enter Cathedral Park between Homer and Richards Street. Similar EMF levels at Emery Barnes Park are expected above the two 230 kV transmission cables that will enter the park from Richards Street.

Because the strength of electric fields, such as those produced by a power line, decrease rapidly with distance, and can be blocked by solid materials, transmission of energy will be limited through placement of transmission cables at a minimum depth of 1.5 m (BC Hydro 2017c). Bundling of underground cables also leads to the cancellation and rapid decline of magnetic fields, further limiting potential for over ground exposure (EMFS 2017b).

Despite the patterns in EMF-related effects observed across taxa, the relationship between exposure levels and exposure-related effects for each species group continues to be poorly understood.

Current evidence does not confirm that low levels of EMF exposure result in definitive health or behavioural consequences for humans or birds and other wildlife, and Health Canada has not developed exposure guidelines for either group (Health Canada 2016). In absence of exposure guidelines, Health Canada refers to the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines that reference magnetic field levels below 2,000 mG as safe for the general public (ICNIRP 2010; Appendix E). Current and predicted EMF exposure levels at Emery Barnes Park are well below the 2,000 mG ICNIRP guideline. A recent review of the literature (2012-2016) indicates there is no new evidence that changes the conclusion of both Health Canada and World Health Organization that there are no confirmed health consequences associated with exposure to low level electromagnetic fields (Exponent, 2017). Accordingly, EMF-related effects to birds and other wildlife are expected to be low.

Operational effects of the Emery Barnes Park Project on birds and other wildlife are negligible, and replanting trees will replace habitat lost for birds and other wildlife.

Additional studies related to EMF can be found in appendix E and G of this report.

2.3.12.3 Mitigation Measures

The following mitigation measures are recommended to reduce effects of construction and operation of the proposed Emery Barnes Project on birds and other wildlife. These measures are conceptual only, and will be finalized prior to construction in consultation with the VPB.

- Construction
  - Consideration will be given to design strategies to reduce the magnetic fields from underground transmission cables, to the extent feasible (e.g., depth of cable placement, mu-metal shielding, optimize conductor spacing and phasing). These strategies will further lower EMF levels below the ICNIRP guideline value of 2,000 mG.
  - In accordance with Environment Canada's policy on Avoidance of Detrimental Effects to Migratory Birds and the BC Wildlife Act, pre-construction vegetation clearing activities will occur outside of the breeding season for migratory birds (March 28 through August 8) and raptors (February 5 through August 31) to avoid incidental take of birds (BC MOE 2013; ECCC 2017).

  - If clearing or disturbance to bird nesting habitats is required during the migratory bird breeding season, surveys will be conducted by a qualified biologist in advance of clearing, and nest-specific mitigation measures will be implemented by the qualified biologist to minimize the potential for incidental take, in compliance with the Migratory Birds Regulations of the MBCA and the BC *Wildlife Act*. No-disturbance setbacks will be established around active nests and clearly marked to show the extent of clearing (BC MOE 2013, 2014; ECCC 2017). Vegetation clearing and construction activities will be prohibited within no-disturbance setbacks for the period of time the nests remain active, as determined by the qualified biologist.
  - Waste management practices will be managed or mitigated through guidelines and best management practices to eliminate or reduce potential wildlife attractants to negligible levels. Waste will be temporarily stored onsite in wildlife-proof containers and disposed of regularly at an approved facility (BC MOE 2016).
- Post-Construction
  - Tree protection or replacement measures, outlined for Vegetation (see Vegetation Mitigation Measures and Appendix C) will limit effects of habitat loss to birds and other wildlife.
  - Consistent with the City of Vancouver's Bird Friendly Design Guidelines (2014c), tree replacement and landscaping will consider, to the extent feasible:
    - Establishing native mature trees and fruit-bearing shrubs
    - Consider continuous forest canopy and the location and spacing of tree planting
    - Increase vertical vegetation structure and complexity by incorporating coniferous and deciduous trees, shrubs, and grasses into landscape features
    - Incorporate a diversity of native trees, shrubs, and plants into landscape design (including seed, fruit, and nectar-bearing species)
    - Retain and/or incorporate wildlife trees, snags, and downed wood to support cavity nesting and foraging

2.3.12.4 Recommendations for Future Study

Given the timelines between when this study was completed and when potential construction is scheduled to occur, it is recommended that a pre-construction survey be completed by a qualified biologist to re-assess the presence of wildlife habitat features of concern (e.g., raptor nests, wildlife trees) within the park limits.

3.0 PROPOSED NELSON PARK PROJECT

3.1 NELSON PARK CONTEXT STATEMENT

The following context statement was provided by the Vancouver Park Board and provides a description of Nelson Park, including its size, location, history, and service area/catchment.

Nelson Park is located in the centre of the Nelson Plateau Character area (as defined by the West End Community Plan), at 1030 Bute Street, Vancouver. This 1.16 ha (11, 656 m^2) park is one of six parks in the West End area. Lord Roberts Annex, a VSB Elementary School, is located on the northeast corner of the park.

Nelson Park is the only major park on the Comox Helmcken greenway. The Greenway Project provides an important east-west connection through Downtown Vancouver for active transport, urban forest, and community development.

Throughout the summer, Nelson Park hosts a popular weekly farmers market next to the community garden, which was established in 2009. In February 2014, after a community engagement process that sought input from residents, the VPB approved an expansion of the community garden, to be built in the spring of that year. The expansion added 454 m^2 to the community garden (an increase of 52%), 30 additional garden plots, a children's nook next to the school and daycare, a picnic table, seating, and a new water connection.

Nelson Park was redeveloped in 2007 after a three-year consultation period with the community. The redeveloped park features new entryways, a pathway system, seating plaza, metal arbours, a water feature, and the off-leash dog area on the park's west side was enclosed with decorative metal fencing. During redevelopment, the VPB retained, amended, and reused the soil in the park, and granite removed from the dismantled park fieldhouse was used to as a base for the new water feature.

- Planning Context
  - West End—Nelson Plateau Neighborhood
  - West End Community Plan, 2013

3.1.1 Acquisition History

In the 1940s, the West End's population grew rapidly as many homeowners built additions or renovated to allow for rental suites, and apartment buildings took the place of single family homes. In the 1950s, to provide more green space, the City of Vancouver started buying properties around the area that is now called "Mole Hill". Over the next two decades, houses were razed in stages, to create present day Nelson Park. Some properties that were purchased for the creation of the park were not demolished due to community demand for retention of heritage buildings. These properties are still owned by the City and contribute to the character of the Mole Hill area and the City's Property Endowment Fund.

3.1.2 Service Area/Catchment

Within an eight-minute walk:

- Daytime population 2011–13,259
- Nighttime population 2011–17,273
- Projected nighttime population 2041–25,004
- Increase in population within an eight-minute walk, predicted by 2041 = 31%

The West End neighbourhood area has limited park space; 1.15 ha per 1,000 persons. This is very close to the Park Board minimum provision target of 1.1 ha per 1,000 persons. Given projected population growth, and without the addition of new park space, the provision is likely to be 0.86 ha per 1,000 persons by 2041. Optimum service levels, incorporating a more qualitative approach, are currently under review as a part of the Parks and Recreation Services Master Planning process.

3.1.3 **Excerpts** from the West End Community Plan (2013)

The West End has a diversity of parks and green spaces, ranging from the neighbourhood mini-parks to the large, vibrant waterfront beach parks. These special places contribute greatly to the West End's distinctive character. Green space is highly valued by residents and helps maintain livability in a high-density community.

There is a need to find opportunities for expanded outdoor recreation facilities, particularly for children, youth, and the older adult population. In particular, there is strong demand for additional community gardens in the West End, demonstrating recognition of their vital role within this high-density area, where almost 81% of households live in studio or one bedroom units. Since the majority of high-rise rental apartment buildings were built before 1975, they do not support, nor can they be retrofitted for urban infrastructure and design for food initiatives.

3.2 PROPOSED DEVELOPMENT

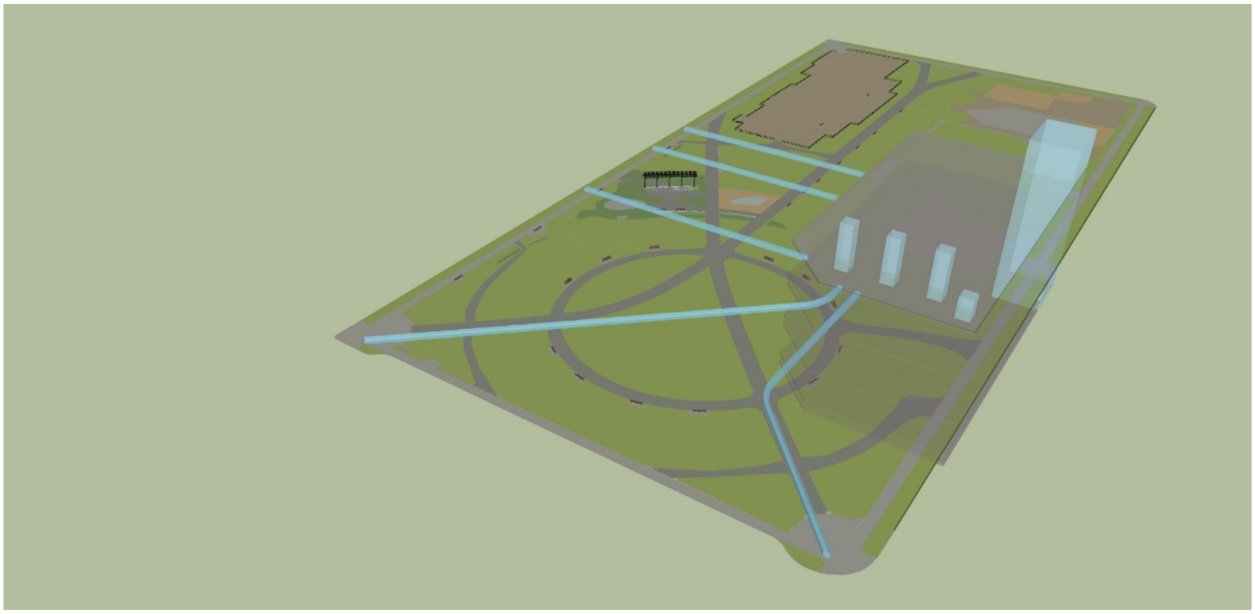


Figure 3-1 3D Rendering Image Showing Above Ground and Below Ground Infrastructure—Nelson Park

3.2.1 Design of Substation and Underground Infrastructure

The proposed substation is anticipated to be located entirely on Lord Roberts Annex property (refer to Section 4.2.2) near Nelson Park and it is anticipated that transmission and distribution lines to transfer power into and out of the substation will be constructed underground in Nelson Park.

Nelson Park is bound on all four sides by city streets (Thurlow Street, Comox Street, Nelson Street, and Bute Street). The park appears to share space with the VSB lands, although there is a fence line that divides the two spaces along the current property line.

The total gross area of the city block (road curb to road curb to eastern edge of development is 21,617 m^2 with the total net park and school area (inside sidewalk to inside sidewalk) is 19,123 m^2. An inventory of park surfaces and elements is described below.

3.2.2 Summary of Construction

3.2.2.1 Construction Sequencing

Construction of the proposed Nelson Park/Annex Project is expected to take approximately five years (refer to Section 4.2.2 for substation construction summary) with the start of construction commencing as soon as 2020 and an expected in-service date to occur near the end of 2025.

The first phase of construction in Nelson Park will require fencing off portions of the park for one to two months to allow for the installation of the underground cables.. BC Hydro will maximize the amount of park space remaining open for public use while allowing for the utmost safety of those interacting near the construction zone.

Ductwork Installation for both the 230 kV transmission lines and the distribution lines coming in from the street and going to the adjacent substation on Lord Roberts School Annex property is anticipated to be the main construction activity in Nelson park. There will be three major 230 kV transmission lines installed into the substation: two in the initial stage and one in the future. The transmission lines will be installed in conduit buried approximately 1.5 to 2.0 m below the surface. The trenches will be excavated with a standard excavator and the conduits will be installed in sand at the bottom of the trench. The trench will then be backfilled with special concrete mixture and the trench will then be backfilled with native fill. These trenches can be installed at any time and the cables will then be pulled in once all construction of the substation has been completed.

3.2.2.2 Lay Down Areas

It is anticipated that the Project will primarily use the construction footprint of Lord Roberts School Annex property for material and equipment laydown for the substation construction, but as design for the substation is only conceptual at present it is unknown if portions of Nelson park will need to be used as a laydown area.

Temporary laydown area's will be required for a short period of time for the Duct work installation within Nelson Park.

3.2.2.3 Access/Egress

It is anticipated that the substation construction will take place primarily on Lord Roberts Annex property and portions of Nelson Park will remain open to the public during construction and will be accessed from Bute, Comox, and Thurlow streets.

Construction access to the substation and Duct work Installation will be provided from Nelson Street and the north west corner of Bute Street, adjacent to the current Lord Roberts Annex.

Traffic control measures will be implemented on Nelson Street to facilitate all construction access into and out of site and on Thurlow Street during cable connections. A detailed traffic impact assessment would be undertaken and a Traffic Management Plan would be implemented during construction to reduce impacts in the project area.

3.2.2.4 Construction Schedule and Areas Impacted

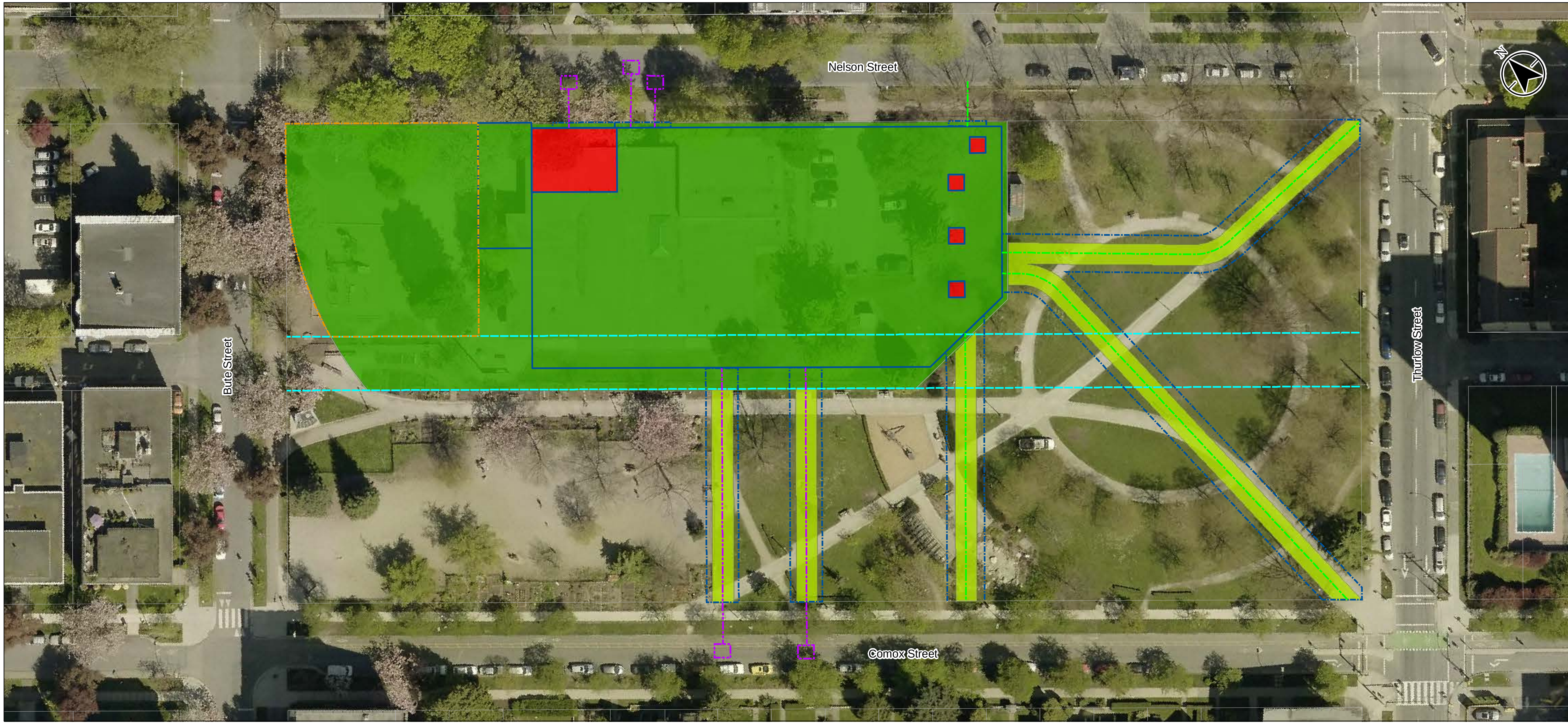
Total construction of the BC Hydro substation on the adjacent Lord Roberts Annex property will take approximately five years. Ductwork Installation will occur in Nelson park within this period with an anticipated schedule of one to two months. For details on the substation construction, please see Section 3.2.2.

A summary of the temporary areas impacted by the proposed project on Nelson Park is described in Table 3-1 below. Figure 3-2 below presents the temporary and permanent impacts to Nelson Park and Lords Roberts Annex in terms of the areas and duration.

Table 3-1 Construction Impact and Duration

Site	Construction Impact and Duration	Area (m^2)	Percent
Nelson Park	Permanently Lost: BC Hydro Infrastructure	0	0
	Temporary Lost: Substation Construction (min. 3 years)	0	0
	Temporary Lost: Cable Installation (1-2 months)	1,171	10
	Not impacted	10,487	90
	Total Area	**11,658**	

At Nelson Park, installing the underground cables will temporarily impact an area of 1171 m^2, or 10% of the park for approximately one to two months. Once construction is complete, there will be no permanent loss to any surface area within Nelson Park due to BC Hydro infrastructure.



- Statutory Right Of Way
- Proposed Statutory Right Of Way
- Temporary Work Area
- Proposed Distribution Duct
- Proposed Transmission Duct
- Proposed Substation
- Property Line

Construction Impact and Duration

- Permanent
- Temporary, min. 3 years
- Temporary, 1-2 months

0 10 20 metres

1:750 (At original document size of 11x17)

Stantec

Project Location	123220737
Vancouver, BC	Prepared by L. Trudell 2017-02-15 Reviewed by L. Thompson 2017-02-15

Client/Project

Lord Roberts School Annex / Nelson Park

BC Hydro SEED Program Study

Figure No.

3-2

Title

Lord Roberts School Annex / Nelson Park
Construction Impact and Timelines

Notes

1. Coordinate System: NAD 1983 UTM Zone 10N
2. Base features: DataBC, Government of British Columbia (GovBC); Surrey History National Topographic System, GovBC; CanVec v12,Government of Canada (GC)
3. Orthoimagery: City of Vancouver Open Data catalogue 2015

3.3 EXISTING CONDITIONS, IMPACTS AND MITIGATION

The following section describes the existing environmental and social values that currently exist at Nelson Park, how those values could be impacted by BC Hydro's proposed project, and recommendations to avoid, mitigate or compensate for potential impacts. For addition information related to EMF and real estate, please see the stand alone reports in Appendix E, F and G.

3.3.1 Park Inventory and Conditions

3.3.1.1 Baseline Data and Findings

A survey was completed for Nelson Park picking up a variety of elements including but not limited to:

- Edges of pavement (delineation between hard and soft surfaces)
- Park features—(outlines of planters, walls, custom seat walls/benches, water fountains)
- Park structures—(trellis, shelters, playground equipment etc.)
- Park buildings (washroom buildings, storage buildings, etc.)
- Utility boxes, lids, and equipment
- Trees—locations and caliper size (Stantec to field measure canopy extents)
- Furnishing and lighting—lights posts, bollards, benches
- legal property lines
- Edge of curb in between the road and the municipal sidewalks that bound each park

NOTE: bench placements and other minor paving details were field verified and photos of existing site furniture were taken to capture their condition at the time of this report. A photo capture of various views into the park have also been recorded to document Emery Barnes Park current condition.

This survey was completed to create a "record drawing" that identifies the current layout and location of major elements within Nelson Park. This survey was used to develop a digital base plan for the park site that included all property lines and rights-of-ways. The prepared base plan was used to calculate existing project metrics such as; amount of concrete, amount of tuff, number of benches, number and size of trees, etc.

3.3.1.1.1 Desktop Study—Online Reviews

According to Google and YELP.com, the park is rated as being 3.9 starts out of 5 (based on 45 reviews) and 3.9 out of 5 stars (based on 28 reviews) respectively. On Fourquare.com it is rated as 7.4 out of 10 (based on 38 reviews). Below is a wordle (Figure 3-3) which summarizes all of the comments from all three online review sources into a wordle generator, which makes words that were mentioned more often, are larger in the graphic below.

Figure 3-3 Wordle Diagram that Depicts Park Uses Identified through Desktop Review

Table 3-2 Inventory of Current Park Features and Amenities

Item	Description	Quantity	Unit
Materials			
1.1	Open Grassed Area (park space)	9,638	m^2
1.2	Grassed Area (city boulevard)	1,458	m^2
1.3	Planting Bed	383	m^2
1.4	Water Feature	44	m^2
1.5	Sand (playground areas)	560	m^2
1.6	Dirt (dog park)	2071	m^2
1.7	Dirt (school ground)	503	m^2
1.8	Concrete Paving (internal park)	273	m^2
1.9	Concrete Paving (perimeter City sidewalk)	1,257	m^2
1.10	Gravel Walkways	1,600	m^2
1.11	Natural Stone Banding	194	m^2
1.12	School Building	1,788	m^2
1.13	Asphalt Paving (school ground)	923	m^2
1.14	Concrete Paving (school ground)	266	m^2
Total Gross Area		**9,861**	**m^2**
Amenities and Furnishings			
2.1	Chain Link Fence	386	Linear metres
2.2	Metal Fence (dog park)	226	Linear metres
2.3	Post and Rail Fence (at school main entry)	47	Linear metres
2.4	Trellis Structure Above	40	m^2
2.5	Benches	31	each
2.6	Lamp Standards	13	each
2.7	Playground Feature	2	each
2.8	Swing Set	1	each

The following chart (Figure 3-3) indicates the breakdown the total 19,123 m^2 of park and school ground surface area composition. Note that "paved" areas comprising of 29% of the park surface area includes all concrete paving, dog park sand and the rubber surface for the playground:

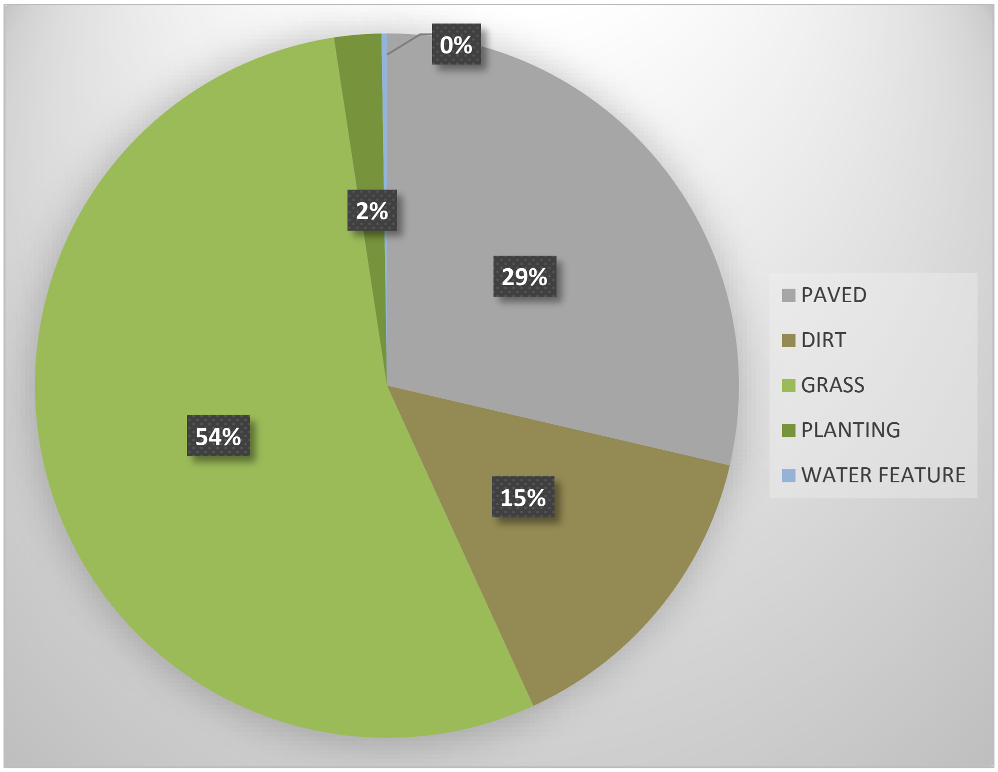


Figure 3-4 Percent Composition of Various Substrate Comprising the Surface Area at Nelson Park

A photo capture has also been taken of each park element and of various views into the park to document its current condition.

3.3.2 Park Use and Programming

3.3.2.1 Baseline Data and Findings

Nelson Park is centrally located in the West End of Downtown Vancouver in a very dense neighbourhood. The park is used by many local residents, for its dog park, passive play areas, and agricultural plots. Additionally, the park space is used by commuters walking from the west end area traveling to Downtown.

A series of desktop studies and on-site studies were employed to understand how the park is used. It is recognized that the on-site studies were conducted in January of 2017, which is not an ideal time of year to observe the maximum potential of users and activities taking place in the park. This would likely be the summer months (with the most ideal park weather being typically in August). The site studies completed in January, however, should provide a good indication of frequency of use in winter months as a sample, as well as the routes of travel of local pedestrians (such as walking commuters) and how they use the park.

The following desktop and on-site studies were completed in January of 2017:

1. Three on-site studies of the park were conducted in 2 hour durations each, in late January of 2017 at three key time frames:
   a. Study Type 1—weekday rush hour (8:00 AM to 10:00 AM)
   b. Study Type 2—weekend review (2:00 PM to 4:00 PM)—Saturday afternoon
   c. Study Type 3—weekday mid-morning (10:00 AM to 12:00 PM)
2. Desktop study (study type 4) of the summer use was conducted by reviewing Emery Barnes Park through Google Earth, ECW Orthophotos as well as Google street view to observe both frequency of users and the types of activities those users were engaged with
3. Desktop review of online reviews of Nelson Park were studied including:
   a. Google reviews
   b. YELP reviews
   c. Trip Advisor reviews
   d. Foursquare reviews

3.3.2.2 Park Programming

The programming for the park consists of both structured and non-structured uses. Structured uses refer to the park being used for specific purposes for community events, groups or city-wide events typically planned in advance. Non-structured uses refer to informal activities (active or passive) by visitors at any given time at their discretion.

3.3.2.2.1 Structured Uses

Table 3-3 provides a summary of a listing of various events and other group activities that have used the park in the past five years and when they occurred (note this is not a conclusive list but a sampling of the types of events that typically happen).

Table 3-3 Summary of the Events and Group Activities Held in Nelson Park over the Past 5 Years

Season	Event/ Festival	Description	Open to Public/ Group Event	Dates
Summer	West End Farmer's Market	Laid-back Saturday market on Comox Street looks onto Nelson Park and adjacent community gardens. Weekly, West Enders can enjoy the best in local produce, prepared foods and crafts. Hot food and coffee on-site as well.	Open to Public	May 28 to October 22
Summer	Pokemon Go Meet Up	Gathering for Pokemon Go enthusiasts	Open to Public	7/29/2016

Table 3-3 Summary of the Events and Group Activities Held in Nelson Park over the Past 5 Years

Season	Event/ Festival	Description	Open to Public/ Group Event	Dates
Summer	West End Food Festival: Pop-Up Potluck	Free event for local residents and community gardeners to network and share food and ideas	Open to Public	9/15/2016
Summer	Vancouver Pride Society: Salaam Vancouver Eid and Pride Potluck Picnic	Vancouver LGBT event targeting queer Muslim community in celebration of end of Ramadhan and Vancouver Pride	Open to Public	7/17/2016
All Year	Running Groups	Running groups meet up in the west end and use Nelson Park to jog through (the main angled path that runs south to north)	Group Event	All year
Spring	Jane's Walk	Citizen-led kids-focused walking tours towards community-based city buildings lead by local planners. Meeting Spot Corner of Thurlow St. and Comox St. Last stop at entrance to Nelson Park on Bute St.	Group Event	typically in May

The Nelson Park Community Gardens organization also has a dedicated Facebook page with 151 page likes and 141 followers.

3.3.2.2.2 Non-Structured Uses

The variety of amenities at the park as well as the physical layout of these amenities contribute to a variety of informal uses and experiences at the park. Uses mainly include:

- Casual strolling
- Bench dwelling
- Fitness use (yoga, group classes, individual fitness (tai chi, running, etc.)
- Grass sitting/laying (summer only)
- Urban gardening in the community garden plots
- Active play at the playground
- Active play (e.g., ball sports) in the open grass area
- Dog walking as well as off-leash playing at the dog park

All the above non-structured uses take place across the park site based on amenity locations. Please refer to Appendix A.1 - Park Programming and Use for a graphic depiction of where these non-structured uses take place at any given time.

3.3.2.3 PARK USE

As noted, landscape field technicians visited the site at three key time frames:

1. Study 1—weekday rush hour (8:00 AM to 10:00 AM)
2. Study 2—weekend review (12:00 PM to 2:00 PM)—Saturday afternoon
3. Study 3—weekday mid-morning (10:00 AM to 12:00 PM)

Study 1—Weekday Rush Hour

Overall, there was a high frequency of weekday commuters that use the park to "cut-through" on their way to work. Given the grid like fabric of surrounding West End neighbourhood, and the elongated shape of Nelson Park in the northwest to southeast direction, Nelson Park is a great park for commuters to cut across, and is estimated to cut off approximately 5 minutes from the walking commute (based on measuring the length and frequency of commuters compared with the length of the direct "cut-across" routes.

Between the hours of 8:30 AM and 9:00 AM, there were multiple adults observed travelling with children across the park. It was observed that they were travelling from the surrounding community and cutting across the south half of the park to go around the chain link fence into the school main entrance off Nelson Street.

There were not many bench dwellers in the rush hour timeslot as compared to Saturday afternoon or mid-day.

Dog-walkers were observed. On average, the dog park at Nelson Park was more widely used than the dog park at Emery Barnes Park.

Table 3-4 summarizes the types of users observed at this study timeframe.

Nelson Park User Study #1

Date: Monday, January 23, Time: 8:00 AM to 10:00 AM

Weather: Sunny (no clouds) 4ºC

Table 3-4 Summary of the Types of Users Observed on Monday, January 23

User Types	8:00 AM	8:15 AM	8:30 AM	8:45 AM	9:00 AM	9:15 AM	9:30 AM	9:45 AM	Total
Primary Route (Direct Path)	30	45	59	48	37	22	21	17	**249**
Second Priority Route (opposite the direct route)	2	3	4	5	5	7	6	3	**35**
Third Priority Route (straight through)	4	5	5	5	4	3	2	2	**30**
Commuters (Total)	**36**	**53**	**68**	**58**	**46**	**32**	**29**	**22**	**314**
Dog Walkers	1		1	3	4	3	3	3	**18**
Strollers		1	1		1	1	1		**5**
Casual Walkers			1			1	1	2	**5**
School Walkers				7	4	3			**14**
Bench Dwellers					1	1	1	1	**4**
Dog Park Users (arriving to dog park)	*4*	5	3	2	1	1	2	2	**20**
Total All Users	**41**	**59**	**74**	**70**	**57**	**42**	**37**	**30**	**360**

Study 2—Weekday Mid-Morning

As expected, the park was the least busy during this time frame. The dog park was the most frequented spot in the park at this time. The most frequent user at this time was either the dog park users (congregating in the centre of the dog park) or dog walkers walking through the park and adults with strollers. It should be noted that the only people using the benches during the weekday appeared to be adult users that would be seated at the benches for extended periods of time. Weekends saw broader use by families and other users for the benches.

Table 3-5 summarizes the types of users observed at this study timeframe.

Nelson Park User Study #2

Date: Thursday, January 19, 2017, Time: 9:30 AM to 11:30 AM
Weather: Sunny (some clouds) 6ºC

Table 3-5 Summary of the Types of Users Observed on Thursday, January 19

User Types	9:30 AM	9:45 AM	10:00 AM	10:15 AM	10:30 AM	10:45 AM	11:00 AM	11:15 AM	Total
Primary Route (Direct Path)	15	12	10	6	5	6	7	8	**54**
Second Priority Route (opposite the direct route)	3	4	3	4	4	5	6	3	**32**
Third Priority Route (straight through)	2	2	1	1	2		1	2	**11**
Commuters (Total)	**20**	**18**	**14**	**11**	**11**	**11**	**14**	**13**	**97**
Dog Walkers	3	2	1	3	3	2	2	1	**17**
Strollers	1		1		2		1		**5**
School Walkers									**0**
Bench Dwellers	1		1		1			2	**5**
Dog Park Users (arriving to dog park)	*3*	4	5	2	1	2	3	2	**22**
Total All Users	**28**	**24**	**22**	**16**	**18**	**15**	**20**	**18**	**124**

Study 3—Weekend Afternoon

The park was visited again on the afternoon of Saturday, January 21 from 2:00 PM to 4:00 PM. During this time, it rained between 1:00 PM and 2:00 PM. The majority of park users at this time were at the dog park or couples and families casually walking through the park going to or from the West End.

Photo 3-1 A Woman Who Routinely Frequents Nelson Park on the Weekends

Table 3-6 summarizes the types of users observed at this study timeframe.

Nelson Park User Study #3
Date: Saturday, January 21, Time: 12:00 PM to 2:00 PM
Weather: Overcast; 8ºC

Table 3-6 Summary of the Types of Users Observed on Saturday, January 21

User Types	12:00 PM	12:15 PM	12:30 PM	12:45 PM	1:00 PM	1:15 PM	1:30 PM	1:45 PM	Total
Commuters		1	1		1	2	1	2	**8**
Dog Walkers	1		1	3	4	3	3	3	**18**
Strollers		2			1	2	1	1	**7**
School Walkers									**0**
Casual Walkers	4	5	8	8	12	13	14	12	**76**
Bench Dwellers				1	1	2	2	1	**7**
Dog Park Users (arriving to dog park)	*4*	3	2	4	5	6	9	8	**41**
Total All Users	**9**	**10**	**11**	**16**	**23**	**26**	**29**	**25**	**108**

Study 4—Desktop Study (Summer Use)

A desktop study of Google street view and available air photos was conducted depicting high park use in the warm summer months (May-September). Most park benches and seating areas were occupied on a sunny day. Park users were observed sun bathing on grassy areas, children playing in the water feature and the playground, people walking their dogs and groups playing Frisbee/tag/kick ball in the open grassy areas of the park. Gardeners in the community garden plots surrounding the busy dog park are busy tending to their gardens. Additionally, festivals and farmers markets on Comox Street overflow into the park on weekends when Comox is closed for these various regular summer events.

Google reviews has an application that allows cell phones, when located within the park, to communicate with satellites, allowing Google to track users throughout the year. The peak times according to Google's data on an average Saturday is shown in Figure 3-5 (and it is observed by Google that the average person typically spends about 45 minutes in the park):

Figure 3-5 A Graphic provided by Google that Tracks Park Visitors

Summary of Types of Users

Utilizing both on-site and desktop review/observation methods, different park users were identified and inventoried. Table 3-7 depicts the identified users along with a description and an image capture of these users in action at the park.

Table 3-7 Summary of Nelson Park User Groups

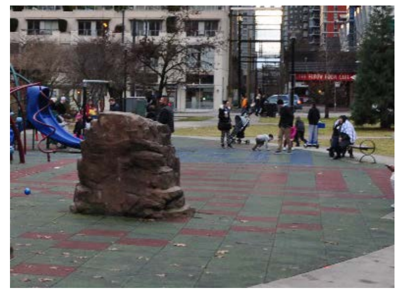
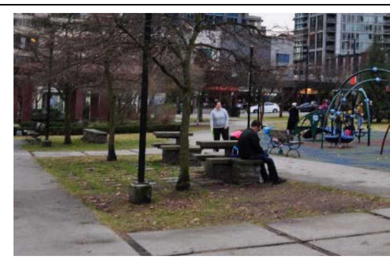
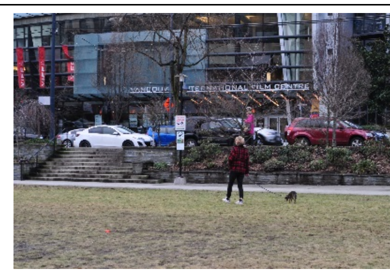
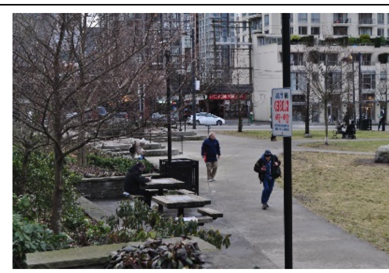
Icon	Type	Description	Image Example
	Strollers	Adult with stroller and baby/toddler walking along the paths through the park.	
	Families	Mostly two adult families with multiple children, typically observed at the park, or on grassed areas in a social setting.	
	Commuters	People walking fast with very direct routes through the park. They use the shortcut paths most often.	
	Dog Walkers	Typically consists of one person with their dog on a leash, walking slowly around the circular path while the dog sniffs things.	

Table 3-7 Summary of Nelson Park User Groups

Icon	Type	Description	Image Example
	Bench Dwellers	People sitting on benches. Typically benches in the sun are most frequented.	
	Dog Park Users	Dog owners with their dogs off leash in the dog park. Almost all dog owners congregate in the middle of the dog park to socialize while their dog plays.	
	School Walkers (Nelson Park)	Typically one adult and one or two children walking to school with backpacks on.	
	Joggers	Joggers running through the park. These users are mostly observed on the weekend or in the early weekday morning (although less frequent).	
	Casual Walkers	Couples or small groups of adults walk through the park.	
	Garden Tender	A member of the community garden who is leasing a garden plot and working in the garden.	

Frequency of Use of Amenities

The types of users vary depending upon the time of day and the day of the week. For a graphic depiction of these types of users, including the overall frequency of users in the park, and what areas and amenities are frequented the most at any given time, has been graphically depicted in Appendix A.1.

3.3.2.4 Discussion of Impacts

Based on the information gathered about the amenities and the users for the park, as well as the proposal for the substation below ground and the need for distribution lines to cut through the park boundary, it is anticipated that Nelson Park will be impacted as well as the School Board Property. The potential for impact to Nelson Park is based on a combination of infrastructure requirements and construction use. The impacts to the Park Programming is summarized below:

3.3.2.4.1 Impacts to Park During Construction

While at present, the anticipated development site for the construction site is largely on School board property, the loss of the school playground, replacement of the school building, and associated construction activities will create a disturbance to the park site during construction.

It is anticipated some of the park spaces will be unusable due to construction activity for the duration of the construction schedule.

As the park is located in an area that includes residential uses, construction traffic will affect the surrounding community on days of heavy construction activity. Should the project move forward, BC Hydro will work with contractors to establish proper construction sequencing in an effort to minimize neighborhood disruption.

3.3.2.4.2 Potential Changes to Park Design and Programming Post-Construction

With the exception of portions of the park that will be affected though the construction process. It is not anticipated that the park will need a great deal of redesign and programming. However, as the park is older, consideration may be given to update designs, uses, and materials at the time of substation construction to better reflect current and trending uses of the public space.

3.3.2.5 Mitigation Measures

As a result of noise impacts during construction of both the school and the substation, some portions of Nelson Park will not be usable during this period. Therefore alternative open spaces or temporary parks during the construction period should be considered.

3.3.3 Park Experience and Aesthetics

3.3.3.1 Baseline Data and Findings

- Gateways and nodes
- Shadow study, etc.)
- Views/vistas

3.3.3.2 Discussion of Impacts

Understanding the high level impacts the substation would have on the overall experience of the park includes considering how the location of the vehicle elevator at the north corner would block the "arrival" experience at the north corner of the park, how the ventilation stacks may affect park aesthetics, and understanding the types of trees and vegetation that can safely be planted on top of the substation.

It is clear that the high voltage cable alignment will impact the location of some existing trees, and therefore those trees would likely need to be removed in order to install the cables. Losing large trees in the centre of the park might have a lasting impact on the visual quality of Nelson Park, situated in the west end of where large trees is part of the overall character of the neighbourhood.

The three ventilation stacks are not located on the park property but will have a visual impact on the park. The ventilation stacks are currently proposed in an area of the school property that has many existing trees. While this is school property the trees blend in with the background of the park making it appear visually and sensationally a part of the park, thus making the park feel larger than it is. Placing ventilation stacks will have an impact on that sensation, especially with the loss of the trees that would be in the way. This will change the experience as you arrive to the park from Thurlow street. Loss of trees overall will have an impact on the quality of the park, and may have an impact on the park being used for film and other events that require a "treed" backdrop.

3.3.3.3 Mitigation Measures

The mitigation measures proposed to deal with the above impacts could include creative ways to incorporate the design of the vehicle elevator at the north corner of the park to minimize the loss of usable park space and interruption to the north entrance. Consider how to utilize the roof of this vehicle elevator as usable park space by creating a focal feature within the park. Ways to mitigate the visual impact of the required ventilation stacks could include designing them to work with other proposed park upgrades, consider different heights, materials and commissioned public art.

3.3.3.4 Recommendations for Future Study

Recommended future studies could include the following:

- Visual impact assessment of the venting structures and the loss of trees
- Further detail on what the vent stacks can handle in terms of public art, or other structures on top that integrate them with the overall experience of the park

3.3.4 Vegetation

3.3.4.1 Baseline Data/Findings

An arborist study was conducted to inventory and document the location, species, DBH, and general condition of each tree within Nelson Park (Appendix D Nelson Park/Lord Roberts School Annex Arborist Report). The Vancouver Street Tree Inventory (City of Vancouver 2017b) and design drawings and specifications for the park supplemented the baseline knowledge (Appendix A.3). The tree inventory for Nelson Park was combined with Lord Roberts Annex. The Project footprint within the park consists of the locations of the proposed transmission and distribution ducts.

Urban forest canopy cover is an important part of the Urban Forest Strategy and Greenest City Action Plans. To determine the canopy cover of the parks, aerial photos were used to digitize the tree canopy. The area of the canopy cover was determined and divided by the total area of the park (1.16 ha; City of Vancouver 2017g).

As of 2014, the urban forest canopy cover in the West End neighbourhood was 18.6% (City of Vancouver 2014a). Nelson Park has an existing canopy cover of approximately 49% of the park. Nelson Park is less than 1% of the total area of the West End neighbourhood.

Street trees are present along all four sides of the park. An off-leash dog park is present in the southwest corner of the park. A community garden is present along the south fence of Lord Roberts Annex, and south of the dog park. The east side of the park is primarily lawn with mature trees.

Table 3-8 provides a summary of the tree species, DBH and count of trees within Nelson Park. A total of 127 trees within Nelson Park were recorded, of this total, 98 trees are ≥20 cm DBH (see Appendix D, Lord Roberts Annex/Nelson Park Arborist Report).

Table 3-8 Summary of Trees within Nelson Park

Common Name	Scientific Name	Minimum DBH (cm)	Average DBH (cm)	Maximum DBH (cm)	Number of Trees	Number of Trees ≥20 cm DBH
paperbark maple	*Acer griseum*	8	9	10	2	0
Japanese maple	*Acer palmatum*	5	5	5	1	0
red maple	*Acer rubrum*	10	29	37	8	6
maple	*Acer* sp.	47	78	107	4	4
horse-chestnut	*Aesculus hippocastanum*	54	54	54	1	1
monkey puzzle tree	*Araucaria araucana*	18	18	18	1	0
Deodar cedar	*Cedrus deodara*	44	49	54	2	2
Turkish hazelnut	*Corylus colurna*	14	21	29	5	3
English hawthorne	*Crataegus oxyacantha*	17	26	43	18	16
beech	*Fagus* sp.	25	48	79	9	9
Rayburn ash	*Fraxinus oxycarpa*	13	15	18	5	0
giant sequoia	*Sequoiadendron giganteum*	66	66	66	1	1
American sweetgum	*Liquidambar styraciflua*	17	17	17	1	0
tulip tree	*Liriodendron tulipifera*	27	27	27	1	1
southern magnolia	*Magnolia grandiflora*	7	11	13	4	0
magnolia	Magnolia sp.	10	12	13	3	0
shore pine	*Pinus contorta*	13	13	13	1	0
ponderosa pine	Pinus ponderosa	44	44	44	1	1
cherry	*Prunus* sp.	7	37	71	14	10
oak	*Quercus* sp.	27	45	58	10	10
hemlock	*Tsuga* sp.	15	15	15	1	0
little-leaf linden	*Tilia cordata*	21	33	40	32	32
unknown	*Unknown*	24	29	33	2	2
Total					**127**	**98**

No invasive plants, noxious weeds or rare plant species were observed during the survey.

3.3.4.2 Discussion of Impacts

Five trees would be removed from the park for construction of the proposed distribution and transmission ducts as part of the Project, three of which are ≥ 20 cm DBH. Tree clearing for the proposed Project will result in a loss of approximately 2% of the existing canopy cover from the park, which is less than 0.1% of the canopy cover in the West End neighbourhood.

Excavation of soil and rock to install the cable ducts has the potential to affect subsurface hydrology, which may in-turn adversely affect vegetation remaining outside the excavation footprint.

3.3.4.3 Mitigation Measures

The following mitigation measures are recommended to reduce effects of construction on the urban forest in the West End neighbourhood. These are preliminary and will be finalized prior to construction in consultation with the VPB.

- Pre-Construction
  - The subsurface hydrology section of this report recommends conducting groundwater monitoring for one year to generate a better understanding of groundwater fluctuations during the seasons. This information would help assess the risk of effects on vegetation due to changes in subsurface hydrology and inform accompanying mitigation measures.
- Construction
  - Where possible, the location of the transmission ducts will be placed under existing hardscape infrastructure, such as gravel or concrete pathways, to reduce the number of trees that may be affected.
  - Tree protection barriers for remaining trees should be installed prior to the start of construction. The tree protection barriers should follow the Tree Protection standard 32 01 56 in the Park Development Standards (PWL Partnership Landscape Architects Inc. 2015).
  - Smaller trees currently located within the footprint could be moved elsewhere within Nelson Park, or to existing parks within the West End neighbourhood. If this occurs, relocation should follow the Tree Digging and Relocation standards 32 96 43.05 in the Park Development Standards (PWL Partnership Landscape Architects Inc. 2015).
  - An Erosion and Sediment Control Plan will need to be submitted as part of the permit application to the City of Vancouver. This plan will include elements to protect storm drain inlets; to remove mud and debris from City property; to reduce sediment run-off; to schedule construction to limit vegetation clearing until necessary; to provide minimum-impact access; and provide a monitoring plan to sample discharge water (City of Vancouver 2017e).
  - Where possible, construction staging areas should be placed to avoid removing trees.
  - Construction activities involving movement of soil should follow best management practices to reduce the spread of invasive plants by arriving on-site with clean vehicles, and ensuring that any soil transported is clean and free of invasive species seeds or vegetative propagules.
- Post-Construction
  - BC Hydro will work with the VBP to replace the number of trees required by the City of Vancouver to achieve no net loss of trees or urban canopy due to the Project.
  - The landscaping of Nelson Park will be restored following Project construction.

- The aim of the Project is to achieve no-net-loss of the urban canopy in the long-term. Trees will be replaced following Schedule D of the Protection of Trees Bylaw (City of Vancouver 2017d).
- Replacement trees should be planted on-site; if this is not possible, then they should be planted off-site but within the West End to maintain canopy cover within the neighbourhood. Opportunities and constraints pertaining to tree replacement on-site and within the West End neighbourhood will be determined during the design phase of the Project, which will include the detailed landscape design of the park for the post-construction timeframe.
- Although large trees will not be replanted on top of the underground substation, other vegetation, such as grass, small shrubs and small trees (e.g., <5 m mature height and <15 cm DBH at mature height) may be planted on top of the underground substation.
- To reduce the temporal loss of canopy cover during construction, replacement trees should be planted prior to the removal of trees, where feasible.
- Trees, shrubs, and herbaceous plants should be installed following the Plants and Planting standard 32 93 10 in the Park Development Standards (PWL Partnership Landscape Architects Inc. 2015).
- Soil placement should follow the Growing Medium standard 32 91 13 in the Park Development Standards (PWL Partnership Landscape Architects Inc. 2015).
- Surface and groundwater management should maintain pre-construction conditions following construction to reduce long-term adverse effects on vegetation (see details in Sections 2.3.9 and 2.3.10).

3.3.4.4 Recommendations for Future Study

Prior to construction, an additional arborist survey should be completed to flag the trees that will require removal and to monitor tree protection barriers.

Future study should also identify the opportunities and constraints for reducing the temporal loss of the urban canopy during Project construction by identifying suitable locations and amounts of trees to be replaced, along with the schedule for replacement. This process would proceed in conjunction with the parks design process for the post-construction condition to identify on-site tree replacement options, and would extend to off-site options within the West End neighborhood, or city-wide, if necessary.

3.3.5 Air Quality

Air quality is the state of the atmosphere with respect to the presence of substances that are potential contaminants. Air quality is assessed because of its intrinsic importance to the health and well-being of humans, wildlife, vegetation, and other biota. CACs are Nationally recognized air contaminants. They have been regulated and used as measurable parameters for air quality). Understanding the amount of CACs released and the ambient concentrations in the atmosphere are crucial in assessing the air quality and the potential to affect the receiving environment. The CACs considered include: NOx presented as NO_2, SO_2, CO, and $PM_{2.5}$.

3.3.5.1 Baseline Data and Findings

Metro Vancouver's air quality objectives for CACs were used for this air quality study and are summarized in Table 3-9.

Table 3-9 Metro Vancouver's Ambient Air Quality Objectives for CACs

Substance	Averaging Period	Objectives (µg/m³) [1]
NO_2	1-hour	200
	Annual	40
SO_2	1-hour	196 [2]
	24-hour	125
	Annual	30
CO	1-hour	30,000
	8-hour	10,000
$PM_{2.5}$	24-hour	25
	Annual	8 (6) [3]

NOTES:

1 Metro Vancouver's 8-hour and 24-hour objectives are intended to be compared against concentrations calculated as a rolling average. Metro Vancouver objectives are "not to be exceeded", meaning the objective is achieved if 100% of the validated measurements are at or below the objective level.

2 This 1-hour SO_2 objective is interim and is intended to apply to all applications for new or significantly modified discharge authorizations under Greater Vancouver Regional District Air Quality Management Bylaw No. 1082 made on or after May 15, 2015 but not intended to apply to existing facilities. "Significantly modified" refers to an increase in authorized quantity of emission of greater than 10%. The interim SO_2 objective will be revisited after the Canadian Council of Ministers of the Environment adopts a new Canadian Ambient Air Quality Standard, likely in 2016.

3 Metro Vancouver's Annual $PM_{2.5}$ Planning Goal of 6 µg/m³ is a longer term aspirational target to support continuous improvement.

SOURCE: Metro Vancouver 2016

The potential impacts of the proposed installation of transmission cables in Nelson Park may include the change in CAC concentrations during construction. During the operation phase, the cables will be buried and there will be no sources of CAC emissions. The operations phase will therefore not be further evaluated in this air quality study.

Potential impacts of the proposed Nelson Park construction on air quality are based on professional judgment and a qualitative study of the relationship between construction emissions and baseline air quality.

The baseline or existing air quality is determined from the nearest, most representative, continuous air monitoring station in proximity to the Project. No one station measures all CACs considered in this study, therefore data from two stations are evaluated, as presented in Table 3-10. Data from the Vancouver Downtown station is used for the evaluation of NO_2, SO_2 and CO baseline concentrations. This station is located in the Robson Square Complex which is approximately 600 m east of Nelson Park. For context, $PM_{2.5}$ concentrations from Vancouver Kitsilano station is used because $PM_{2.5}$ is not monitored at the Vancouver Downtown station. This station is located at the Kitsilano Secondary School, approximately 3,400 m southwest of Nelson Park.

Table 3-10 Continuous Ambient Air Quality Monitoring Stations Used in the Baseline Air Quality Analysis

Station Name	Latitude	Longitude	Elevation (m asl)	Location (UTM NAD83)			Substances Monitored			
				mE	mN	Zone	SO_2	NO_2	CO	$PM_{2.5}$
Vancouver Downtown [1]	49.2823°N	123.1219°W	32	491134	5458846	10	x	x	x	-
Vancouver Kitsilano [1]	49.2617°N	123.1635°W	34	488104	5456562	10	-	-	-	X

NOTES:
x = continuous monitoring data available for the baseline air quality analysis
- = monitoring data not available

SOURCE: [1] Metro Vancouver 2014 Lower Fraser Valley Air Quality Monitoring Report (Metro Vancouver 2014)

The results of a baseline air quality analysis from 2008 to 2015 are presented in Table 3-11.

Table 3-11 Summary of Continuous Ambient Air Quality Monitoring Data at Stations Used in the Baseline Air Quality Analysis

Substance	Averaging Period	Objectives (µg/m³)	Vancouver Downtown (µg/m³)	Vancouver Kitsilano (µg/m³)
NO_2 [1]	1-hour	200	84.1	
	Annual	40	37.7	
SO_2 [2]	1-hour	196	82.4	
	24-hour	125	19.0	
	Annual	30	7.50	
CO [3]	1-hour	30,000	768	
	8-hour	10,000	699	
$PM_{2.5}$ [4]	24-hour	25	-	12.5
	Annual	8(6)	-	4.92

Table 3-11 Summary of Continuous Ambient Air Quality Monitoring Data at Stations Used in the Baseline Air Quality Analysis

Substance	Averaging Period	Objectives (µg/m³)	Vancouver Downtown (µg/m³)	Vancouver Kitsilano (µg/m³)
NOTES:				
1 BC MOE summary database for NO2 observations at Vancouver Downtown are for 2008, 2009 and 2012, 2013, and 2014. The 1-hour background NO2 concentration was determined based on the daily 1-hour maximum concentrations, followed by the calculation of the 98th percentile for each year, then averaged over the BC MOE database period. Annual NO2 background concentration was based on the average of annual mean values.				
2 BC MOE summary database for SO2 observations at Vancouver Downtown are for 2008, 2009 and 2012, 2013, and 2014. The 1-hour background SO2 concentration was determined based on the daily 1-hour maximum concentrations, followed by the calculation of the 99th percentile for each year, then averaged over the BC MOE database period. The 24-hour background SO2 concentrations were determined based on the 98th percentile of 24-hour SO2 concentrations for each year, then averaged over the period of record. Annual SO2 background concentration was based on the average of annual mean values.				
3 BC MOE summary database for CO observations at Vancouver Downtown for 2009, 2012, 2013, 2014, and 2015. The 1-hour and 8-hour background CO concentrations were determined based on the 98th percentile of 1-hour and 8-hour CO concentrations for each year, then averaged over the period of record.				
4 BC MOE summary database for $PM_{2.5}$ observations at Vancouver Kitsilano are for 2009, 2010, 2011, 2012, and 2013, The 24-hour $PM_{2.5}$ background was determined based on average of the 98th percentile values for the 24-hour averaging interval. For the annual averaging interval, it is the average of the annual mean values.				
SOURCE: BC MOE 2016b				

BC MOE monitored concentrations of NO_2, SO_2, CO, and $PM_{2.5}$ are demonstrated to be below the applicable Metro Vancouver Air Quality Objectives (Table 3-11). Baseline air quality of NO_2, CO, and SO_2 in Downtown Vancouver is influenced primarily by dense traffic close to a busy street (Vancouver Downtown station) (Metro Vancouver 2012). Baseline air quality of $PM_{2.5}$ in the vicinity of the Kitsilano monitoring station, is influenced primarily by a sandy beach volleyball court a few metres away from the monitoring station (Metro Vancouver 2012).

Generally, the baseline ambient air quality in the vicinity of Nelson Park is good. Expected sources of CACs near Nelson Park include vehicular traffic, space heating, and other dust sources.

Estimated substation construction activities are separated into off-road excavation and construction equipment. US EPA NONROAD emission factors were used in conjunction with a list of representative off-road excavation and construction equipment. For this study, it is assumed that all equipment has Tier 3 engines (ECCC 2012). The sulphur content for off-road diesel is assumed to be 15 ppm based on ultra-low sulphur diesel limit (Environment Canada 2002). Following the EPA NONROAD model, all PM emissions are assumed to be smaller than $PM_{2.5}$ (USEPA 2004) for this study.

Sources of PM from wind erosion and dust from mobile equipment are not quantified in this study. These sources are difficult to quantify as they are highly dependent on the activities/techniques used onsite. These emissions will be managed through the proposed mitigations for the Project as well as recommendations for future study, discussed below.

Table 3-12 presents the estimated annual CAC emissions related to fuel combustion during excavation and construction activities at Nelson Park. It is predicted that the annual emissions from excavation will be more than the annual emissions from construction. Excavation emissions exceeded construction emissions mainly due to the equipment count and operating time required to complete these activities.

Table 3-12 Predicted Annual CAC Emissions from Excavation and Construction Activities at Nelson Park

Activity	Emissions (tonnes/year)			
	NO_2	SO_2	CO	$PM_{2.5}$
Off-road excavation equipment	15.0	0.01	15.0	0.9
Off-road construction equipment	12.8	0.01	13.5	0.8

Excavation and construction activities are each estimated to last more than one year; therefore, Table 3-12 presents the total emissions from these activities. The CAC emissions in Table 3-13 include those emitted from fuel combustion only.

Table 3-13 Predicted Total CAC Emissions for Excavation and Construction of the Substation at Nelson Park

Activity	Emissions (Tonnes)			
	NO_2	SO_2	CO	$PM_{2.5}$
Off-road excavation equipment	16.9	0.02	16.9	1.0
Off-road construction equipment	20.4	0.02	21.6	1.3
Total	**37.3**	**0.04**	**38.5**	**2.3**

3.3.5.2 Discussion of Impacts

Professional judgement was used to qualitatively assess the potential impacts of the proposed Nelson Park/Annex Project on air quality. This study is based on the types of construction activities, as well as the duration and frequency of construction activities. Activities associated with the construction of the substation will increase CAC concentrations in the vicinity of Nelson Park. However, if best management practices to control CAC emissions are implemented, the degree of change to CAC concentrations are expected to be low. Activities will also be limited to daytime hours, temporary, and irregular in occurrence. As well, impacts would be reversible upon completion of the construction phase.

Baseline conditions are good with all CACs measuring less than the ambient air quality objectives. The Project's impact on air quality is qualitatively assessed to remain within the ambient air quality objectives if construction best management practices are implemented.

3.3.5.3 Mitigation Measures

Mitigation measures applicable to air quality are limited to construction best management practices. These include:

- Water road surfaces and exposed surfaces prone to wind erosion to suppress fugitive dust
- Operate vehicles within the posted maximum speed limits to limit fugitive dust and fuel combustion emissions
- Implement wheel-cleaning for vehicles leaving site to prevent dust "track-out" onto the surfaces of public roads
- Maintain vehicles in good operating condition to meet emission standards (such as catalytic converters and particulate filters for diesel engines)
- Use appropriate-sized, and modern (Tier 3) fleet of construction equipment to reduce fuel consumption
- Reduce vehicle idling and limit rapid starts and stops
- Use low-sulphur diesel fuel

3.3.5.4 Recommendations for Future Study

Emissions from sources other than fuel combustion have not been included in this study. Due to the type of the Project, PM (dust) from wind erosion and mobile equipment are difficult to quantify as they are highly dependent on the activities/techniques used onsite. It's recommended that impacts be evaluated on an ongoing basis. This can be accomplished with the investigation of the cause for complaints (if any) related to PM emissions. Results of these investigations can yield continuous improvements to the best management practices over the duration of construction.

3.3.6 Noise

3.3.6.1 Baseline Data and Findings

Noise was selected as an environmental effect because activities during construction and operations of the Project will generate noise at Nelson Park (including Lord Roberts Annex school). Noise has been identified as a topic of concern to BC Hydro, VPB, VSB, stakeholders, and the public. For the purpose of this study, noise is defined as unwanted sound and has the potential to affect the health and well-being of humans.

The noise study will quantify potential noise effect during the construction and operation of the Project. The predicted results will be compared to the applicable noise limit to assess compliance. If required, high-level mitigation measures will be provided to reduce the noise effect.

The City of Vancouver Noise Control By-Law No. 6555, November 15, 2016 (Noise By-Law) regulates noise or sound within the City of Vancouver. The Noise By-Law prescribes different noise threshold for the quiet zone, intermediate zone, event zone, and activity zone. Quiet zone means any portion of the City not defined as an activity zone, intermediate zone, or event zone. Nelson Park/Lord Roberts Annex is located in the RM-5B (West End) District and is classified as quiet zone. Based on the City of Vancouver Noise By-Law, in a quiet zone, the continuous daytime noise limit is 55 dBA and nighttime noise limit is 45 dBA. During construction, the noise effect should not exceed 85 dBA for a quiet zone, when measured at the property line, of the parcel of land where the construction is taking place, which is nearest to the point of reception of the sound or noise. The Noise By-Law regulated the construction activities hours as presented in Section 2.3.4.7.

Based on the by-law, the noise study extends 200 m outward from the proposed Nelson Park/Annex Project boundary. This study area will include the "most affected" point of receptions near the proposed Nelson Park/Annex Project.

Nelson Park/Lord Roberts Annex school is in a residential area. The residential housings are mixture of single detached residential houses, town-houses, and multi-storey apartment buildings. The closest point of reception is located less than 10 m from the Nelson Park/Lord Roberts Annex School boundary.

Similar to the Emery Barnes Parks, continuous noise measurement was conducted within the boundary of Nelson Park on January 20, 2017. The measurement was conducted during two daytime periods within the same day. The measurements results provide preliminary information on the existing acoustic environment for the Project during the two daytime periods. A baseline field program with longer monitoring period (including nighttime) is recommended as a future study. The daytime equivalent sound levels (L_{eq}) and percentile sound level (L_{90}) values for the measurement periods were calculated, the results are summarized in Table 3-14.

Table 3-14 Baseline Noise Measurement Results

Location	UTM Locations (m)	Date	Time Period	Time Duration	L_{eq} (dBA)	L_{90} (dBA)
Nelson Park	Easting: 490624 Northing: 5458879 Zone 10	01/20/2017	2:06 PM to 3:09 PM	1 hr 3 min	56.1	52.3
			4:12 PM to 5:14 PM	1 hr 2 min	57.6	53.3

During the daytime period, the existing acoustic environment around Nelson Park is influenced by local activities within the park (e.g., people, dogs), Lord Roberts Annex school (i.e., lunch, recess), natural environment (i.e., wind and birds), and vehicle traffic on the surrounding roads as well as air traffic.

3.3.6.2 Discussion of Impacts

The study methods for impact evaluation, including approach and noise modelling, are similar to the Noise section for Emery Barnes Park (See Section 2.3.4.8).

3.3.6.2.1 Construction Noise Source

The construction of the substation at Lord Roberts Annex and cable system at Nelson Park site is expected to last five years. During construction, various phases of excavation, foundation works, civil work, and equipment installation will take place. Heavy construction equipment such as excavators, jack hammers, and trucks will generate noise. This study focuses on the "worst case" scenario at the Nelson Park site during jack hammering, when operating at closest to the point of reception

The noise emissions of jack hammering activities are summarized in Table 3-15.

Table 3-15 Construction Activities Noise Emission

Activities	Sound Power Level (dBA)	Reference
Jack hammering	120	FTA and Defra

3.3.6.2.2 Operation Noise Source

Noise emission sources during the operation phase are associated with the transformers and ventilation (air intake and outlet) from the substation.

There will be three 200 MVA rated gas insulated transformers inside each substation. The noise rating of the transformer is estimated to be approximately 82 dBA at 1 m.

The conceptual design includes an air intake structure and three exhaust shafts connected to supply or exhaust fans for the substation. The supply or exhaust air fans are noise emission sources. The noise transmits through the ventilation ducting to the ventilation openings (i.e., intake structure or exhaust shaft). The fans for inlet or exhaust are expected to be equipped with silencers. The detail specifications of the ventilation fans (i.e., supply or exhaust air) are not available at the current design phase. The ventilation fans will be mitigated with silencers such that the noise level at "closest" point of reception is below the noise limits prescribed in the Noise By-Law. The mitigated sound power level of each ventilation opening is summarized in Table 3-16.

Table 3-16 Operation Noise Emission

Noise Source	Sound Power Level (dBA)
	Nelson Park
Air Intake Opening	79
Exhaust Opening	78

3.3.6.2.3 Results for Construction

The predicted noise level at most impact receptions during jack hammering near Nelson Park site is summarized in Table 3-17. Figure 3-6 presents the noise contour results for the jack hammering activities (i.e., sound power level of 120 dBA) within the Nelson Park site. The point of reception (i.e., PR1) is shown in the figure.

Table 3-17 Noise Level during Excavating

Project	Activities	Point of Reception	Distance from Closest Noise Source (m)	Predicted L_{eq} (dBA)
Nelson Park	Jack hammering	PR1	3	101.2

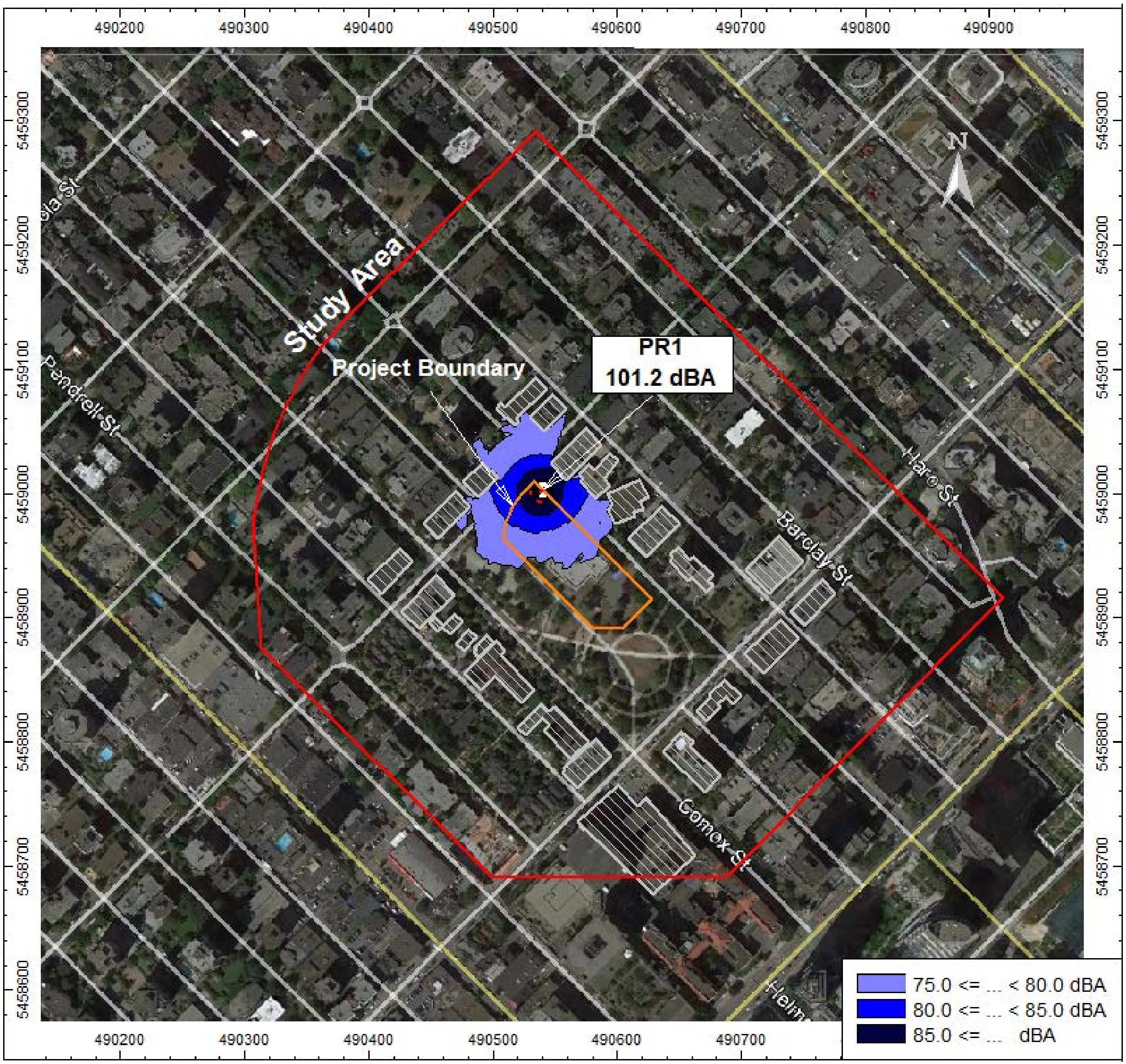


Figure 3-6 Predicted Jack Hammering Noise Contour at Nelson Park/ Lord Roberts Annex School

During jack hammering activities, the predicted noise level at the nearest point of reception PR1 is 101.2 dBA, which exceeds the noise limit of 85 dBA.

The construction noise effect predicted in previous section exceed the noise limit of 85 dBA prescribed in the Noise By-Law for the "worst" case. The noise effect will be restricted to the daytime period. The predicted levels at all points of reception are outdoor noise levels. The indoor noise effect from the Project will be lower due to the sound transmission loss though the walls and window of a building. However, the noise effects are expected to be noticeable for indoor occupants during certain activities (i.e., jack hammering, excavation). The perceptibility of construction noise could result in annoyance. Mitigation measures will be required to reduce the annoyance effects during construction.

3.3.6.2.4 Results for Operation

The dominant noise effect from the proposed Nelson Park/Annex Project during operation will be the intake structure and exhaust shafts with noise emission from the ventilation fans transmitting through the ventilation ducting. The predicted noise levels from the ventilation intake structure and shafts are presented in Table 3-18 at different point of receptions, which are the closet points to the openings based on the Noise By-Law. Figure 3-7 presents the proposed Nelson Park/Annex Project only noise contour results within the study area for Nelson Park site. The points of reception are also shown in the figure.

The results indicate that the predicted sound levels are below the continuous daytime and nighttime quiet zone noise limits of 55 dBA and 45 dBA, respectively for Nelson Park. The noise model assumes that all noise sources are operating continuously during both the daytime and nighttime period; therefore, prediction results are the same for both periods. Locations along the southeast boundary of Nelson Park are the highest predicted noise level locations within the study area.

The proposed Nelson Park/Annex Project operation noise effect is in compliance with the Noise By-Law at all point of receptions.

Table 3-18 Predicted Project Operation Noise Level at Different Point of Receptions

Project	Point of Reception	Distance from Closest Noise Source (m)	Predicted L_{eq} (dBA)
Nelson Park	PR1	14	45.0
	PR2	23	45.0

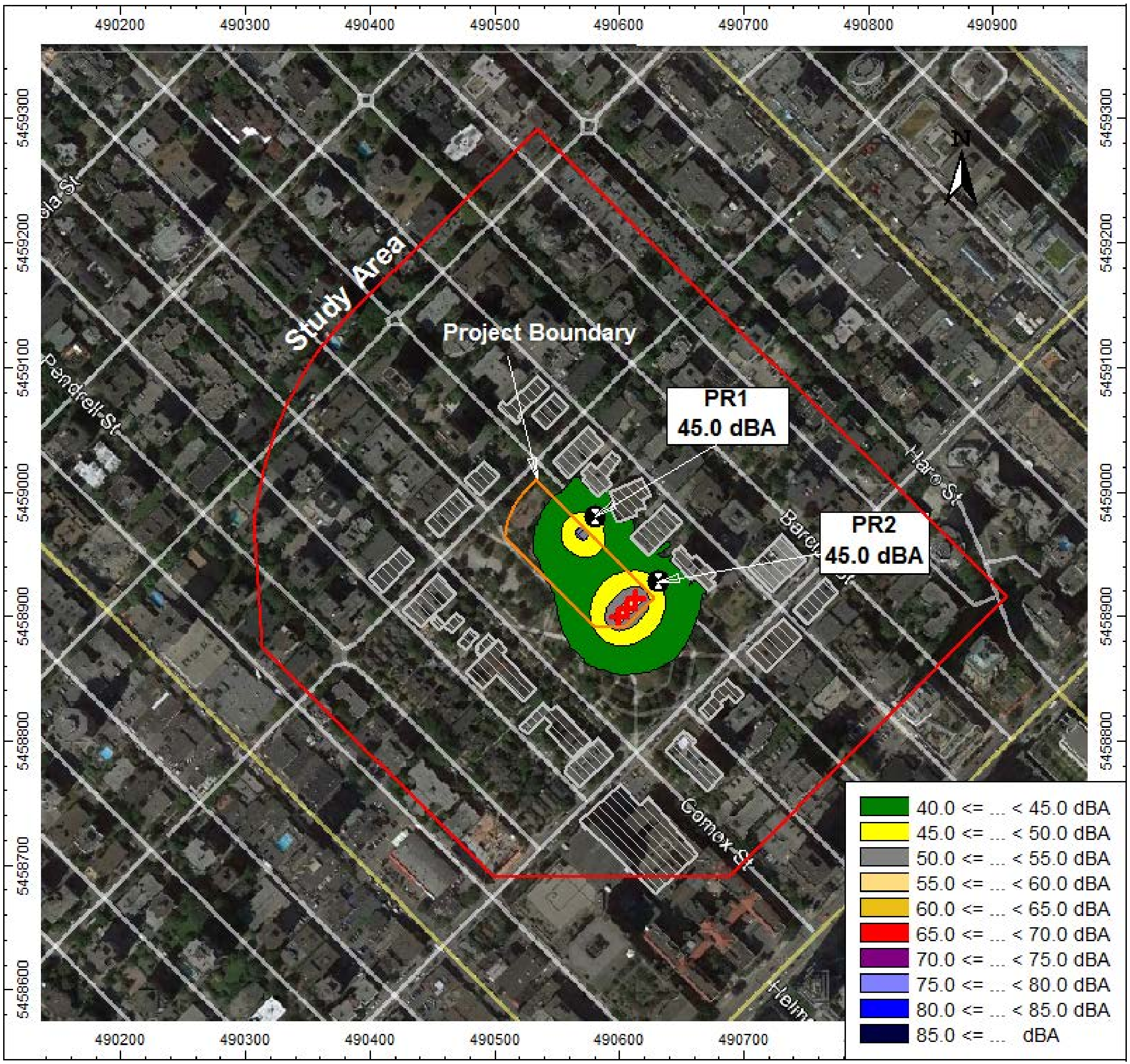


Figure 3-7 Predicted Operation Noise Contour at Nelson Park/Lord Roberts Annex School

3.3.6.3 Mitigation Measures

The following potential mitigation measures referenced by the Australia Department of Environment and Climate Change Construction Guideline New South Wales (NSW 2009) can be considered during the construction phase:

- Teach workers and contractors to use equipment in ways to minimize noise
- Ensure site managers periodically check the site, nearby residences, and other sensitive land uses for noise problems so that solutions can be quickly applied
- Include in tenders, employment contracts, subcontractor agreements, and work method statements, clauses that require minimization of noise and compliance with directions from management to minimize noise
- Avoid the use of radios or stereos outdoors where neighbours can be affected
- Avoid the use of public address systems
- Avoid shouting and minimize talking loudly and slamming vehicle doors
- Keep truck drivers informed of designated vehicle routes, parking locations, acceptable delivery hours or other relevant practices (for example, minimizing the use of engine brakes, and no extended periods of engine idling)
- Develop a one-page summary of approval or consent conditions that relate to relevant work practices, and pin it to a noticeboard so that all site operators can quickly reference noise information
- Workers may, at times, need to discuss or negotiate practices with their managers
- Minimize the need for reversing or movement alarms
- Avoid dropping materials from a height
- Avoid metal-to-metal contact on equipment
- Schedule truck movements to avoid residential streets if possible
- Ensure periods of respite are provided in the case of unavoidable maximum noise level events

Mitigation measures for the Project during the construction phase include the following:

- A 2 m high temporary barrier around the entire site could reduce the noise effect by up to 10 dBA at the point of receptions
- Immediate barrier around the noise emission source
- Quieter equipment for construction activities can be used in combination with noise barrier to further reduce the noise effect

Figure 2-7 presents the mitigated noise contour for jack hammering at Nelson park when a 2 m higher barrier is used in combination with jack hammer of lower noise emission level (i.e., 114 dBA instead of 120 dBA).

Mitigation measures during the Project operation phase include silencers for the ventilation air inlet and exhaust. The silencers will be designed to meet the noise emission requirements specified in Table 3-9.

3.3.6.4 Recommendations for Future Study

There is no baseline information collected during the nighttime period. Also, the ambient sound levels vary from time to time due to the changes in local activities. Therefore, a longer baseline measurement program will provide a complete baseline sound level for comparison to the Project operation noise effect.

Noise modelling for construction activities is recommended when the detailed construction equipment list and estimated equipment operating schedule are available if applicable during subsequent studies.

3.3.7 Vibration

3.3.7.1 Baseline Data and Findings

The scope of work, regulation requirements, study area, and baseline conditions are similar to the Section 2.3.5.1 (“Baseline Data and Findings” for Emery Barnes Park).

3.3.7.2 Discussion of Impacts

The vibration study methods are similar to the Section 2.3.5.2 (“Discussion of Impacts” for Emery Barnes Park).

The heavy construction equipment associated with excavation during construction is expected to generate ground vibration up to 1 mm/s at a distance of 25 m (FTA 1995 and ASCE 2000). The predicted vibration level at the nearest point of reception due to excavation at the Nelson site is 0.5 mm/s.

Drilling typically generates a ground vibration level of up to 0.4 mm/s at a distance of 25 m (FTA 1995). The predicted vibration level at the nearest point of reception (residential building located north of Nelson Park) due to drilling is 1.2 mm/s.

The ground vibration effects from different construction activities (i.e., excavation, drilling) are below 8 mm/s at the nearest point of reception (residential building located north of Nelson Park).

The zone of influence is the area where the peak particle velocity measured at the point of reception is equal to or greater than 5 mm/s at any frequency. The proposed Nelson Park/Annex Project construction activities zones of influence are summarized in Table 3-19. There are no building structures identified within the zone of influence for Nelson Park site.

Table 3-19 Zone of Influence of the Project

Activity	Distance from Source (m)
Excavation	9
Drilling	5

The predicted vibration effect due to excavation and drilling at the closest point of reception is below the recommended level of 8 mm/s. The City of Toronto By-Law focuses on structural damage threshold with no guidance on annoyance threshold for ground vibration.

The typical threshold of human perception of ground vibration is 0.5 mm/s peak particle velocity (Blasters' Handbook 2011); however, the perceptibility threshold varies from person to person. In an urban and suburban environment, a person may be subjected to a wide range of vibration effect, depending on the location, time of the day, proximity to day-to-day vibration sources (e.g., vehicle, train). The vibration effects due to certain construction activities (i.e., drilling, excavation) may be noticeable for indoor occupants. The perceptibility of construction vibration could result in annoyance. Mitigation measures should be considered to reduce the annoyance effects during construction activities.

3.3.7.3 Mitigation Measures

The potential strategies for managing construction vibration were presented in Section 2.3.54 for Emery Barnes Park. These strategies should be applied to Nelson Park site as well.

3.3.7.4 Recommendations for Future Study

Baseline vibration level is recommended at specific vibration-sensitive receptors (i.e., most impacted location or locations with high existing vibration level). The vibration baseline study for the Project may be considered as a subsequent study.

3.3.8 Public Safety—Crime Prevention

3.3.8.1 Baseline Data and Findings

A desktop study was undertaken to determine the potential effects on public safety related to the construction and operation of the proposed cable infrastructure under Nelson Park (the substation would be located under the adjacent School Board lands). The study was based on the design principles and strategies identified by the National Crime Prevention Councils' *Crime Prevention Through Environmental Design Guidebook (2003).* Additional secondary sources were also consulted to reflect provincial and municipal approaches in the use of crime prevention through environmental design principles. These include, BC Housing's *Crime Prevention through Environmental Design (Section 7)* in *BC Housings Design and Construction Standards* (2014), and the City of New Westminster's *Crime Prevention Through Environmental Design, Guidelines for Safe Urban Design* (1999).

Using Project concept plans and Google Earth 2017 imagery the study included consideration of how the placement of the cable infrastructure would affect the current and future safety of the park users.

CPTED is a multi-disciplinary approach to deterring criminal behaviour and nuisance activity through environmental design (BC Housing 2014). Although, there are several different related design principles available, the general theory of CPTED is based on the following design concepts:

- **Territoriality**—a design concept that clearly delineates private space from semi-public and public spaces, and creates a sense of ownership. Ownership thereby creates an environment where appearances of strangers and intruders stand out and are more easily identified.
- **Natural Surveillance**—is based on the "eyes on the street" principle, where surveillance or legitimate intent to observe decreases the potential for criminal behaviour.
- **Access Control**—is aimed at limiting the number of entry points to discourage or deny entry to intruders.
- **Maintenance and Management**—is related to the 'pride of place' and territorial reinforcement. Essentially, the more dilapidated an area, the more likely it is to attract unwanted activities (BC Housing 2014; City of New West Minister 1999; NCPC 2003).

3.3.8.2 Discussion of Impacts

Potential public safety effects that may result from installation of the cable infrastructure under Nelson Park include: impediment of sight-lines, increased demand for lighting, potential increase in concealed, isolated, and entrapment areas, the timeline of construction and diminishment of maintenance and management of the park, greater demand for signage, and loss of positive aesthetic environment.

During operations, the potential impacts to park users will be few to none, based on the current conceptual design plans to bury the cables underground. Overall, the incorporation of CPTED design principles in the park redesign may result in several positive effects, such as: reducing the overall number of concealed, isolated or entrapment areas, increasing the net area of green space, adding new areas to support programming activities, and overall improvement in the use and design of the park.

3.3.8.3 Mitigation Measures

The following mitigations should be implemented during design, construction, and post-construction to improve the use of CPTED principles, which will increase the safety of future park users:

- Design
  - Implement CPTED lighting principles in park redesign, such as:
    - Spreading lighting to reduce contrast between shadows and illuminated areas
    - Outdoor spaces are considered in the type, placement, and intensity of lighting
    - Light colour finishes to be used in underground car parks, around washrooms, and isolated walking routes
  - In park redesign, incorporate principles of CPTED that limit and reduce concealed or isolated areas, such as:
    - Provide opportunities for natural and formal surveillance, such as either by police, park attendants or community organized patrols
    - Reinforce activity generators along an "active edge" or along one or two pedestrian paths
    - Include areas for appropriately licensed street or food vendors to informally generate activity along the edge of paths
    - Avoid entrapment areas such as sites closed from three sides by barriers, narrow deep recessed areas for fire escape, grade-separated driveways, and parking lots
  - Identify areas of land-use mix e.g., areas for vendors, public events such as plazas, or seated areas that will increase land-use mix. Cluster uses to support intended activity (e.g., a picnic area near food vendors).
- Construction
  - Where practical, temporary and permanent walkways should have clear sight lines, especially when they curve or change grade
  - Provide highly visible signage of park closure area(s), expected time-line of closure(s), and temporary pedestrian access points utilizing visual maps, where applicable
  - Conduct a site risk assessment using CPTED principles to identify areas where lighting may be affected during construction and provide temporary lighting fixtures where applicable. As part of the site risk assessment, identify concealed and isolated areas, and plan to reduce or eliminate them in park redesign.
  - To reduce effects of construction on the aesthetic environment of Nelson Park, the following should be undertaken:
    - Park and open spaces areas should be well-maintained
    - Litter and graffiti should be removed and vandalized or burned out bulbs should be replaced immediately after discovery
    - Highly visible signs should be provided and be used to guide reporting of maintenance or vandalism issues
- Post-Construction
  - Provide a follow-up assessment on the incorporation and application of CPTED principles

3.3.8.4 Recommendations for Future Study

The findings noted above were limited to a CPTED qualitative analysis of the cable ducts proposed to be constructed under Nelson Park using concept plans and Google Earth 2017 imagery. It is recommended that a full CPTED site risk assessment be undertaken to provide specific CPTED design elements that can be incorporated into the future redesign of Nelson Park and Lord Roberts Annex.

3.3.9 Public Safety—Accidents and Malfunctions

3.3.9.1 Baseline Data and Findings

A desktop study was undertaken to determine potential effects that could result from accidents or malfunctions that may occur during the construction and operation of the proposed Nelson Park/Annex Project. For Nelson Park, this includes the laying of electric cables within the park and their operation. However, and accident or malfunction of the substation adjacent to the park may also result in adverse effects to park users.

This included a review of EIAs that addressed potential accidents and malfunctions at substations (e.g., BCTC 2010, Manitoba Hydro 2015). Information interviews with the City of Vancouver Fire Department were undertaken to identify potential risks, emergency response measures, and approaches used to respond to electrical-related emergencies. A number of initiatives/mitigations are also identified by the Vancouver Fire Department that BC Hydro could undertake to reduce risks posed from the construction and operation of the substation. Mitigation measures were also identified from a review of applicable EIAs, BC Hydro's internal policies and procedures, and studies that reflect learning outcomes from past events (e.g., *BC Hydro Report: Downtown Vancouver Outage: July 14, 2008 [BC Hydro 2008]*). This information, along with feedback directly from BC Hydro's lead safety engineer, can be used to reduce specific risks posed by a substation accidents or malfunctions.

Potential accidents and malfunctions include: potential hazards to the public; to the substation's construction, maintenance, and operating workforce; and to emergency response personnel. The following potential effects were identified that could result from an accident or malfunction of the proposed substation infrastructure:

- Use of energized equipment and hazardous test energy may result in failed equipment causing electrocution, electrical burns, ventricle fibrillation hazards, and fire.
- Working in a toxic environment or with hazardous substances (e.g., fuel and lubricants, oils, solvents, and greases), may result in spills or human contact causing harmful exposure, burns, or asphyxiation to workforce personnel during construction related activities.
- Public interactions with the Project may result in potential risk of traffic accidents involving vehicles and equipment travelling to and from the construction site(s), and accidents involving local motorists, other commercial operations, pedestrians, and cyclists. Such traffic hazards can result in damage to personal or commercial property, and injury or death to the public or workforce.

- The potential for electrical hazards to residents, communities, or other individuals conducting activities near substations is primarily related to unauthorized entry into restricted areas (for example a substation compound), or other forms of illegal activity involved with tampering or attempts to destroy or dismantle circuit components.
- Natural disasters such as an earthquake, flood, storm, fire, or explosion may result in substation malfunctions and power outages. Such events have potential to affect community and emergency response services, commercial and industrial operators, and residential tenants.
- Human-caused error during operations of the substations may result in component failures, causing fires or explosions.

3.3.9.2 Discussion of Impacts

During construction, most risks to the public and workforce will be related to the movement of materials and people at the construction sites. These risks will be reduced through applicable signage, fencing, and adherence to local, municipal and provincial traffic and safety bylaws, policies, and plans.

The subsurface design of the cable infrastructure may reduce some risks while increasing others. Potential risks that may result from human error, use/operation of energized equipment, working with hazardous materials, maintenance of infrastructure, or from natural disasters may be reduced because the overall physical impact of effects (e.g., fire, release of hazardous materials, or explosions) will be confined and retained underground. However, because the cables are located underground the ability to manage effects from a potential accident or malfunction may be more challenging. For instance, the ability to access the cables will be limited, and the cables will be located in confined spaces. These aspects may result in more smoke from reduced airflow/ventilation in the event of a fire (Foster A., City of Vancouver Assistant Fire Chief. *Personal communications*. January 26, 2017). These effects increase the risks for emergency response providers in responding to a potential operational outage or cable malfunctions. BC Hydro can undertake several initiatives to manage and reduce these risks, such as using a worst-case scenario approach when designing the cable infrastructure working with the City of Vancouver in developing a specific emergency response plan, training, and applying the Best Available Technology Economically Achievable (BATEA) in the design of the cable infrastructure (e.g., application of fire retardants, advanced ventilations systems and shut-offs) (Foster, pers. comm. January 26, 2017).

3.3.9.3 Mitigation Measures

Several mitigations have been identified that may manage and reduce potential effects from accidents or malfunctions during the design, construction, and post-construction phases. Most mitigations identified are based on a) avoiding risks through effective design, b) managing potential risk through engineering controls and emergency response procedures, and c) protecting the health and safety of the public and workforce. These measures include:

- Design
  - Apply engineering controls designed to reduce the potential for release of hazardous materials such as secondary containment systems and the use of oil detection sensors
  - Use a worst-case scenario approach when designing substations—consider who could be impacted and how underground incidents related to electrical hazards are heightened (e.g., more smoke, confided spaces, limited access, limited ventilation = increased risks to emergency response personnel)
  - Design substation and associated infrastructure to reduce the potential for the release of spills or hazardous material by using:
    - Spill response and containment systems
    - Fast-acting protection and control equipment
    - Fire walls and barriers
    - Explosion and blast protection barriers
    - Security surveillance systems
    - Vents and exhaust assessment systems (e.g., detention for location of exhaust, nature of exhaust, etc.)
  - Encased cables to ensure no negative impacts on tree roots. In the event of an accident or malfunction, implement policies and plans that reduce potential for the release of spill of hazardous material including, but not limited to:
    - Fire safety and response plan
    - Hazmat safety and response plan
    - Emergency response plan (include initial entry to investigate and assess by first responders and BCH workers, and re-entry for clean-up/switching, etc.) which can vary depending on the event
    - Spill response plan
  - Develop an emergency response plan with the City of Vancouver's Fire Department. The plan will include policies and ensure applicable training (where appropriate) is provided to the City of Vancouver's Fire Department to support fire suppression, inspection, communication, and liaison activities (Foster, pers. comm. January 26, 2017 and BC Hydro 2008).
  - BC Hydro will use GIS for the substation. GIS uses SF_6 as an insulating medium for high and medium voltage switchgear systems. Unlike conventional oil insulated switchgears, GIS does not pose a fire risk, so the overall risk of substation fire will be reduced.
- Construction
  - During construction, maintenance, and repair activities, use fences, signs, and surveillance systems or other measures will be used to prevent public access
  - Prepare and maintain a local inventory of all hazardous materials handled, stored, or used at the substation sites (see BC Hydro's Stationary Form #80420 –Toxic/Hazardous Product Inventory form)

- During construction adhere to all applicable municipal, provincial, and federal regulatory requirements relating to traffic management including, but not limited to:
  - Street and Traffic By-Law No. 2849 (City of Vancouver 2016)
  - WorkSafeBC OHS Regulation, Traffic Control (WorkSafeBC 2009)
  - Ministry of Transportation and Highways Engineering Branch, 1999—Traffic Control Manual for Work on Roadways (BC Ministry of Transportation and Highways 1999)
- Adhere to a project-specific Traffic Management Plan
- Ensure all work undertaken during construction and operating activities comply with BC Hydro's Occupation Health and Safety Standards Guidelines (BC Hydro 2016)

- Post-Construction
  - In the event of an accident or malfunction BC Hydro will activate its CEC until power was restored to all customers and all damaged circuits were repaired (BC Hydro 2008)
  - In accordance with BC Hydro's Incident Action Plan, the following priorities would be established in the event of an accident of malfunction:
    - Ensure public and employee safety
    - Identify impacted critical infrastructure, customer key accounts, and feeder prioritization for a Restoration Plan
    - Facilitate effective and timely communication
    - Establish the impacts based on the damage assessment and receive situation updates from site (BC Hydro 2008)
  - In the event of an outage, BC Hydro will implement its priority sequence restoration of services in sequence of the following:
    1. Generation and transmission facilities to supply distribution customers
    2. Communications facilities for civil authorities
    3. Hospitals
    4. Critical customers which include police stations, fire stations, ambulance stations, municipal emergency centres
    5. Facilities as directed by Municipal, Provincial, and Federal authorities
    6. Utility facilities which include gas, sewer, water, telephone, and cellular
    7. Emergency reception centres (schools, civil centres)
    8. General commercial, industrial, and residential customers (BC Hydro 2008).

  - In the event of an outage, BC Hydro will coordinate with the City of Vancouver's Fire Department and Emergency Management Department who will lead the initial response of an electrical or fire related emergency, which includes:
    1. Establish command (i.e., determine who is in charge)
    2. Undertake hazard identification and risk assessment (HIRA) or "size up"
    3. Isolate incident
    4. Test for toxins
    5. Apply 2 in 2 out rule
    6. Ensure full personal protective equipment is used
    7. Apply touch approach to external/unobserved risks
    8. Wait for confirmation from BC Hydro that power has been shut off(Foster A., City of Vancouver Assistant Fire Chief, pers. comm. January 26, 2017)

3.3.9.4 Recommendations for Future Study

The preceding identification of risks and mitigation measures is based on a preliminary review of the proposed Nelson Park/Annex Project. A project-specific assessment of potential accidents and malfunctions should be undertaken once more detailed design and engineering information on the Project has been developed. Additionally, given the number of agencies that are involved in maintaining public safety (e.g., BC Hydro, VPB, VSB, City of Vancouver Emergency Management Department and Fire Department, and Emergency Management BC) it is recommended that additional research and consultation be undertaken to develop an up-to-date integrated emergency response plan specific to responding to potential substation accidents and malfunctions in Vancouver.

3.3.10 Storm Water Management

3.3.10.1 Baseline Data and Findings

A desktop study was undertaken to determine potential effects that could result from the construction and operation of the proposed Nelson Park/Annex Project. This included a review of impacts of the addition of various services to the substation. Information was obtained from the VPB website and the City of Vancouver's VanMap for existing service locations and pipe sizes.

3.3.10.2 Discussion of Impacts

Nelson Park's existing utilities include an underground 200 mm dia. storm main that traverses the centre of the park in the southwest direction, parallel to Nelson Street. Offsite services include: a 200 mm dia. water main along Nelson Street; a 200 mm dia. water main, 200 mm dia. storm main, and a 300 sanitary main along Bute Street; and, a 300 mm dia. water main along Comox Street.

For a plan of the site and storm water management section details see figures in Appendix A.9.

Similar to the Emery Barnes Park site, the goal in terms of storm water management at the proposed Nelson Park site is primarily to limit the post-development runoff flow such that it will not exceed the pre-development runoff flow entering the existing system. The existing park surface is mostly grass surfacing, however, in the area where the substation is proposed under the current school site there is a large portion of impervious surfaces such as walkways and vehicle parking areas. Since the current park layout and proportions are conceptual, it is assumed that the proportion of post-development impervious surface would be the equivalent to the current park site. Detailed calculations will be undertaken in the next phase of the Project.

It is anticipated that seepage will be encountered from the walls of the excavation; therefore, weep holes and/or horizontal drains about 3 m long should be installed to dewater and depressurize the face. The majority of excavation dewatering will likely be limited to perimeter ditches connected to collection sumps. The collected water should be retained in the sumps for a sufficient length of time to allow precipitation of sediment before the water is pumped to the city storm sewer system.

3.3.10.3 Mitigation Measures

The following mitigation measures are recommended to limit effects of construction on the storm water management and site services on the site. These are conceptual only, and will be finalized prior to construction, and in consultation with the VPB.

- To achieve the flows with the minimal increase in the discharge, a network of subsurface drainage system is proposed. The system should consist of 150 mm dia. perforated or slotted rigid wall pipe above the substation vault. The drainage pipe should be surrounded by a minimum of 150 mm of 19 mm drain rock or 19 mm clear crushed gravel encased in a permeable geotextile fabric. The invert elevation of the drain pipe should be at least 150 mm below any structure or base. The pipes of the system would be configured such that lengths of pipe are spaced 3 m to 4 m apart, placed longitudinally, parallel to the length of the substation. The slope of the pipes may be -0.3% or even flat. The system will discharge into a rock pit where the infiltrated surface flow will permeate in the surrounding area. Further investigation of the soil infiltration rates will be required to determine the required volume of the rock pits. In extreme rainfall situations, excess flow will discharge to the existing drainage system.
- At the Nelson Park site, excavation of surficial soil, including till, should be possible using conventional equipment. There is a risk that bedrock may be close to the surface which would require the use of hydraulic breakers or explosives to excavate. Support of the excavation sides should be possible using conventional shotcrete and tie-back anchors; however, depending on the performance of the native sand with the till deposit, hollow anchor bars may be needed.

3.3.10.4 Recommendations for Future Study

Further investigation of the soil infiltration rates will be required to determine the required volume of the rock pits.

3.3.11 Subsurface Hydrology and Ground Conditions

3.3.11.1 Baseline Data and Findings

Stantec understands it is proposed to construct electrical conduits into the substation with trenches up to approximately 2 m depth below ground level.

The Geological Survey of Canada map for Vancouver (Map 1486A) indicates that at the Nelson Park site bedrock is within 10 m or less of the surface. Glaciated till soils are likely to overlay the bedrock and comprise clay, silt and sand with gravel and cobbles. The occasional boulder may be encountered in the Glacial deposits. Topsoil and fill material are likely to overlie the till soils in the upper 1 to 2 m. The bedrock is likely to comprise interbedded Sandstone and Shale initially soft becoming harder with depth. Cementitious hard rock (typically referred to as "Floaters") is commonly encountered within sandstone bedrock and are typically elongated shapes less than 1 m thick.

Perched groundwater is expected to be encountered at variable depths depending on the season and weather conditions during the construction period. Local projects encountered groundwater during investigations at up to 18 m below ground level; however, groundwater can be expected at shallow depths during wet weather periods. Water levels measured during investigations are not considered to be a true representation of the regional groundwater table, but rather perched water flowing within the glaciated sand interlayers within the glacial till deposit.

3.3.11.2 Discussion of Impacts

It is expected that the conduit excavations will be within topsoil, fill materials, or till soils comprising clay, silt and sand with gravel and cobbles. Potential impacts for shallow excavations up to 2 m depth include:

- Perched groundwater and/or surficial water runoff may enter the excavations requiring removal using standard sumps and pumps
- Groundwater seepage may cause instability to temporary excavation sides
- Temporary shoring may be required should construction workers require entry to excavations over 1.2 m depth
- Excavation of soil and rock may disturb existing subsurface hydrology which can impact some trees and other vegetation

3.3.11.3 Mitigation Measures

Minimal mitigation measures are considered necessary for the temporary excavations required for the electrical conduits. Typical temporary construction techniques should consider:

- All excavations should be carried out in accordance with Part 20 of the current WorkSafeBC regulations (WorkSafeBC 2013) and be safe for worker entry.
- For temporary excavations over 1.2 m depth, sloping and/or shoring is required.
- Excavation side slopes should be protected from exposure to precipitation and associated ground surface run-off and should be regularly inspected by a professional geotechnical engineer for signs of instability.

3.3.11.4 Recommendations for Future Study

Stantec recommends that a comprehensive Geotechnical investigation be conducted to determine the subsoil and bedrock conditions and to characterize the soil and rock materials. The investigation should include the installation of piezometer groundwater monitoring wells installed in the soils and the bedrock materials to measure groundwater levels in the various soil and rock layers. Groundwater monitoring should be undertaken regularly for at least a full calendar year to fully understand the potential groundwater level fluctuations during the seasons. The Geotechnical and groundwater investigations should include the preparation of a factual report available to Engineers during subsequent design and engineering stages.

3.3.12 Birds and Other Wildlife

3.3.12.1 Baseline Data and Findings

3.3.12.1.1 Desktop Review

Over 600 resident, migratory, and overwintering birds and other wildlife occur regularly in Metro Vancouver (City of Vancouver 2014c, 2017f). Nelson Park supports a variety of urban birds and mammals that are tolerant of highly manicured landscaping and human disturbance (e.g., vehicle and pedestrian traffic). A review of wildlife information sources (e.g., BC CDC, eBird, City of Vancouver, Species at Risk Public Registry, published literature) was undertaken to understand existing conditions of birds and other wildlife, and their habitats within the park, and to characterize potential effects of the Project on birds and other wildlife. The review included identifying occurrence records of birds and other wildlife, including provincial (i.e., Red or Blue-listed) or federal (i.e., Threatened, Endangered, or Special Concern) species at risk.

As with Emery Barnes Park, Nelson Park is generally manicured landscaping comprised of lawn areas interspersed with a combination of native and ornamental trees. Similar to Emery Barnes Park, native birds and other wildlife are commonly observed in Vancouver parks, including glaucous-winged gull, northwestern crow, American robin, song sparrow, black-capped chickadee, raccoon, and striped skunk (City of Vancouver 2014c, 2017f, Cornell Lab of Ornithology 2017). Nelson Park also supports invasive or exotic birds and mammals, including eastern grey squirrel, rat, rock pigeon, European starling, and house sparrow (City of Vancouver 2014d, 2017f). Feral or free-ranging domestic cats can also interact with native birds and other wildlife in park settings.

Species at risk have not been recorded in the park and are not expected to use the park for breeding, foraging, or roosting primarily due to lack of habitat and high level of disturbance. However, Nelson Park is adjacent to the English Bay and Burrard Inlet Important Bird Area, which is recognized in part for its importance to the breeding population of the *fannini* subspecies of great blue heron (IBA BC020, IBA 2017). The great blue heron *fannini* subspecies is Blue-listed in BC and designated as Special Concern on Schedule 1 of the *Species at Risk Act* (SARA). Nelson Park and the Lord Roberts Annex are approximately 1.5 kilometres (km) from an existing great blue heron rookery (breeding colony) located at the southeast end of Stanley Park. The rookery supports up to 128 nests, although the numbers fluctuate between years (SPES 2016). Stanley Park supports approximately 6% of the total population of the *fannini* subspecies in BC (SPES 2006).

3.3.12.1.2 Field Survey

Field surveys were completed at Nelson Park and Lord Roberts Annex on January 18 and 27, 2017, to record observations and assess value for birds and other wildlife in conjunction with surveys for urban forestry. The survey team included two qualified biologists. The survey team documented observations of birds and other wildlife (e.g., visual detections) and evidence of use (e.g., nests, tree cavities), the availability and condition of habitat for birds and other wildlife, and presence of wildlife habitat features (e.g., raptor stick nests) that may require mitigation.

The field surveys also provided site-specific information to support the characterization of habitat availability for birds and other wildlife that potentially occur in Nelson Park. The park supports 127 urban trees, 98 of which had a measured DBH ≥ 20 cm. Most park trees were either little-leaf linden (*Tilia cordata*), cherry (*Prunus* sp.), or English hawthorne (*Crataegus oxyacantha*). A detailed summary of trees located in Nelson Park is found in Appendix D.

Trees in the park support nesting, foraging, and daytime roosting opportunities for urban birds and other wildlife. One mammal and eight bird species were detected during the field survey (see Table 3-20). One eastern grey squirrel nest and two northwestern crow nests were detected in Nelson Park. The squirrel nest was in a black pine (*Pinus nigra,* Tree 2; Figure 1 of Appendix D) The crow nests were located in a cherry tree (Tree 12; Figure 1 of Appendix D) and a beech tree (*Fagus* sp., Tree 63; Figure 1 of Appendix D). Several cavities were identified in a topped maple tree (*Acer* sp., Tree 45; Figure 1 of Appendix D) in Nelson Park; this tree could be a potential habitat feature.

Table 3-20 Birds and other Wildlife Species Detected at Nelson Park and Lord Roberts Annex during the January 18, 2017 Field Survey

Common Name	Scientific Name	Detection Type
Mammals		
Eastern grey squirrel [1]	*Sciurus carolinensis*	Nest
Birds		
Anna's hummingbird	*Calypte anna*	Visual
Black-capped chickadee	*Poecile atricapillus*	Visual
Dark-eyed junco	*Junco hyemalis*	Visual
Downy woodpecker	*Picoides pubescens*	Visual
European starling [1]	*Sturnus vulgaris*	Visual
Northwestern crow	*Corvus caurinus*	Visual (16), Nest (2)
Rock pigeon [1]	*Columba livia*	Visual (30)
Sparrow species	–	Visual
NOTE: [1] Species listed as Exotic by the BC CDC (2017)		

3.3.12.2 Discussion of Impacts

3.3.12.2.1 Vegetation Clearing, Noise, and Vibrations at Nelson Park

As part of the *Greenest City Action Plan*, the City of Vancouver developed the *Vancouver Bird Strategy* to improve methods for incorporating nature into the urban environment. The strategy outlines five action areas to support improving or maintaining healthy urban environments for birds (City of Vancouver 2014b). Permanent removal or alteration of trees and understory vegetation in Nelson Park will reduce nesting, foraging, and daytime roosting opportunities for migratory, resident, and overwintering birds as well as other urban wildlife (e.g., racoons, skunks). Tree removal and reduction in canopy cover will further reduce habitat connectivity for some species. Based on the current proposed Project design, construction of the underground substation (and supporting infrastructure) at this location will result in the removal of five trees. Efforts to reduce or compensate for loss of urban habitats that support birds and other wildlife are outlined in Section 3.3.12.3: Mitigation Measures (below) and are developed in accordance with objectives and actions outlined in the City of Vancouver's *Urban Forest Strategy*, *Vancouver Bird Strategy*, and *Bird Friendly Design Guidelines* reports (City of Vancouver 2014a, 2014c, 2014d).

As described for Emery Barnes Park, the MBCA and the BC *Wildlife Act* manage migratory and resident breeding bird populations by prohibiting the destruction of individuals, eggs, and occupied nests. If construction activities at Nelson Park are scheduled to coincide with the nesting window for migratory birds, there may be increased potential for incidental take (i.e., mortality or destruction) of breeding individuals and nests located in sections of the park that are subject to vegetation clearing. Non-native (i.e., invasive or exotic species) are not protected under the MBCA or the BC *Wildlife Act*.

Sensory disturbance due to noise and vibrations, caused by vegetation clearing and grubbing, excavation, construction, and start-up and testing can result in avoidance behaviour for birds and other wildlife at Nelson Park. Some forest songbirds show avoidance of habitats subjected to noise disturbances (Bayne et al. 2008, McClure et al. 2013), while other species (e.g., crows, gulls) are likely habituated or more tolerant of regular human disturbance during periods of foraging or roosting (Verbeek and Butler 1999). Studies suggest some great blue herons may respond to noise disturbances or natural predators by abandoning their nests, which results in indirect mortality of young due to starvation or exposure to weather (i.e., rain or cold), while others are more tolerant of anthropogenic environments (Vennesland and Butler 2004, Environment Canada 2016). The use of rookeries located in disturbed, fragmented habitat (e.g., Stanley Park rookery) can be dynamic (Environment Canada 2016). Although the size of the heronry at the Stanley Park varies between years, herons are expected to be habituated to routine urban disturbances (e.g., vehicle traffic) (SPES 2006, 2016, Environment Canada 2016). This rookery is approximately 1.5 km from Nelson Park; therefore, Project activities at Nelson Park are not expected to result in disturbance to the rookery.

Poor waste management can also lead to human-wildlife conflict (e.g., garbage serving as an attractant for crows, racoons, skunks). Contemporary practices can be effective in reducing conflicts resulting in animal removal or the destruction of nuisance animals (BC MOE 2016).

Adherence to applicable legislation and regulations, and implementation of mitigation measures (see below) are expected to reduce residual effects of these activities on birds and other wildlife.

3.3.12.2.2 Electromagnetic Fields at Nelson Park

As with potential effects of EMFs on birds and other wildlife at Emery Barnes Park, low level EMF exposure is not expected to affect fertility, navigation, immune system health, or foraging behaviour (Dell'Omo et al. 2009; BC Hydro 2017b,c; EMFS 2017a).

To assess baseline EMF levels at Nelson Park and Lord Roberts Annex, BC Hydro measured magnetic field levels at several locations within the park during non-peak hours on January 21, 2017. The highest magnetic field level was measured at 11.2 mG above the 12 kV distribution line along Bute Street, and 25.7 mG influenced by a mount transformer (see Appendix E). Operational EMF levels for Nelson Park were predicted based on measurements in and above the existing underground substation at Cathedral Square. The highest magnetic field level of 100 mG occurred where three 230 kV transmission cables enter Cathedral Park between Homer and Richards Street. Similar EMF levels at Nelson Park are expected above the three 230 kV transmission cables; two of which will enter the park near Comox and Thurlow Streets, and one from Nelson Street.

A full discussion of the potential effects of EMFs to birds and other wildlife is provided in Electromagnetic Fields at Emery Barnes Park. Similar to results from Emery Barnes Park, current and predicted EMF exposure levels at Nelson Park are well below the 2,000 mG ICNIRP guideline. A recent review of the literature (2012-2016) indicates there is no new evidence that changes the conclusion of both Health Canada and World Health Organization that there are no confirmed health consequences associated with exposure to low level electromagnetic fields (Exponent, 2017). Accordingly, EMF-related effects to birds and other wildlife at this location are expected to be low.

Operational effects of the Nelson Park Project on birds and other wildlife are negligible, and replanting trees will replace habitat lost for birds and other wildlife.

Additional studies related to EMF can be found in appendix E and G of this report.

3.3.12.3 Mitigation Measures

The following mitigation measures are recommended to reduce effects of construction and operation of the proposed Nelson Park/Annex Project on birds and other wildlife. These measures are conceptual only, and will be finalized prior to construction in consultation with the VPB.

- Construction
  - The proposed Nelson Park/Annex Project will consider design strategies to further reduce the magnetic fields from underground transmission cables, to the extent feasible (e.g., depth of cable placement, mu-metal shielding, optimize conductor spacing and phasing). These strategies will further lower EMF levels further below the ICNIRP guideline value of 2,000 mG.
  - In accordance with Environment Canada's policy on Avoidance of Detrimental Effects to Migratory Birds and the BC Wildlife Act, pre-construction vegetation clearing activities will occur outside of the breeding season for migratory birds (March 28 through August 8) and raptors (February 5 through August 31) to avoid incidental take of birds (BC MOE 2013, ECCC 2017).
  - If clearing or disturbance to bird nesting habitats is required during the migratory bird breeding season, surveys will be conducted by a qualified biologist in advance of clearing, and nest-specific mitigation measures will be implemented by the qualified biologist to minimize the potential for incidental take, in compliance with the Migratory Birds Regulations of the MBCA and the BC Wildlife Act. No-disturbance setbacks will be established around active nests and clearly marked to show the extent of clearing (BC MOE 2013, 2014, ECCC 2017). Vegetation clearing and construction activities will be prohibited within no-disturbance setbacks for the period of time the nests remain active, as determined by the qualified biologist.
  - Waste management practices will be managed or mitigated through guidelines and best practices to eliminate or reduce potential wildlife attractants to negligible levels. Waste will be temporarily stored onsite in wildlife-proof containers and disposed of regularly at an approved facility (BC MOE 2016).
- Post-Construction
  - Tree protection or replacement measures, outlined for Vegetation (see Vegetation Mitigation Measures and Appendix D) will limit effects of habitat loss to birds and other wildlife.
  - Consistent with the City of Vancouver's *Bird Friendly Design Guidelines* (2014c), tree replacement and landscaping will consider, to the extent feasible:
  - Establishing native mature trees and fruit-bearing shrubs
  - Consider continuous forest canopy and the location and spacing of tree planting
  - Increase vertical vegetation structure and complexity by incorporating coniferous and deciduous trees, shrubs, and grasses into landscape features
  - Incorporate a diversity of native trees, shrubs, and plants into landscape design (including seed, fruit, and nectar bearing species)
  - Retain and/or incorporate wildlife trees, snags, and downed wood to support cavity nesting and foraging.

3.3.12.4 Recommendations for Future Study

Given the timelines between when this study was completed and when construction is scheduled to occur, it is recommended that a pre-construction survey be completed by a qualified biologist to re-assess the presence of wildlife habitat features of concern (e.g., raptor nests, wildlife trees) within the park limits.

4.0 PROPOSED LORD ROBERTS ANNEX REPLACEMENT PROJECT

4.1 SCHOOL HISTORY

Opened in 1972, the Kindergarten to Grade 3 Lord Roberts Annex (the Annex) was an extension of an existing West End school named for Frederick Sleight Roberts (1832-1914), a British Field Marshall. Demographically, the West End has a growing proportion of children, with an average of 8.8 per ha compared to the Vancouver average of 6.4 (West End Community Plan – 2011). The Annex is connected to Nelson Park, a well-used greenspace for the highly-densified neighbourhood.

The Annex has a Facility Condition Index (FCI) of 0.75. A rating of 0.60 or above does not meet requirements and needs immediate attention to most of its building systems. Most of the building systems will be at the end of their life cycle and the risk for system failure is high.

The FCI is a comparative index that ranks the condition of schools against others. The FCI audit includes structural, architectural, mechanical, electrical, plumbing, fire protection, equipment, furnishings, and life safety. The FCI index is a decimal percentage of the cost to remediate deficiencies divided by the current replacement value. For Lord Roberts Annex, it will cost 75% of a new replacement school to upgrade building systems. Generally, if the FCI is close to or above 0.6, a replacement school is considered rather than a renewal.

4.2 PROPOSED SCHOOL PROJECT SUMMARY

BC Hydro requires new infrastructure facilities in the downtown area of Vancouver to meet current and future demand. The Vancouver School Board (VSB) requires a significantly larger capacity full K to 7 school to replace its current K to 3 Lord Roberts Annex school which is too small to serve current and future school population in the West End. There is a need for additional childcare in the West End as well as additional all-weather play field space.

The Lord Roberts Annex site is located at the corner of Bute Street and Nelson Street; the property runs approximately 50 m along Bute and 128 m along Nelson. BC Hydro is proposing to locate a new underground substation on the east side of the property with the new school located beside the substation to the west, adjacent to Bute Street. The underground substation will be a concrete structure, with the roof approximately 3 metres below grade, and the bottom extending 30 meters down. A new ¾ sized artificial turf field would be located on top of the substation.

The existing single storey Lord Roberts Annex School that currently serves approximately 140 kindergarten to grade three children is proposed to be replaced with a -510 capacity modern 21st Century multi-storey school that will cater to kindergarten to grade seven with underground parking facilities. The exterior play areas will be located to south and east of the school with a new artificial turf play field located on top of the roof of the substation to the east.

The new state of the art school is proposed to be net-zero energy use, Passivhaus and/or LEED Gold Certified and would include many more classrooms than currently available at the Annex. It would include a larger gymnasium, library, and multipurpose room that could provide up to 45 spaces for before-and-after school childcare. A City of Vancouver (COV) 0 to 4 childcare is also proposed to be located on the top floor of the new school. The model of combined school and childcare would be a partnership agreement between the Vancouver School Board (VSB) and COV to provide much needed non-profit childcare spaces to the West End. This model is currently being implemented at three other replacement schools: Nelson Elementary school which is currently in construction and, Fleming Elementary school and Tennyson Elementary school which are currently in design.

4.2.1 General Considerations

The proposed replacement of Lord Robert Annex school with a new school, childcare, and artificial turf field includes the following considerations that are being further developed through consultation with the VSB, VPB, and COV.

- The present school building is near the end of its serviceable life with respect to engineering systems and seismic performance.
- The present building is too small to meet current and future needs of the West End.
- The optimized layout of the proposed substation assets relative to the school requires that the school be re-located to the north-west end of the VSB property. This layout would maximize separation of the substation assets from the new school facilities from an operational and EMF perspective. It would also minimize the amount of outdoor space in shade caused by the school.
- The building footprint available to build the new school would be reduced along with more floor area required for the increased capacity would require the new facility to multi-story
- The Project will trigger the need for the existing Lord Roberts annex community to be relocated off site during construction of their new school. It is proposed that that they be housed in the new Coal Harbour school until their school is completed construction. The new Coal Harbour facility, located at the foot of Broughton Street attached to the Coal Harbour Community Center, would consist of a new school, childcare, and non-market housing. Both of these projects are on the high priority on the VSB capital plan, COV childcare and affordable housing strategy for the Downtown /West End.

4.2.1.1 Vancouver School Board Basic Objectives to be Maintained

- The VSB endeavors to keep a re-located school community together whenever possible, and within/nearby neighborhood catchments whenever possible during the construction of a replacement school. The Coal Harbour school (with a capacity of 320 students) would have to be delivered ahead of current VSB capital plan target dates in order to provide temporary accommodations during construction for Lord Roberts Annex school community (140 students). Once Coal Harbour school is no longer required as a temporary accommodation site, the facility will become a new school to service the downtown core.

- Safety of students and the public is a primary concern for all stakeholders including BC Hydro, the VSB, the COV and VPB. It is for this reason that the concept of trying to rebuild the Annex school ahead of the proposed substation and having the kids adjacent to the construction of both their new school (about 3 years of construction) and then adjacent to the construction of the substation (another 5 years of construction) was quickly discounted as practical.
- The proposed replacement for Lord Roberts School Annex is targeting a 510 capacity including Kindergarten, plus a COV 0-4 year old childcare on the roof which begins to address the need of community to provide more of these types of spaces in their community

4.2.1.2 Site Optimization Strategies to be Developed Through Further Collaboration

- School and associated playground equipment is not physically placed on top of the BC Hydro substation assets.
- To provide a three-quarter artificial turf field to service both the school educational program and community use.
- Connection of the playfield and exterior play areas with school public spaces including the gym and multipurpose space to make them more serviceable to the school and community during and after school hours
- To maximize green/open space, all vehicle parking will be placed in a garage below grade.
- Access to both the school underground school parkade and the substation is consolidated to a shared ramp to maximize public open space.
- Wherever possible, the design should consider maximizing the replacement of trees lost to construction, community gardens etc.

To rethink typical BC Hydro venting (both fresh air intake and exhaust venting) and access to the substation so that the substation has little visual impact at grade, and to maximize open space for optimum use such as a three-quarter artificial turf field.

4.2.1.3 School Configuration Considerations to be Developed Through Further Collaboration

- Consideration for common areas such as the gymnasium and multi-purpose rooms placed adjacent to the artificial turf field.
- The new facility supports 21st century learning include spaces such as learning commons in proximity to classrooms, provision for project based learning, and tech integration in classrooms.
- The use of different size floor plates to allow for green spaces/outdoor learning spaces on different floor level adjacent to classrooms providing direct external access.
- Maximizing roof overhangs for covered play spaces
- To be sensitive to the surrounding neighbours with respect to sun and view corridors
- That the school design integrates with the park design to maximize opportunities for accessible washrooms for the park etc.

4.2.2 Discussion of Impacts

Further exploration, building design and coordination with the technical requirements for the facility will provide more detail with respect to the school. Project exploration to date suggests the following impacts:

- **Adjacencies:** The school will be adjacent to the substation. BC hydro will only allow soft landscaping and fields to be placed on top of the roof of the substation. They also require vertical access to the substation to move both people and equipment into the substation impacting the amount of open space available.
- **Height:** To meet the increased capacity/floor area, the school is anticipated to be up to five stories in height to accommodate a three to four storey full size elementary school and a proposed roof top COV non-profit operated childcare complete with associated outdoor spaces.
- **Play areas:** The location and size of play areas will evolve with future building design in consultation with the school community, VPB, and COV. Playground equipment presently on site is slated to be replaced in 2017. This will likely proceed as planned, and the new equipment will be incorporated into the new building and site design.
- **Urban design considerations:** The new school building will be within the existing site boundaries, in a shifted location, to the north- west. The design will have to look at sun and view corridors. It will also have to conform to all urban design guidelines for the area
- **Field considerations:** The current design process seeks to resolve the relationships between the field and technically required substation vents and entrance structure, in order to achieve a three-quarter size regulation soccer playing field and to maximize open areas.
- **Future Development**: In light that the BC Hydro limits the type of uses on the roof of their substation to only soft landscaping, it will limit the VSB in constructing any future additions to the school to meet further demand in the area. Moreover, with BC Hydro leasing the land for 99 years as minimum, it will limit the VSB in the future from redevelopment of this site and restricting any future partnerships the Board might consider.

4.2.3 Recommendations for Further Study

Working with the VSC, COV and VPB, future study of the school site will work towards meeting the following objectives:

- **Play areas:** A variety of play areas that can be considered on the site both on grade and on different floors levels of the school.
- **Energy conservation:** Heat recovery from the proposed substation to the school to be explored. Building design to target 21st century COV objectives for sustainable buildings.
- **Venting:** Minimize the spatial and visual impact of the intake and exhaust venting by incorporating them into building elements and urban elements such as garden walls and berms. Ensure that elements present no safety issues for students and the public including no concealed spaces, obscured views, or the potential for accumulation of needles and associated debris.
- **Field:** Coordinate technical requirements for substation venting and substation entrance/exit to obtain the largest field possible by keeping all substation technical elements to the perimeter.

- **Student / Car drop-off:** A Traffic Management Plan will assist in the design of a pick-up and drop off area at street level, or perhaps in the school's underground parkade. It should also consider active transportation objectives and goals.
- **Garage:** Explore options for day-lighting the garage and maximizing the first floor height such that it may partially serve as a drop-off area.
- **Landscaping**: Optimize the integration of trees in the landscape design, the need for community gardens etc.
- **Future Development**: To maximize the footprint of the building and still meet the space requirements for the substation. Also to maximize and integrate school and park shared uses to provide top notch facilities on this shared site.

4.2.4 Design of Substation and Underground Infrastructure

The proposed Nelson Park/ Lord Roberts Annex substation is a facility where electricity is transformed from a high voltage to a lower voltage for distribution to homes and businesses and is a critical link between BC Hydro's transmission network and resident's light switches.

Conceptual design for the proposed underground substation is shown in the 3D renderings below. The substation would be a large concrete structure approximately 78 m long, 48 m wide and 37 m deep and the top of the structure would be buried approximately 3 m under the surface. The substation is in the early conceptual design phase so final configurations have not been finalized, but currently it is designed to have three floors with the 230 kV gas insulated (GIS) switchgear and the 230 kV/25-12 kV gas-insulated transformers in the bottom floor, distribution GIS switchgear in the middle floor and access, cable entrance/exit area and control panels located on the top floor. Each floor would be approximately 8 m in height with 3 m spaces between the floors to allow for the installation of the various cables.

Power transformers are typically immersed in oil for better cooling where the oil serves as a coolant and an insulating medium. In a gas insulated transformer, SF6 gas is used as an insulating as well as cooling agent. SF6 is an important gas used in these types of transformer. The main advantage of gas insulated transformers is the elimination of oil and the dramatic reduction in fire risk and oil spills. These gases are non-flammable in nature and limit the need for firefighting equipment in the transformer room. No liquid or oil purifying process is required, the gas can be recycled, and the substation space can be reduced.

Fully gas-insulated substations, adopting a combination of these transformers and switchgear, offer extra ease for safety assurance, accident prevention, and inspection/ maintenance. GIS is a compact metal encapsulated switchgear consisting of high-voltage components such as circuit-breakers and disconnectors, which can be safely operated. GIS is commonly used where space is limited, for example, underground substations, in city buildings, on roofs, on offshore platforms, industrial plants and hydro power plants.

The substation is proposed to have a large elevator that will move workers, tools and equipment into and out of the substation during construction and operation/maintenance. All of the equipment inside the substation could be moved through this elevator except for the large power transformers. These transformers would be installed through a large hatch in the roof of the structure that would be closed and buried after construction, and would only be opened again if one of the existing transformers must be removed for maintenance. The frequency of having to use this hatch is about once every 30 to 40 years. For the West-End substation, this frequency would likely be even longer as all three transformers are proposed to be installed during initial construction. There would also be three ventilation shafts, as well as a stairwell that will be used as an emergency exit.

Conceptual design concepts for the proposed underground substation and infrastructure are shown in the 3D rendering below.

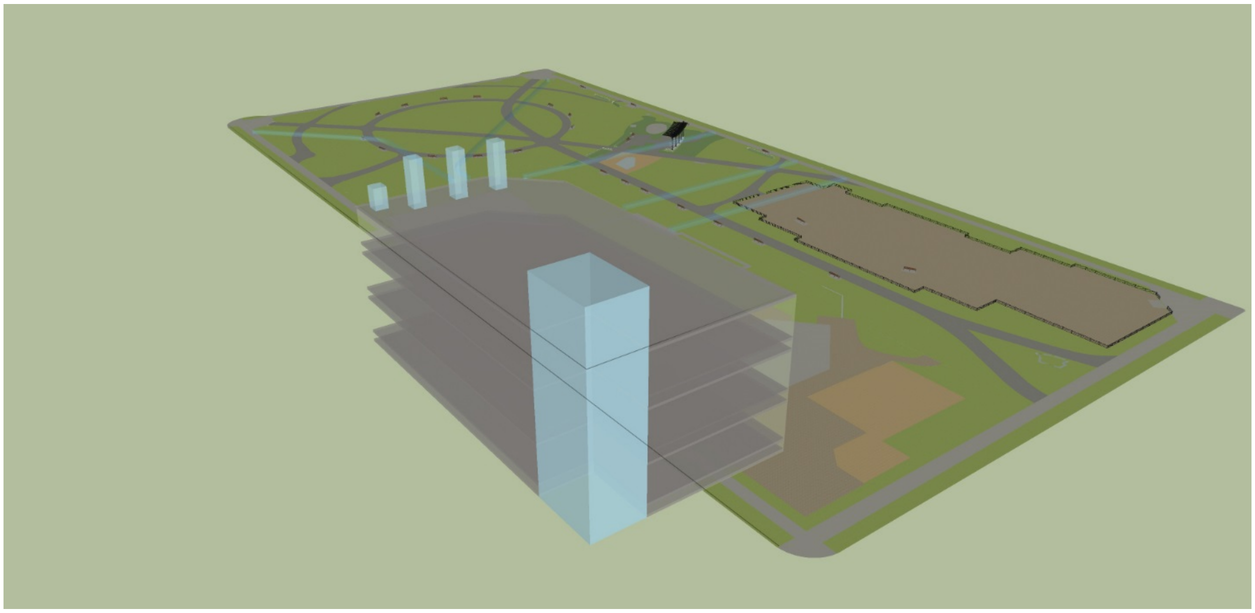


Figure 4-1 3D Rendering Image Showing Conceptual Above Ground and Below Ground Infrastructure at Lord Roberts Annex

4.2.5 Summary of Construction

The following section describes how the proposed underground substation and new school would be constructed, including a description of the estimated timing, location of laydown areas, and access/egress to the site.

4.2.5.1 Construction Sequencing

Construction of the proposed Nelson Park/School Annex Project at the current site of the Lord Roberts Annex School adjacent to Nelson Park is expected to take approximately five years with the start of construction commencing with the demolition of the existing school as early as 2020.

The anticipated in-service date of the substation is expected to occur near the end of 2025 and the anticipated construction of the new school is expected to be complete by summer 2025.

Following the relocation of Roberts Annex school community to a new school at Coal Harbour as early as 2020, the first phase of construction will require fencing off the entire VSB property to allow for the start of the construction. BC Hydro will maximize the amount of park left for public use while ensuring the utmost safety of everyone interacting near the construction zone.

The excavation will start with the removal of the existing Lord Roberts Annex facility and associated parking lots outside of the building. These activities would likely take place after October to limit the impacts to adjacent park users in the summer season. Dewatering wells will then be installed to control local water table. Perched groundwater is expected to be encountered at variable depths depending on the season and weather conditions during the construction period. Local projects encountered groundwater during investigations at up to 18 m below ground level; however, groundwater can be expected at shallow depths during wet weather periods.

Excavation will then commence for an 78 m x 48 m x 37 m underground substation, using a staged excavation process. Excavation will require 3 large excavators. Based on the current size of excavation over 150,000 m^3 of material will need to be removed. This material will be removed from site via tandem trucks, based on the current schedule this will require 35 - 50 trucks per day, similar to the construction requirements for new condo towers.

Excavation of the soil and soft bedrock is expected to be possible using normal construction equipment such as excavators with buckets, ripping and hydraulic breaker attachments. Ripping may be suitable for excavating weak to medium strong rock with hydraulic breaking required to excavate harder materials.

Excessive vibrations, noise and dust may occur due to the excavation of soil and rock. Alternative methods or mitigation measures should be planned for to avoid exceeding permissible or nuisance levels. Excavation work will need to adhere to the City of Vancouver bylaws.

Seepage from the walls of the excavations is to be expected due to perched water within the soils. This can be controlled using weep holes and horizontal drains to dewater and depressurize the excavation face. Drainage panels between the soil/rock face and the shotcrete panels should be installed for the full height of the excavated face covered with shotcrete. Weep holes should be installed through the shotcrete panels connected to the drainage panels and perimeter drains.

Excavation dewatering will likely be limited to perimeter drains connected to collection sumps. The collected water should be retained in the sumps for a sufficient length of time to allow precipitation of sediment before the water is pumped to the City storm sewer system. Alternatively, a sediment collection system should be used prior to water disposal. The requirements for sediment collection should be evaluated during the subsurface investigation stage.

Support of the excavation sides should be possible using conventional shotcrete and tie-back anchors (soil nailing); however, depending on the performance of the native sand with the till deposit, hollow anchor bars (IBOs) may be needed to ensure adequate grout/soil bond. Excavation supports using shotcrete and tie-back anchors are a common practice in Vancouver and several local contractors are very familiar with this construction technique.

A search and survey of all local utilities and underground structures should be conducted to allow ground anchors, or nails, to be located outside these areas. This information will be used by the retention system designer to avoid intercepting utilities and underground structures during anchor drilling. It may be necessary to protect or move underground utilities during construction to avoid damage associated with vibrations and/or ground movements. Encroachment agreements will need to be established with adjacent property owners where anchors, or soil nails, encroach into their property boundaries.

It is recommended that a series of monitoring points be established on the excavation face and selected points on adjacent structures and/or on the ground set back from the excavation. Regular surveying of the monitoring points in all three directions should be undertaken during excavation and construction of the permanent foundation walls. The frequency of the required surveying at site would be established by the engineer based on the actual soil, bedrock and groundwater encountered during bulk excavation work.

A tower crane will typically be installed once part of the excavation reaches the lowest excavation level to permit the movement of construction material and equipment. Conveying equipment may also be used to permit movement of construction materials and excavated soil and rock.

The first stage of new construction will require an under-slab drainage system. The under-slab drainage system will most likely consist of a network of slotted or perforated rigid-wall pipe embedded within a layer of drain rock. The under-slab drainage system will then discharge through non-perforated pipe to a sump-pump system in order to prevent the build-up of any water pressure under the slab.

The construction of the substation will then commence like much of the large commercial construction currently occurring in Downtown Vancouver. Construction techniques will be influenced by geotechnical requirements, and may require the initial pouring of a mud slab, followed by a conventional foundation complete with a waterproofing system. . The internal walls and slab floors will be installed in sequence until the final roof structure is completed. It is estimated that it will take 2.5–3 years to build the initial underground concrete structure and roof, including cover material. A section of the roof structure will contain a large hatch that will be designed so that it can be removed for the initial installation of the large Transformers that cannot be moved through the elevator, and in the future when maintenance may be required.

Once construction is completed an elevator will be installed in the substation, and this elevator will be used to install all other major equipment in the substation, and it will also be used to move construction staff and future maintenance staff in and out of the substation.

When the substation is completed, a new ¾ turf field will be constructed on top of the substation which will serve a playground to the new school and after school hours game space for the community.

At the same time as the substation is being constructed, BC Hydro will manage the construction of the school foundation and underground school parkade on behalf of the VSB. Once the substation roof and school parkade are completed, construction will then commence on the new school.

The school will probably sit on a large concrete raft foundation, but could require some foundation piles depending on final geotechnical requirements. It will be a relatively shallow excavation compared to the substation excavation, probably consisting of 2 floors of underground parking, drop off and service rooms (≈8m). The underground parking sub- structure will be poured in place concrete suspended slab construction with external concrete retaining walls. The superstructure will be non-combustible concrete construction consisting of suspended concrete slab floors installed in sequence until the final roof structure is completed.

The school is only in the conceptual design phase at present but is anticipated be 4/5 storeys high depending on input from various stakeholders. The school is anticipated to be constructed using the in-situ concrete construction process for the internal slabs and exterior shell. Exterior glazing and a cladded exterior façade is anticipated to be installed around the concrete shell. A childcare facility is anticipated to be constructed on the roof with an outdoor play area.

4.2.5.2 Lay Down Areas

Laydown areas will be contained within the VSB property and will likely move between the school and substation construction areas. Initially, the future school footprint will be used as a laydown area (before and/or after the school foundation/parkade is complete). Once the substation roof has been installed, it will become the new laydown area so that construction of the school superstructure can proceed. Approximately six months before construction is completed, the laydown area on the roof of the substation will be cleared and the hatch will be closed so that turf construction and greenspaces can be completed.

4.2.5.3 Access/Egress

Construction access will be provided from Nelson and Bute Street adjacent to the current Lord Roberts Annex school.

Single lane alternating traffic will be implemented on Bute and Nelson street during construction hours and there will be full time traffic control provided to facilitate all construction equipment into and out of site. A detailed traffic impact assessment would be undertaken and a traffic management plan would be implemented during construction to reduce impacts in the project area.

4.2.5.4 Construction Schedule and Areas Impacted

Total construction of the proposed Nelson Park/School Annex Project will take approximately 5 years, with some overlapping construction activities as listed below:

- Removal of existing facilities (four months)
- Excavation of substation and school (14 months)
- Construction of Substation substructure including roof and school foundation/parkade (18 months)
- Fit-out of substation including all electrical and mechanical equipment (18 months)
- Construction of the greenspace (six months). This activity will overlap with the final fit out and commissioning of the substation
- Construction of new Lord Roberts School (above ground portion) (30 months)
- Final commissioning of substation (6 months)

A summary of the permanent and temporary areas impacted by the construction of the substation is described in Table 4-1 below. See Figure 3-2 in Section 3.2.2.4 for a more detailed overview of the construction impacts and timelines for both Nelson Park and Lord Roberts Annex.

Table 4-1 Construction Impact and Duration

Site	Construction Impact and Duration	Area (m^2)	Percent
Lord Roberts Annex	Permanently Lost: BC Hydro Infrastructure	228	4%
	Temporary Lost: Substation Construction (min. 3 years)	6,177	96%
	Not impacted	0	0
	Total Area	**6,405**	

At the Lord Roberts Annex site, construction of the underground substation and replacement school will temporarily impact an area of 6405 m^2 or 100% of the VSB lands for approximately five years. Once construction is complete, 228 m^2 or 4% of the VSB lands will be permanently lost due to the space required for BC Hydro infrastructure, including the vehicle access/intake structure, emergency exit stairwell, and exhaust shafts. The remaining 6177 m^2, or 96% of the land will be available for the new school and sports field.

Options to incorporate the vent shafts into the design of the new school, or allocating them to the perimeter of the properties may further reduce the amount of permanently lost space.

4.3 EXISTING CONDITIONS, IMPACTS AND MITIGATION

The following section describes the existing environmental and social values that currently exist at Lord Roberts Annex, how those values could be impacted by BC Hydro's proposed project, and recommendations to avoid, mitigate or compensate for potential impacts. For addition information related to electric and magnetic fields (EMF) and real estate values, please see the stand alone reports in Appendix E, F and G.

4.3.1 Vegetation

4.3.1.1 Baseline Data/Findings

An arborist study was conducted to inventory and document the location, species, DBH, and general condition of each tree within Lord Roberts Annex (Appendix D; Nelson Park/Lord Roberts School Annex Arborist Report). The Project footprint that coincides with Lord Roberts Annex includes the following elements: the location of the underground substation; above-ground substation entrance structure and public washrooms; above-ground vents; and underground transmission and distribution ducts.

Urban forest canopy cover is an important part of the Urban Forest Strategy and Greenest City Action Plans. To determine the canopy cover of the school property, aerial photography was used to digitize the tree canopy. The area of the canopy cover was determined, and divided by the total area of the school property (approximately 0.8 ha).

As of 2014, the urban forest canopy cover in the West End neighbourhood was approximately 18.6% (City of Vancouver 2014a). Lord Roberts Annex has an existing canopy cover of 36%.

Lord Roberts Annex has a playground with mature trees to the west, and a grassy area with a few mature trees on the east side, near the parking lot.

Table 4-2 provides a summary of the tree species, DBH and count of trees within the Lord Roberts Annex school grounds. A total of 39 trees were recorded on the school grounds; of these, 38 are ≥20 cm DBH.

Table 4-2 Summary of Trees in Lord Roberts Annex School Grounds

Common Name	Scientific Name	Minimum DBH (cm)	Average DBH (cm)	Maximum DBH (cm)	Number of Trees	Number of Trees ≥ 20 cm DBH
maple	*Acer sp.*	44	62	79	2	2
Deodar cedar	*Cedrus deodara*	45	45	45	1	1
dogwood	*Cornus sp.*	20	20	20	1	1
beech	*Fagus sp.*	20	46	80	5	5
black pine	*Pinus nigra*	40	54	99	8	8

Table 4-2 Summary of Trees in Lord Roberts Annex School Grounds

Common Name	Scientific Name	Minimum DBH (cm)	Average DBH (cm)	Maximum DBH (cm)	Number of Trees	Number of Trees ≥ 20 cm DBH
cherry	*Prunus sp.*	26	45	63	11	11
Japanese snowbell	*Styrax japonicus*	9	9	9	1	0
western redcedar	*Thuja plicata*	27	41	56	5	5
little-leaf linden	*Tilia cordata*	34	34	34	1	1
Unknown deciduous	*Unknown*	31	37	46	4	4
Total					**39**	**38**

No invasive plants, noxious weeds or rare plant species were observed during the survey.

4.3.1.2 Discussion of Impacts

Clearing for the proposed Project will result in the loss of most (estimated at 95%) of the existing canopy cover from the Lord Roberts Annex School property.

Most of the trees within the Lord Roberts Annex school property will be removed due to the proposed new school construction, including 36 trees that are ≥20 cm DBH and one that is <20 cm DBH.

Excavation of soil and rock to construct the underground substation structure has the potential to affect subsurface hydrology, which may in-turn adversely affect vegetation remaining outside the excavation footprint

4.3.1.3 Mitigation Measures

The following mitigation measures are recommended to reduce effects of construction on the urban forest in the West End neighbourhood. These are preliminary and will be finalized prior to construction in consultation with the VSB and VPB.

- Pre-Construction
  - The subsurface hydrology section of this report recommends conducting groundwater monitoring for one year to generate a better understanding of groundwater fluctuations during the seasons. This information would help assess the risk of effects on vegetation due to changes in subsurface hydrology and inform accompanying mitigation measures.
- Construction
  - Tree protection barriers for remaining trees should be installed prior to the start of construction. The tree protection barriers should follow the Tree Protection standard 32 01 56 in the Park Development Standards (PWL Partnership Landscape Architects Inc. 2015).
  - Smaller trees currently located within the footprint could be moved elsewhere within Nelson Park, or to existing parks within the West End neighbourhood. If this occurs,

relocation should follow the Tree Digging and Relocation standards 32 96 43.05 in the Park Development Standards (PWL Partnership Landscape Architects Inc. 2015).
  - An Erosion and Sediment Control Plan will need to be submitted as part of the permit application to the City of Vancouver. This plan will include elements to protect storm drain inlets; to remove mud and debris from City property; to reduce sediment run-off; to schedule construction to limit vegetation clearing until necessary; to provide minimum-impact access; and provide a monitoring plan to sample discharge water (City of Vancouver 2017e).
  - Where possible, construction staging areas should be sited to avoid removing trees.
  - Construction activities involving movement of soil should follow best management practices to reduce the spread of invasive plants by arriving on-site with clean vehicles, and ensuring that any soil transported is clean and free of invasive species seeds or vegetative propagules.
- Post-Construction
  - BC Hydro will work with the VBP to replace the number of trees required by the City of Vancouver to achieve no net loss of trees or urban canopy due to the Project.
  - The landscaping of Nelson Park will be restored following Project construction.
  - The aim of the Project is to achieve no-net-loss of the urban canopy in the long-term. Trees will be replaced following Schedule D of the Protection of Trees Bylaw (City of Vancouver 2017d).
  - Replacement trees should be planted on-site; if this is not possible, then they should be planted off-site but within the West End to maintain canopy cover within the neighbourhood. Opportunities and constraints pertaining to tree replacement on-site and within the West End neighbourhood will be determined during the design phase of the Project, which will include the detailed landscape design of the park for the post-construction timeframe.
  - Although large trees will not be replanted on top of the underground substation, other vegetation, such as grass, shrubs, and possibly small trees (e.g., <5 m height, and <15 cm DBH, at maturity) may be planted on top of the underground substation.
  - To reduce the temporal loss of canopy cover during construction, replacement trees should be planted prior to the removal of trees, where feasible.
  - Trees, shrubs, and herbaceous plants should be installed following the Plants and Planting standard 32 93 10 in the Park Development Standards (PWL Partnership Landscape Architects Inc. 2015).
  - Soil placement should follow the Growing Medium standard 32 91 13 in the Park Development Standards (PWL Partnership Landscape Architects Inc. 2015).
  - Surface and groundwater management should maintain pre-construction conditions following construction to reduce long-term adverse effects on vegetation (see details in sections 2.3.9 and 2.3.10).

4.3.1.4 Recommendations for Future Study

Prior to construction, an additional arborist survey should be completed to flag the trees that will require removal and to monitor tree protection barriers.

Future study should also identify the opportunities and constraints for reducing the temporal loss of the urban canopy during Project construction by identifying suitable locations and amounts of trees to be replaced, along with the schedule for replacement. This process would proceed in conjunction with the parks design process for the post-construction condition to identify on-site tree replacement options, and would extend to off-site options within the West End neighborhood, or city-wide, if necessary.

4.3.2 Air Quality

Air quality is the state of the atmosphere with respect to the presence of substances that are potential contaminants. Air quality is assessed because of its intrinsic importance to the health and wellbeing of humans, wildlife, vegetation, and other biota. CACs are Nationally recognized air contaminants. They have been regulated and used as measurable parameters for air quality). Understanding the amount of CACs released and the ambient concentrations in the atmosphere are crucial in assessing the air quality and the potential to affect the receiving environment. The CACs considered include: NOx presented as NO_2, SO_2, CO, and $PM_{2.5}$.

4.3.2.1 Baseline Data and Findings

Metro Vancouver's air quality objectives for CACs were used for this air quality study and are summarized in Table 4-3.

Table 4-3 Metro Vancouver's Ambient Air Quality Objectives for CACs

Substance	Averaging Period	Objectives (µg/m³) [1]
NO_2	1-hour	200
	Annual	40
SO_2	1-hour	196 [2]
	24-hour	125
	Annual	30
CO	1-hour	30,000
	8-hour	10,000
$PM_{2.5}$	24-hour	25
	Annual	8 (6) [3]

NOTES:

1 Metro Vancouver's 8-hour and 24-hour objectives are intended to be compared against concentrations calculated as a rolling average. Metro Vancouver objectives are "not to be exceeded", meaning the objective is achieved if 100% of the validated measurements are at or below the objective level.

2 This 1-hour SO2 objective is interim and is intended to apply to all applications for new or significantly modified discharge authorizations under Greater Vancouver Regional District Air Quality Management Bylaw No. 1082 made on or after May 15, 2015 but not intended to apply to existing facilities. "Significantly modified" refers to an increase in authorized quantity of emission of greater than 10%. The interim SO2 objective will be revisited after the Canadian Council of Ministers of the Environment adopts a new Canadian Ambient Air Quality Standard, likely in 2016.

3 Metro Vancouver's Annual PM2.5 Planning Goal of 6 µg/m3 is a longer term aspirational target to support continuous improvement.

SOURCE: Metro Vancouver, 2016

The potential impacts of the proposed Lord Nelson/School Annex Project include the change in CAC concentrations during construction. During operations, no air quality impacts are expected as activities will be limited to the venting of air for equipment cooling and to maintaining indoor air quality within the substation. Impacts on air quality are based on professional judgment and a qualitative evaluation of the relationship between Project construction emissions and baseline air quality.

The baseline or existing air quality is determined from the nearest, most representative, continuous air monitoring station in proximity to the proposed Nelson Park/School Annex Project. No one station measures all CACs considered in this study, therefore data from two stations are evaluated, as presented in Table 4-4. Data from the Vancouver Downtown station is used for the evaluation of NO_2, SO_2 and CO baseline concentrations. This station is located in the Robson Square Complex which is approximately 600 m east of the Lord Roberts Annex. For context, $PM_{2.5}$ concentrations from Vancouver Kitsilano station is used because $PM_{2.5}$ is not monitored at the Vancouver Downtown station. This station is located at the Kitsilano Secondary School, approximately 3,400 m southwest of the Lord Roberts Annex.

Table 4-4 Continuous Ambient Air Quality Monitoring Stations Used in the Baseline Air Quality Analysis

Station Name	Latitude	Longitude	Elevation (m asl)	Location (UTM NAD83)			Substances Monitored			
				mE	mN	Zone	SO_2	NO_2	CO	$PM_{2.5}$
Vancouver Downtown [a]	49.2823°N	123.1219°W	32	491134	5458846	10	x	x	x	-
Vancouver Kitsilano [a]	49.2617°N	123.1635°W	34	488104	5456562	10	-	-	-	x

NOTES:
x = continuous monitoring data available for the baseline air quality analysis
- = monitoring data not available

SOURCE: [1] Metro Vancouver 2014 Lower Fraser Valley Air Quality Monitoring Report (Metro Vancouver 2014)

The results of a baseline air quality analysis from 2008 to 2015 are presented in Table 4-5

Table 4-5 Summary of Continuous Ambient Air Quality Monitoring Data at Stations Used in the Baseline Air Quality Analysis

Substance	Averaging Period	Objectives ($\mu g/m^3$)	Vancouver Downtown ($\mu g/m^3$)	Vancouver Kitsilano ($\mu g/m^3$)
NO_2 [1]	1-hour	200	84.1	
	Annual	40	37.7	
SO_2 [2]	1-hour	196	82.4	
	24-hour	125	19.0	
	Annual	30	7.50	
CO [3]	1-hour	30,000	768	
	8-hour	10,000	699	
$PM_{2.5}$ [4]	24-hour	25	-	12.5
	Annual	8(6)	-	4.92

NOTES:

1 BC MOE summary database for NO_2 observations at Vancouver Downtown are for 2008, 2009 and 2012, 2013, and 2014. The 1-hour background NO_2 concentration was determined based on the daily 1-hour maximum concentrations, followed by the calculation of the 98th percentile for each year, then averaged over the BC MOE database period. Annual NO_2 background concentration was based on the average of annual mean values.

2 BC MOE summary database for SO_2 observations at Vancouver Downtown are for 2008, 2009 and 2012, 2013, and 2014. The 1-hour background SO_2 concentration was determined based on the daily 1-hour maximum concentrations, followed by the calculation of the 99th percentile for each year, then averaged over the BC MOE database period. The 24-hour background SO_2 concentrations were determined based on the 98th percentile of 24-hour SO_2 concentrations for each year, then averaged over the period of record. Annual SO_2 background concentration was based on the average of annual mean values.

3 BC MOE summary database for CO observations at Vancouver Downtown for 2009, 2012, 2013, 2014, and 2015. The 1-hour and 8-hour background CO concentrations were determined based on the 98th percentile of 1-hour and 8-hour CO concentrations for each year, then averaged over the period of record.

4 BC MOE summary database for $PM_{2.5}$ observations at Vancouver Kitsilano are for 2009, 2010, 2011, 2012, and 2013, The 24-hour $PM_{2.5}$ background was determined based on average of the 98th percentile values for the 24-hour averaging interval. For the annual averaging interval, it is the average of the annual mean values.

SOURCE: BC MOE 2016b

BC MOE monitored concentrations of NO_2, SO_2, CO and $PM_{2.5}$ are demonstrated to be below the applicable Metro Vancouver Air Quality Objectives (Table 4-5). Baseline air quality of NO_2, CO, and SO_2 in Downtown Vancouver is influenced primarily by dense traffic close to a busy street (Vancouver Downtown station) (Metro Vancouver 2012). Baseline air quality of $PM_{2.5}$ in the vicinity of the Kitsilano monitoring station, is influenced primarily by a sandy beach volleyball court a few metres away from the monitoring station (Metro Vancouver 2012).

Generally, the baseline ambient air quality in the vicinity of Lord Roberts Annex is good. Expected sources of CACs near Lord Roberts Annex include: vehicular traffic, space heating, and other dust sources.

Estimated construction activities consider the equipment used following the Nelson Park/chool Annex Project substation construction. US EPA NONROAD emission factors were used in conjunction with a list of representative off-road construction equipment. For this study, it is assumed that all equipment has Tier 3 engines (ECCC, 2012). The sulphur content for off-road diesel is assumed to be 15 ppm based on ultra-low sulphur diesel limit (ECCC 2002). Following the EPA NONROAD model, all PM emissions are assumed to be smaller than $PM_{2.5}$ (U.S. EPA, 2004) for this study.

Sources of PM from wind erosion and dust from mobile equipment are not quantified in this study. These sources are difficult to quantify as they are highly dependent on the activities/techniques used onsite. These emissions will be managed through the proposed mitigations for the Project as well as recommendations for future study, discussed below.

Table 4-6 presents the estimated annual maximum CAC emissions related to construction activities at the Lord Roberts Annex.

Table 4-6 Annual CAC Emissions from Construction Activities at the Lord Roberts Annex

Activity	Emissions (tonnes/year)			
	NO_2	SO_2	CO	$PM_{2.5}$
Off-road construction equipment	15.0	0.01	16.1	1.0

Construction activities are estimated to last more than one year; therefore, Table 4-7 presents the total emissions from the construction phase. The CAC emissions in Table 4-7 include those emitted from fuel combustion only.

Table 4-7 Total CAC Emissions for the Construction of the Lord Roberts Annex School

Activity	Emissions (Tonnes)			
	NO_2	SO_2	CO	$PM_{2.5}$
Off-road construction equipment	22.6	0.02	24.2	1.5

4.3.2.2 Discussion of Impacts

Professional judgement was used to qualitatively assess the potential impacts of the proposed Nelson Park/Annex Project on air quality. This study is based on the types of construction activities, as well as the duration and frequency of construction activities. Activities associated with the construction of the Annex will increase CAC concentrations in the vicinity of Lord Roberts Annex. However, if best management practices to control CAC emissions are implemented, the degree of change to CAC concentrations are expected to be low. Activities will also be limited to daytime hours, temporary, and irregular in occurrence. As well, impacts would be reversible upon completion of the construction phase.

Baseline conditions are good with all CACs measure less than the ambient air quality objectives. The proposed Nelson Park/Annex Project's impact on air quality are qualitatively assessed to remain within the ambient air quality objectives if construction best management practices are implemented.

4.3.2.3 Mitigation Measures

Mitigation measures applicable to air quality are limited to construction best management practices. These include:

- Water road surfaces and exposed surfaces prone to wind erosion to suppress fugitive dust
- Operate vehicles within the posted maximum speed limits to limit fugitive dust and fuel combustion emissions
- Implement wheel-cleaning for vehicles leaving site to prevent dust "track-out" onto the surfaces of public roads
- Maintain vehicles in good operating condition to meet emission standards (such as catalytic converters and particulate filters for diesel engines)
- Use appropriate sized, and modern (Tier 3) fleet of construction equipment to reduce fuel consumption
- Reduce vehicle idling and limit rapid starts and stops
- Use low-sulphur diesel fuel

4.3.2.4 Recommendations for Future Study

Emissions from sources other than fuel combustion have not been included in this study. Due to the type of the Project, PM (dust) from wind erosion and mobile equipment are difficult to quantify as they are highly dependent on the activities/techniques used onsite. It's recommended that impacts be evaluated on an ongoing basis. This can be accomplished with the investigation of the cause for complaints (if any) related to PM emissions. Results of these investigations can yield continuous improvements to the best management practices over the duration of construction.

4.3.3 Noise and Vibration

The results of the noise and vibration studies related to the Annex decommissioning and construction were included Section 3.3.6 and Section 3.3.7 respectively for the Nelson Park site.

The noise and vibration due to the Lord Roberts Annex School operation is not included in this study.

4.3.4 Public Safety—Crime Prevention

4.3.4.1 Baseline Data and Findings

A desktop study was undertaken to determine the potential Project effects related to park accessibility and mitigations that could result from the construction and operation of the proposed substation and associated infrastructure under Lord Roberts Annex. The study was based on the design principles and strategies identified by the National Crime Prevention Councils' *Crime Prevention Through Environmental Design Guidebook (2003).* Additional secondary sources were also consulted to reflect provincial and municipal approaches in the used of crime prevention through environmental design (i.e., CPTED) principles. These include, BC Housing's *Crime Prevention through Environmental Design (Section 7)* in *BC Housings Design and Construction Standards* (2014), and the City of New Westminster's *Crime Prevention Through Environmental Design, Guidelines for Safe Urban Design* (1999).

Using Project concept plans and Google Earth 2017 imagery the study included consideration of how the placement of the proposed substations and applicable infrastructure would affect the current and future safety of the park users.

Crime Prevention Through Environmental Design is a multi-disciplinary approach to deterring criminal behaviour and nuisance activity through environmental design (BC Housing 2014). Although, there are several different related design principles available, the general theory of CPTED is based on the following design concepts:

- **Territoriality**—a design concept that clearly delineates private space from semi-public and public spaces, and creates a sense of ownership. Ownership thereby creates an environment where appearances of such strangers and intruders stand out and are more easily identified.
- **Natural Surveillance**—is based on the "eyes on the street" principle, where surveillance or legitimate intent to observe decreases the potential for criminal behaviour.
- **Access Control**—is aimed at limiting the number of entry points to discourage or deny entry to intruders.
- **Maintenance and Management**—is related to the 'pride of place' and territorial reinforcement. Essentially, the more dilapidated an area, the more likely it is to attract unwanted activities (BC Housing 2014, City of New Westminster 1999, and *NCPC 2003).*

4.3.4.2 Discussion of Impacts

Public safety effects that may result from construction of the substation and associated infrastructure at Lord Roberts Annex school site include: impediment of sight-lines, increased demand for appropriate lighting, potential increase of concealed or isolated areas, and increased demand for improved signage, and degradation of a positive aesthetic environment.

During operations impacts include, but are not limited to public safety concerns in relation to: potential increase of concealed or isolated areas in relation to the proximity of the new urban elementary school and other above-ground infrastructure, new opportunities for isolation and entrapment areas with underground parking, and increased demand for improved signage to direct future students and parents, staff, and the public. As a result of the implementation of mitigations (below), the Project may also result in some positive outcomes, these include, but are not limited to: reducing the overall number of concealed, isolated, or entrapment areas, increasing the net area of green space, adding new areas to support programming activities, and an overall improvement in the use and design of the school.

4.3.4.3 Mitigation Measures

The following mitigations should be implemented during design, construction and post-construction to improve the use of CPTED principles, which will increase the safety of future park users:

- Design
  - Implement CPTED lighting principles in school redesign, such as:
  - Uniformly spread lighting to reduce contrast between shadows and illuminated areas
  - Night time uses of the outdoor spaces are considered in the type, placement and intensity of lighting
  - Light colour finishes to be used in underground car parks, around washrooms, and isolated walking routes.
  - In school redesign, incorporate principles of CPTED that limit and reduce concealed or isolated areas, such as:
    - Eliminating entrapment areas (travelled routes that are shielded by three sides) located within 50–100 m
    - Provide opportunities for natural surveillance, and formal surveillance
    - Reinforce activity generators along an "active edge" or along one or two pedestrian paths
    - Avoid narrow deep recessed areas around fire escape, and grade-separated parking lots
  - Use signs that are: large, legible and identifiable, simple in shape and graphics, convey messages with adequate information, and are positioned at the appropriate height for students.
  - In school redesign, consult with VPB, VSB and current park users regarding their interest in sharing park amenities between students and the public. Consider the sense of isolation students may feel in the opportunity to engage in play if the public using "shared park space", and the potential benefits of sharing (i.e., increased green space and amenities) for all users.

- Consult with the public, VSB, and VPB to identify opportunities to improve overall school design, such as:
  - Parks and open spaces are planned and programmed for a range of activities, even if they are intended for passive use
  - Parks and open spaces are improved to provide access to and from populated areas in order to increase the use of the park system
  - Parks and open spaces complement and are integrated with the sidewalk system to develop an open space and pedestrian network that attract more people
- The planning and design of the parks take into account the possibility of night time use such as night tennis or evening walks.
- To avoid isolation, add benches, fitness trails, tennis or basketball courts and bicycle paths along the perimeter of school and park, or along through roads
- Washrooms should be near children's playgrounds.

- Construction
  - Provide highly visible signage of park closure area(s), expected time-line of closure(s), and temporary pedestrian access points utilizing visual maps, where applicable.
  - Conduct a site risk assessment using CPTED principles to identify areas where lighting may be affected during construction and provide temporary lighting fixtures where applicable.
  - To reduce effects of construction on the aesthetic environment, the following should be undertaken:
    - The park and open spaces areas should be well maintained
    - Litter and graffiti should be removed and vandalized or burned out bulbs should be replaced immediately after discovery
    - Highly visible signs should be provided and be used to guide how to report maintenance or vandalism issues
- Post-Construction
  - Provide landscaping around school yard so that it encourages natural surveillance from surrounding buildings and streets.
  - Provide follow-up assessment on the incorporation and application of CPTED principles.

4.3.4.4 Recommendations for Future Study

The findings noted above were limited to a CPTED qualitative analysis of the substation proposed for the Lord Roberts Annex school site using concept plans and Google Earth 2017 imagery. It is recommended that a full CPTED site risk assessment be undertaken to provide specific CPTED design elements that can be incorporated into the future redesign of the urban elementary schools.

4.3.5 Public Safety—Accidents and Malfunctions

4.3.5.1 Baseline Data and Findings

A desktop study was undertaken to determine potential effects that could result from accidents or malfunctions that may occur during the construction and operation of BC Hydro's proposed Nelson Park/Annex Project. This included a review of EIAs that addressed potential accidents and malfunctions at substations (e.g., BCTC 2010, Manitoba Hydro 2015). Information interviews with the City of Vancouver Fire Department undertaken to identify potential risks, emergency response measures and approaches used to respond to electrical-related emergencies. A number of initiatives/mitigations are also identified by the Vancouver Fire Department that BC Hydro could undertake to reduce risks posed from the construction and operation of the substation. Mitigation measures were also identified from a review of applicable EIAs, BC Hydro's internal policies and procedures, and studies that reflect learning outcomes from past events (e.g., *BC Hydro Report: Downtown Vancouver Outage: July 14, 2008 [BC Hydro 2008]*). This information, along with feedback directly from BC Hydro's lead safety engineer can be used to reduce specific risks posed by a substation accidents or malfunctions.

Potential accidents and malfunctions include potential hazards to the public; the substation's construction, maintenance and operating workforce; and emergency response personnel. The following potential effects were identified that could result from an accident or malfunction of the proposed substation infrastructure:

- Use of energized equipment and hazardous test energy may result in failed equipment causing electrocution, electrical burns, ventricle fibrillation hazards, and fire.
- Working in a toxic environment or with hazardous substances (e.g., fuel and lubricants, oils, solvents, and greases), may result in spills or human contact causing harmful exposure, burns, or asphyxiation to workforce personnel.
- Public interactions with the Project may result in potential risk of traffic accidents involving vehicles and equipment travelling to and from the construction site(s), and accidents involving local motorists, other commercial operations, pedestrians, and cyclists. Such traffic hazards can result in damage to personal or commercial property, and injury or death to the public or workforce.
- The potential for electrical hazards to residents, communities, or other individuals conducting activities near substations is primarily related to unauthorized entry into restricted areas (for example a substation compound), or other forms of illegal activity involved with tampering or attempts to destroy or dismantle circuit components.
- Natural disasters such as an earthquake, flood, storm, fire, or explosion may result in substation malfunctions and power outages. Such events have potential to affect community and emergency response services, commercial and industrial operators, and residential tenants.
- Human caused error during operations of the substations may result in component failures causing fires, or explosions.

4.3.5.2 Discussion of Impacts

During construction, most risks to the public and workforce will be related to the movement of materials and people at the construction sites. These risks will be reduced through applicable signage, fencing, and adherence to local, municipal and provincial traffic and safety bylaws, policies and plans.

The subsurface design of the substation may reduce some risks while increasing others. Potential risks that may result from human error, use/operation of energized equipment, working with hazardous materials, maintenance of infrastructure, or from natural disasters may be reduced because the overall physical impact of effects (e.g., fire, release of hazardous materials, or explosions) will be confined and retained underground. However, the subsurface design of the substation may create additional risks to emergency response personnel, because the design creates: limited access, confined spaces, potential for increase in smoke from reduced airflow/ventilation (Foster A., City of Vancouver Assistant Fire Chief. *Personal communications*. January 26, 2017). These effects increase the risks for emergency response providers in responding to a potential operational outage or substation malfunctions. BC Hydro can undertake several initiatives to manage and reduce these risks, such as: using a worst-case scenario approach when designing substations, working with the City of Vancouver in developing a substation specific emergency response plan, training, and applying BATEA in the design of the substation (e.g., application of fire retardants, advanced ventilations systems and shut-offs) (Foster, *Personal comm*. January 26, 2017).

4.3.5.3 Mitigation Measures

Several mitigations have been identified that may manage and reduce potential effects from accidents or malfunctions during the design, construction, and post-construction phases. Most mitigations identified are based on a) avoiding risks through effective design, b) managing potential risk through engineering controls and emergency response procedures, and c) protecting the health and safety of the public and workforce. These measures include:

- Design
  - Apply engineering controls through BC Hydro's process to reduce the potential for release of hazardous materials such as secondary containment systems and the use of oil detection sensors.
  - Use a worst-case scenario approach when designing substations – consider who could be impacted and how underground incidents related to electrical hazards are heightened (e.g., more smoke, confided spaces, limited access, limited ventilation = increased risks to emergency response personnel)
  - In the event of an accident or malfunction design substation and associated infrastructure that reduces the potential for the release of spills or hazardous material by using:
    - Spill response and containment systems
    - Fast acting protection and control equipment
    - Fire walls and barriers
    - Explosion and blast protection barriers
    - Security surveillance systems
    - Vents and exhaust assessment systems (i.e., detention for location of exhaust, nature of exhaust, etc.)
    - Encased cables to ensure no negative impacts on tree roots
  - In the event of an accident or malfunction implement policies and plans that reduce potential for the release of spill of hazardous material including, but not limited to:
    - Fire safety and response plan
    - Hazmat safety and response plan
    - Emergency response plan (include initial entry to investigate and assess by first responders and BCH workers, and re-entry for clean-up/switching, etc.) which can vary depending on the event
    - Spill response plan

  - During construction, maintenance, and repair activities, use fences, signs, and surveillance systems or other measures will be used to prevent public access.
  - Develop an emergency response plan with the City of Vancouver's Fire Department. The plan will include policies and allow for applicable training (where appropriate) to the City of Vancouver's Fire Department to support fire suppression, training, inspection, communication, and liaison activities (Foster, Personal comm. January 26, 2017 and BC Hydro 2008).
  - BC Hydro will use gas insulated switchgear (GIS) for the substation. GIS uses SF6 as an insulating medium for high and medium voltage switchgear systems. Unlike conventional oil insulated switchgears, GIS does not pose a fire risk, so the overall risk of substation fire will be reduced"
- Construction
  - Prepare and maintain a local inventory of all hazardous materials handled, stored, or used at the substation sites (see BC Hydro's Stationary Form #80420 –Toxic/Hazardous Product Inventory form)
  - During construction adhere to all applicable municipal, provincial, and federal regulatory requirements relating to traffic management including, but not limited to:
    - Street and Traffic By-Law No. 2849 (City of Vancouver 2016)
    - WorkSafeBC OHS Regulation, Traffic Control (WorkSafeBC 2009)
    - Ministry of Transportation and Highways Engineering Branch, 1999 – Traffic Control Manual for Work on Roadways (BC Ministry of Transportation and Highways 1999)
  - Verify that work undertaken during construction and operating activities comply with BC Hydro's *Occupation Health and Safety Standards Guidelines* (BC Hydro 2016)
  - Adhere to a project-specific Traffic Management Plan
- Post-Construction
  - In the event of an accidents of malfunction BC Hydro will activate its Corporate Emergency Center (CEC) until power was restored to all customers and all damaged circuits were repaired (BC Hydro 2008)
  - In accordance with BC Hydro's Incident Action Plan, the following priorities would be established in the event of an accident of malfunction:
    - Ensure public and employee safety
    - Identify impacted critical infrastructure, customer key accounts, and feeder prioritization for a Restoration Plan
    - Facilitate effective and timely communication
    - Establish the impacts based on the damage assessment and receive situation updates from site (BC Hydro 2008)
  - In the event of an outage, BC Hydro will implement its priority sequence restoration of services in sequence of the following:
    1. Generation and transmission facilities to supply distribution customers
    2. Communications facilities for civil authorities;
    3. Hospitals
    4. Critical customers which include police stations, fire stations, ambulance stations, municipal emergency centres
    5. Facilities as directed by Municipal, Provincial, and Federal authorities
    6. Utility facilities which include gas, sewer, water, telephone, and cellular
    7. Emergency reception centres (schools, civil centres)
    8. General commercial, industrial and residential customers (BC Hydro 2008)

- In the event of an outage, BC Hydro will coordinate with the City of Vancouver's Fire Department and Emergency Management Department who will lead the initial response of an electrical or fire related emergency , which includes:
  1. Establish command (i.e., determine who is in charge)
  2. Undertake hazard identification and risk assessment (HIRA) or "size up"
  3. Isolate incident
  4. Test for toxins
  5. Apply 2 in 2 out rule
  6. Ensure full personal protective equipment is used
  7. Apply touch approach to external/unobserved risks
  8. Wait for confirmation from BC Hydro that power has been shut off (Foster A., City of Vancouver Assistant Fire Chief. Personal communications. January 26, 2017).

4.3.5.4 Recommendations for Future Study

The preceding identification of risks and mitigation measures is based on a preliminary review of the proposed Nelson Park substation. A project-specific assessment of potential accidents and malfunctions should be undertaken once more detailed design and engineering information on the Project has been developed. Additionally, given the number of agencies that are involved in maintaining public safety (e.g., BC Hydro, VPB, VSB, City of Vancouver Emergency Management Department and Fire Department, and Emergency Management BC) it is recommended that additional research and consultation be undertaken to develop an up to date integrated emergency response plan specific to responding to potential substation accidents and malfunctions in Vancouver.

4.3.6 Storm Water Management

4.3.6.1 Baseline Data and Findings

A desktop study was undertaken to determine potential effects that could result from the construction and operation of the proposed Nelson Park/Annex Project. This included a review of impacts of the addition of various services to the substation. Information was obtained from the Vancouver parks website and the City of Vancouver's VanMap for existing service locations and pipe sizes.

4.3.6.2 Discussion of Impacts

Lord Roberts Annex and Nelson Park existing utilities include an underground 200 mm dia. storm main traversing the centre of the park in the southwest direction, parallel to Nelson Street. Offsite services include: a 200 mm dia. water main along Nelson Street; a 200 mm dia. water main along, 200 mm dia. storm main, and a 300 sanitary main Bute Street and a 300 mm dia. water main along Comox Street.

For a plan of the site and section details see figures in Appendix A.9.

The goal in terms of storm water management is primarily to limit the post-development runoff flow such that it will not exceed the pre-development runoff flow entering the existing system. The existing park surface is mostly grass surfacing, however, the area where the substation is proposed under the current school site there is a large portion of impervious surfaces such as walkways and vehicle parking areas. Since the current park layout and proportions are conceptual, it is assumed that the proportion of post-development impervious surface would be the equivalent to the current park site. Detailed calculations will be undertaken in the next phase of the Project.

Access to the city sanitary and water system may be obtained from the existing mains running along Bute Street.

4.3.6.3 Mitigation Measures

The following mitigation measures are recommended to reduce effects of construction and operation of the Project stormwater. These measures are conceptual only, and will be finalized prior to construction in consultation with the VPB and VSB.

- An Erosion and Sediment Control Plan should be developed prior to construction (as per the City of Vancouver requirement) and during construction, a sediment collection system should be used prior to water disposal.
- Any stormwater runoff entering the excavated site should be directed to a pump and discharged to surface tanks and a sediment flocculation system to remove sediments prior to discharge to the existing municipal drainage system.

4.3.6.4 Recommendations for Future Study

It is recommended that further investigation of the soil infiltration rates will be required to determine the required volume of the rock pits, if necessary. Stormwater harvesting is an option to reduce water use in the school, however, such a program would require VSB and City approvals.

4.3.7 Subsurface Hydrology and Ground Conditions

4.3.7.1 Baseline Data and Findings

Stantec understands it is proposed to construct a substation underground in Nelson Park with the excavation required to be approximately 36 m depth below the existing ground level. Based upon Google Earth imagery; Lord Roberts Annex, adjacent to Nelson Park, is at an approximate Geodetic elevation of 45 m.

The Geological Survey of Canada map for Vancouver (Map 1486A) indicates that at the Nelson Park site bedrock is within 10 m or less of the surface. Glaciated till soils are likely to overly the bedrock and comprise clayey Silt and Sand with gravel and cobbles. The occasional boulder may be encountered in the Glacial deposits. Topsoil and fill material are likely to overlie the till soils in the upper 1 to 2 m. The bedrock is likely to comprise interbedded Sandstone and Shale initially soft becoming harder with depth. Cementitious hard rock (typically referred to as “Floaters”) is commonly encountered within sandstone bedrock and are typically elongated shapes less than 1 m thick.

Perched groundwater is expected to be encountered at variable depths depending on the season and weather conditions during the construction period. Local projects encountered groundwater during investigations at up to 18 m below ground level; however, groundwater can be expected at shallow depths during wet weather periods. Water levels measured during investigations are not considered to be a true representation of the regional groundwater table, but rather perched water flowing within the glaciated sand interlayers within the glacial till deposit.

4.3.7.2 Discussion of Impacts

Excavation of soil and rock to construct the underground substation structures is likely to cause noise, vibrations and dust associated with normal construction activities similar to other basement excavations in the Downtown area. Excavation of bedrock may involve the use of heavier than normal construction equipment will require consideration to reduce potential impact to nearby structures or nuisance to the local population.

Groundwater control during the excavation will be required which will involve the use of pumps and sediment collection systems either within the excavation or at the surface near the excavation. Ground subsidence associated with temporary groundwater control is not considered to be a significant risk to the Project as fines loss from the soils is likely to be minimal. The risk of ground movement associated with the excavation of soil and rock is also considered to be minimal.

Excavation of soil and rock to construct the underground substation structures will cause a disturbance to existing subsurface hydrology which will impact some trees and other vegetation.

A retention system, such as ground anchors and shotcrete panels, is likely to be used during the temporary construction of the excavation. Ground anchors will penetrate through the soil and/ or rock providing temporary stability of the excavation faces. Consideration should be given to the proximity of adjacent underground structures and utilities when designing the location and drill length of anchors.

4.3.7.3 Mitigation Measures

The negative effects of construction noise can be limited by undertaking the following actions:

- Avoid undertaking potentially noisy construction activities during unsociable hours
- Use noise barriers around the excavation to reduce noise transmittal
- Use protection blankets during bedrock excavation

The generation of dust can be limited by the following actions:

- Use of wetting during excavation; particularly during dry periods
- Covering excavated material prior to, and during, transport away from the excavation work site

The mitigation on potential ground vibrations generated during construction is discussed in Section 2.3.5.

An assessment of underground and the above ground utility locations should be completed to limit the effect of potential ground movements on utilities. A condition survey of nearby structures should be conducted to check for defects or potential structural weakness. A review of adjacent underground structures and their foundation/basement construction should be conducted to assess the potential risk of damage. Special measures can be carried out, if necessary, to provide for temporary and permanent stability of nearby structures and utilities during and after construction such as temporary shoring and underpinning.

4.3.7.4 Recommendations for Future Study

Stantec recommends that a comprehensive Geotechnical investigation be conducted to determine the subsoil and bedrock conditions and to characterize the soil and rock materials. The investigation should include the installation of piezometer groundwater monitoring wells installed in the soils and the bedrock materials to measure groundwater levels in the various soil and rock layers. Groundwater monitoring should be undertaken regularly for at least a full calendar year to fully understand the potential groundwater level fluctuations during the seasons. The Geotechnical and groundwater investigations should include the preparation of a factual report available to Engineers during subsequent design and engineering stages.

4.3.8 Birds and Other Wildlife

4.3.8.1 Baseline Data and Findings

4.3.8.1.1 Desktop Review

Over 600 resident, migratory, and overwintering birds and other wildlife occur regularly in Metro Vancouver (City of Vancouver 2014c, 2017f). Lord Roberts Annex supports a variety of urban birds and mammals that are tolerant of highly manicured landscaping and human disturbance (e.g., vehicle and pedestrian traffic). A review of wildlife information sources (e.g., BC CDC, eBird, City of Vancouver, Species at Risk Public Registry, published literature) was undertaken to understand existing conditions of birds and other wildlife, and their habitats within the Annex, and to characterize potential effects of the Project on birds and other wildlife. The review included identifying occurrence records of birds and other wildlife, including provincial (i.e., Red of Blue-listed) or federal (i.e., Threatened, Endangered, or Special Concern) species at risk.

As with the two park locations, Lord Roberts Annex is highly manicured; lawn areas are interspersed with a combination of native and ornamental trees. Lord Roberts Annex also supports typical native birds and other wildlife, including glaucous-winged gull, northwestern crow, American robin, song sparrow, black-capped chickadee, raccoon, and striped skunk as well as previously described invasive or exotic birds and mammals (City of Vancouver 2014c, 2014d, 2017f; Cornell Lab of Ornithology 2017). Species at risk have not been recorded in the Annex and are not expected to use the Annex for breeding, foraging, or roosting primarily due to lack of habitat and high level of disturbance, however there is potential for common nighthawk (*Chordeiles minor*; BC Yellow List; SARA Threatened) and barn swallow (*Hirundo rustica*; BC Blue List; SARA Threatened) to nest on the school.

As with Nelson Park, the Lord Roberts Annex is adjacent to the English Bay and Burrard Inlet Important Bird Area, which is recognized in part for its importance to the breeding population of the *fannini* subspecies of great blue heron (IBA BC020; IBA 2017). The great blue heron *fannini* subspecies is Blue-listed in BC and designated as Special Concern on Schedule 1 of SARA. Nelson Park and the Lord Roberts Annex are approximately 1.5 km from an existing great blue heron rookery (breeding colony) located at the southeast end of Stanley Park. The rookery supports up to 128 nests, although the numbers fluctuate between years (SPES 2016). Stanley Park supports approximately 6% of the total population of the *fannini* subspecies in BC (SPES 2006).

4.3.8.1.2 Field Survey

Field surveys were completed at Nelson Park and Lord Roberts Annex on January 18 and 27, 2017, to record observations and assess value for birds and other wildlife in conjunction with surveys for urban forestry. The survey team included two qualified biologists. The survey team documented observations of birds and other wildlife (e.g., visual detections) and evidence of use (e.g., nests, tree cavities), the availability and condition of habitat for birds and other wildlife, and presence of wildlife habitat features (e.g., raptor stick nests) that may require mitigation.

The field surveys also provided site-specific information to support the characterization of habitat availability for birds and other wildlife that potentially occur in Lord Roberts Annex. The park supports 39 urban trees, 38 of which had a measured DBH ≥ 20 cm. Most park trees were either little-leaf linden (*Tilia cordata*), cherry, or English hawthorne. A detailed summary of trees located in Nelson Park and Lord Roberts Annex is found in Appendix D.

Trees in the park support nesting, foraging, and daytime roosting opportunities for urban birds and other wildlife. A summary of detections of birds and other wildlife is provided for Nelson Park and the Lord Roberts Annex in Table 2-23. One eastern grey squirrel nest and two northwestern crow nests were identified in Nelson Park.

4.3.8.2 Discussion of Impacts

4.3.8.2.1 Vegetation Clearing, Noise, and Vibrations at Lord Roberts Annex

As part of the *Greenest City Action Plan*, the City of Vancouver developed the *Vancouver Bird Strategy* to improve methods for incorporating nature into the urban environment. The strategy outlines five action areas to support improving or maintaining healthy urban environments for birds (City of Vancouver 2014c). Permanent removal or alteration of trees and understory vegetation in the Lord Roberts Annex will reduce nesting, foraging, and daytime roosting opportunities for migratory, resident, and overwintering birds as well as other urban wildlife (e.g., racoons, skunks). Tree removal and reduction in canopy cover will further reduce habitat connectivity for some species. Demolition of the school building also has potential to remove nests for provincially and federally listed species at risk (i.e., common nighthawk and barn swallow). Based on the current proposed Project design, construction of the underground substation (and supporting infrastructure) at this location will result in the removal of 37 trees. Efforts to reduce or compensate for loss of urban habitats that support birds and other wildlife are outlined in Section 4.3.8.3 Mitigation Measures (below) and are developed in accordance with objectives and actions outlined in the City of Vancouver's *Urban Forest Strategy*, *Vancouver Bird Strategy*, and *Bird Friendly Design Guidelines* reports (City of Vancouver 2014a, 2014c, 2014d).

As described for Emery Barnes Park, the MBCA and the BC *Wildlife Act* manage migratory and resident breeding bird populations by prohibiting the destruction of individuals, eggs, and occupied nests. If construction activities at Lord Roberts Annex are scheduled to coincide with the nesting window for migratory birds, there may be increased potential for incidental take (i.e., mortality or destruction) of breeding individuals and nests located in sections of the park that are subject to vegetation clearing. Non-native (i.e., invasive or exotic species) are not protected under the MBCA or the BC *Wildlife Act*.

Sensory disturbance due to noise and vibrations, caused by vegetation clearing and grubbing, excavation, construction, and start-up and testing can result in avoidance behaviour for birds and other wildlife at Lord Roberts Annex. Some forest songbirds show avoidance of habitats subjected to noise disturbances (Bayne et al. 2008; McClure et al. 2013), while other species (e.g., crows, gulls) are likely habituated or more tolerant of regular human disturbance during periods of foraging or roosting (Verbeek and Butler 1999). Studies suggest some great blue herons may respond to noise disturbances or natural predators by abandoning their nests, which results in indirect mortality of young due to starvation or exposure to weather (i.e., rain or cold), while others are more tolerant of anthropogenic environments (Vennesland and Butler 2004, Environment Canada 2016). The use of rookeries located in disturbed, fragmented habitat (e.g., Stanley Park rookery) can be dynamic (Environment Canada 2016). Although the size of the heronry at the Stanley Park varies between years, herons are expected to be habituated to routine urban disturbances (e.g., vehicle traffic) (SPES 2006, 2016, Environment Canada 2016). This rookery is approximately 1.5 km from the Lord Roberts Annex; therefore, Project activities at the Annex are not expected to result in disturbance to the rookery.

Poor waste management can also lead to human-wildlife conflict (e.g., garbage serving as an attractant for crows, racoons, skunks, etc.). Contemporary practices can be effective in reducing conflicts resulting in animal removal or the destruction of nuisance animals (BC MOE 2016).

Adherence to applicable legislation and regulations, and implementation of mitigation measures (see below) are expected to reduce residual effects of these activities on birds and other wildlife.

4.3.8.2.2 Electromagnetic Fields at Lord Roberts Annex

As with potential effects of EMFs on birds and other wildlife at Emery Barnes and Nelson parks, low level EMF exposure is not expected to affect fertility, navigation, immune system health, or foraging behaviour (Dell'Omo et al. 2009; BC Hydro 2017b,c; EMFS 2017a).

To assess baseline EMF levels at the Lord Roberts Annex, BC Hydro measured magnetic field levels at several locations within the park during non-peak hours on January 21, 2017. Peak magnetic field levels could not be measured at this location due to a security fence, but EMF levels along the southwest perimeter of the fence ranged from 0.4 to 9 mG (see Appendix E). The Lord Roberts Annex is expected to be moved from its current location to the west side of the underground substation where no transmission or distribution cables will occur. Accordingly, the above-ground EMF levels are not expected to deviate from current baseline levels.

A full discussion of the potential effects of EMFs to birds and other wildlife is provided in Electromagnetic Fields at Emery Barnes Park. Similar to results from Emery Barnes and Nelson parks, current and predicted EMF exposure levels at the Lord Roberts Annex are well below the 2,000 mG ICNIRP guideline. A recent review of the literature (2012-2016) indicates there is no new evidence that changes the conclusion of both Health Canada and World Health Organization that there are no confirmed health consequences associated with exposure to low level electromagnetic fields (Exponent, 2017). Accordingly, EMF-related effects to birds and other wildlife at this location are expected to be low.

Operational effects of the Lord Roberts Annex Replacement Project on birds and other wildlife are negligible, and replanting trees will replace habitat lost for birds and other wildlife.

Additional studies related to EMF can be found in appendix E and G of this report.

4.3.8.3 Mitigation Measures

The following mitigation measures are recommended to reduce effects of construction and operation of the proposed Nelson Park/Annex Project on birds and other wildlife. These measures are conceptual only, and will be finalized prior to construction in consultation with the Vancouver Parks Board and VSB.

- Construction
  - The Project will consider and incorporate design strategies to reduce the magnetic fields from underground transmission cables, to the extent feasible (e.g., depth of cable placement, mu-metal shielding, optimize conductor spacing and phasing). These strategies will further lower EMF levels further below the ICNIRP guideline value of 2,000 mG.

- In accordance with Environment Canada's policy on Avoidance of Detrimental Effects to Migratory Birds and the BC Wildlife Act, pre-construction vegetation clearing activities and demolition of the school building will occur outside of the breeding season for migratory birds (March 28 through August 8) and raptors (February 5 through August 31) to avoid incidental take of birds (BC MOE 2013; ECCC 2017).
- If clearing or disturbance to bird nesting habitats, including demolition of the school building, is required during the migratory bird breeding season, surveys will be conducted by a qualified biologist in advance of clearing or demolition of the building, and nest-specific mitigation measures will be implemented by the qualified biologist to minimize the potential for incidental take, in compliance with the Migratory Birds Regulations of the MBCA and the BC Wildlife Act. No-disturbance setbacks will be established around active nests and clearly marked to show the extent of clearing (BC MOE 2013, 2014; ECCC 2017). Vegetation clearing and construction activities will be prohibited within no-disturbance setbacks for the period of time the nests remain active, as determined by the qualified biologist.
- Waste management practices will be managed or mitigated through guidelines and best practices to eliminate or reduce potential wildlife attractants to negligible levels. Waste will be temporarily stored onsite in wildlife-proof containers and disposed of regularly at an approved facility (BC MOE 2016).

- Post-Construction
  - Tree protection or replacement measures, outlined for Vegetation (see Vegetation Mitigation Measures and Appendix D will limit effects of habitat loss to birds and other wildlife.
  - Consistent with the City of Vancouver's *Bird Friendly Design Guidelines* (2014c), tree replacement and landscaping will consider, to the extent feasible:
  - Establishing native mature trees and fruit-bearing shrubs
  - Consider continuous forest canopy and the location and spacing of tree planting
  - Increase vertical vegetation structure and complexity by incorporating coniferous and deciduous trees, shrubs, and grasses into landscape features
  - Incorporate a diversity of native trees, shrubs, and plants into landscape design (including seed, fruit, and nectar bearing species)
  - Retain and/or incorporate wildlife trees, snags, and downed wood to support cavity nesting and foraging.

4.3.8.4 Recommendations for Future Study

Given the timelines between when this study was completed and when construction is scheduled to occur, it is recommended that a pre-construction survey be completed by a qualified biologist to re-assess the presence of wildlife habitat features of concern (e.g., raptor nests, wildlife trees) within the Annex limits.

5.0 REFERENCES

Bayne, E.M., L. Habib, and S. Boutin. 2008. Impacts of chronic anthropogenic noise from energy-sector activity on abundance of songbirds in the boreal forest. Conservation Biology, 22(5): 1,186–1,193.

BC Conservation Data Center (BC CDC). 2017. BC Species and Ecosystems Explorer. Available at: http://a100.gov.bc.ca/pub/eswp/. Accessed: January 2017.

BC Housing. 2014. Section 7: Crime Prevention through Environmental Design in BC Housings Design and Construction Standards. Available at: file:///C:/Users/kesims/Downloads/CrimePreventionThroughEnvironmentalDesignSpecifications.pdf. Accessed: January 18, 2016.

BC Hydro. 2008. BC Hydro Report: Downtown Vancouver Outage: July 14, 2008. BC Hydro to British Columbia Utility Commission. Available at: http://collaboration/sites/ES/BC/1232/he/se/Projects/2017/bc%20hydro%20DVES/Research%20-%20Public%20Safety/BC%20Hydro%20Report_Cathedral%20Square%20Downtown%20Vancouver%20Outage_July%2014_2008.pdf/. Accessed: January 2017.

BC Hydro. 2016. BC Hydro's Occupational Safety and Health Standards. Available at: https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/safety/bchydro-osh-standards-guidelines.pdf. Accessed: January 2017.

BC Hydro. 2017a. Seed: a power smart innovation. 2017. Community consultation: interests and ideas. Available at: bchydro.com/seed. Accessed: January 2017.

BC Hydro. 2017b. Powerlines and your health. Available at: http://www.bchydro.com/safety-outages/power-lines-and-your-health/emf-and-your-health.html. Accessed: February 2017.

BC Hydro. 2017c. Understanding Electric and Magnetic Fields. Available at: http://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/safety/understanding-emf-booklet-jan2017.pdf. Accessed: February 2017.

British Columbia Ministry of Environment (BC MOE). 2013. Guidelines for Raptor Conservation during Urban and Rural Land Development in British Columbia (2013). Victoria, BC.

British Columbia Ministry of Environment (BC MOE). 2014. Develop with Care 2014: Environmental Guidelines for Urban and Rural Land Development in British Columbia. Available at: http://www.env.gov.bc.ca/wld/documents/bmp/devwithcare/index.html#Main. Accessed: January 2017.

British Columbia Ministry of Environment (BC MOE). 2016a. Personal Communication with Robles, Jerome A. Air Data and Systems Management Specialist. Environmental Monitoring, Reporting & Economics, Victoria, BC. Email conversations. June 21, 2016.

British Columbia Ministry of Environment (BC MOE). 2016b. A Guide to Solid Waste Management Planning. Available at: http://www2.gov.bc.ca/assets/gov/environment/waste-management/garbage/swmp.pdf. Accessed: January 2017.

BC Ministry of Transportation and Highways. 1999. Ministry of Transportation and Highways Engineering Branch, 1999 – Traffic Control Manual for Work on Roadways. Available at: http://www.th.gov.bc.ca/publications/eng_publications/tcm/tcm_consolidated_1999.pdf Accessed: January 2017.

City of Vancouver. 2012. Climate Change Adaptation Strategy. Available at: http://vancouver.ca/files/cov/Vancouver-Climate-Change-Adaptation-Strategy-2012-11-07.pdf. Accessed: January 2017.

City of Vancouver. 2013. What feeds us: The Vancouver Food Strategy. Available at: http://vancouver.ca/files/cov/vancouver-food-strategy-brochure-what-feeds-us.pdf. Accessed: January 2017.

City of Vancouver. 2014a. City of Vancouver Urban Forest Strategy. Available at: http://vancouver.ca/files/cov/Urban-Forest-Strategy-Draft.pdf. Accessed: January 2017.

City of Vancouver. 2014b. Section 4.5 – Tree Permits; of Protection of Tree Bylaw 9958. Available at: http://vancouver.ca/your-government/protection-of-trees-bylaw.aspx. Accessed: January 2017

City of Vancouver 2014c. Draft City of Vancouver Bird Strategy. Available at: http://vancouver.ca/files/cov/vancouver-bird-strategy-draft-2014-09-01.pdf. Accessed: January 2017.

City of Vancouver. 2014d. Draft City of Vancouver Bird Friendly Design Guidelines Explanatory Note. Available at: http://vancouver.ca/files/cov/bird-friendly-strategy-design-guidelines-draft-2014-09-01.pdf. Accessed: January 2017.

City of Vancouver. 2015a. Renewable City Strategy: our future to 2050. Available at: http://vancouver.ca/files/cov/renewable-city-strategy-2015.pdf. Accessed: January 2017.

City of Vancouver. 2015b. A Healthy City for All – Healthy City Strategy – Four Year Action Plan 2016-2018 Phase 2. Available at: http://vancouver.ca/files/cov/Healthy-City-Strategy-Phase-2-Action-Plan-2015-2018.pdf. Accessed: January 2017.

City of Vancouver. 2016. Street and Traffic By-Law No. 2849. A Bylaw to Regulate Traffic and Use of Streets in the City of Vancouver. Available at: http://former.vancouver.ca/bylaws/2849c.PDF. Accessed: January 2017.

City of Vancouver. 2017a. Green Vancouver; Greenest City Action Plan. Available at: http://vancouver.ca/green-vancouver/greenest-city-action-plan.aspx. Accessed: January 2017.

City of Vancouver. 2017b. Open Data Catalogue: Vancouver Street Trees. Available at: http://data.vancouver.ca/datacatalogue/streetTrees.htm. Accessed: January 2017.

City of Vancouver. 2017c. Emery Barnes Park. Available at: http://covapp.vancouver.ca/parkfinder/parkdetail.aspx?inparkid=20. Accessed: January 2017.

City of Vancouver. 2017d. Protection of Trees Bylaw 9958. Available at: http://vancouver.ca/your-government/protection-of-trees-bylaw.aspx. Accessed: January 2017.

City of Vancouver. 2017e. Erosion & Sediment Control Large Lot Development (More Than 1,000 m2). Available at: http://bulletins.vancouver.ca//2002/2002-003.pdf. Accessed: January 2017.

City of Vancouver 2017f. Wildlife. Available at: http://vancouver.ca/parks-recreation-culture/wildlife.aspx. Accessed: January 2017.

City of Vancouver. 2017g. Nelson Park. Available at: http://covapp.vancouver.ca/parkfinder/parkdetail.aspx?inparkid=203. Accessed: January 2017.

Cornell Lab of Ornithology. 2017. eBird. Available at: http://ebird.org/content/ebird/. Accessed: January 2017.

Dell'Omo, G., D. Constantini, V. Lucini, G. Antonucci, R. Nonno, A. Polichetti. 2009. Magnetic fields produced by power lines do not affect growth, serum melatonin, leukocytes and fledging success in wild kestrels. Comparative Biochemistry and Physiology, Pact c, 150: 372-376.

Environment Canada. 2016. Management Plan for the Great Blue Heron fannini subspecies (*Ardea herodias fannini*) in Canada [Proposed]. Species at Risk Act Management Plan Series. Environment Canada, Ottawa. iii + 26 pp.

Environment and Climate Change Canada (ECCC). 2002. Sulphur in Diesel Fuel Regulations, SOR/2002-253. July 2002.

Environment and Climate Change Canada (ECCC). 2012. http://ec.gc.ca/lcpe-cepa/default.asp?lang=En&n=5C98F8FB-1. Accessed January 2017.

Environment and Climate Change Canada (ECCC). 2017. General Nesting Periods for Migratory Birds in Canada. Available at: https://www.ec.gc.ca/paom-itmb/default.asp?lang=En&n=4F39A78F-1. Accessed: January 2017.

EMFS Info (EMFS). 2017a. EMFs, agriculture, and the environment – Animals and plants. Available at: http://www.emfs.info/effects/agriculture/. Accessed: February 2017.

EMFS Info (EMFS). 2017b. Underground power cables. Accessed: http://www.emfs.info/sources/underground/. Available: February 2017.

Exponent, Inc. (2017). Electric and Magnetic Fields and Health: Review of the Scientific Research from March 1, 2012 to December 31, 2016. February 14, 2017.

Foster A., City of Vancouver Assistant Fire Chief. Personal communications. Telephone interview. January 26, 2017.

Greenest City Action Team. 2009. Vancouver 2020: A Bright Green Future; An action Plan for Becoming the World's Greenest City by 2020. Available at: http://vancouver.ca/files/cov/bright-green-future.pdf. Accessed: January 2015.

Health Canada. 2016. Electric and magnetic fields from power lines and electrical appliances. Available at: https://www.canada.ca/en/health-canada/services/home-garden-safety/electric-magnetic-fields-power-lines-electrical-appliances.html. Accessed: January 2017.

Important Bird Areas Canada. 2017. English Bay and Burrard Inlet, Vancouver, British Columbia. Available at: http://www.ibacanada.com/site.jsp?siteID=BC020. Accessed: January 2017.

International Commission on Non-Ionizing Radiation Protection (ICNIRP). 2010. ICNIRP Guidelines for limiting exposure to time-varying electric and magnetic fields (1 Hz – 100 kHz). Available at: http://www.icnirp.org/cms/upload/publications/ICNIRPLFgdl.pdf. Accessed: January 2017.

McClure, C.J.W., H.E. Ware, J. Carlisle, G. Kaltenecker and J.R. Barber. 2013. An experimental investigation into the effects of traffic noise on distributions of birds: avoiding the phantom road. Proceedings of the Royal Society B 280: 1-9.

Metro Vancouver, 2012. Station Information: Lower Fraser Valley Air Quality Monitoring Network. Available at: http://www.metrovancouver.org/services/air-quality/AirQualityPublications/2012LowerFraserValleyAirQualityMonitoringReport.pdf. Accessed: January 2017.

Metro Vancouver. 2016. Metro Vancouver's Ambient Air Quality Objectives. Available at: http://www.metrovancouver.org/services/air-quality/AirQualityPublications/CurrentAmbientAirQualityObjectives.pdf. Accessed: January 2017.

National Crime Prevention Council (NCPC). 2003. Crime Prevention Through Environmental Design Guidebook. Available at: http://www.popcenter.org/tools/cpted/PDFs/NCPC.pdf. Accessed: January 17, 2016.

PWL Partnership Landscape Architects Inc. 2015. Vancouver Board of Parks and Recreation Park Development Standards. Prepared for Vancouver Board of Parks and Recreation. Available at: http://vancouver.ca/files/cov/VPB_Design_Standards_20150515.pdf. Accessed: January 2017.

Rescan. 2010. Section 13: Accidents and Malfunctions in Northwest Transmission Line Project: Application for an Environmental Assessment Certificate. British Columbia Transmission Corporation (BCTC). Available at: http://a100.gov.bc.ca/appsdata/epic/documents/p299/d32054/1271430890678_70679abae257b77cb049dd0d5f020cc53ffd95d0f7999c6e6f7df1d4e533615c.pdf. Accessed: January 2017.

Stanley Park Ecological Society (SPES). 2006. Stanley Park Heronry Management Plan. Vancouver, BC. 7 pp.

Stanley Park Ecological Society (SPES). 2016. Stanley Park Heronry Annual Report 2016. Vancouver, BC. 70 pp.

US Environmental Protection Agency (US EPA). 2004. Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling- Compression-Ignition. April 2004. Available at: http://www.epa.gov/OMS/models/nonrdmdl/nonrdmdl2004/420p04009.pdf.

Vancouver Bird Advisory Committee. 2015. Vancouver Bird Strategy; City of Vancouver. Available at: http://vancouver.ca/files/cov/vancouver-bird-strategy.pdf. Accessed: January 2017.

Vancouver Board of Parks and Recreation (Park Board). 2012. Park Board Strategic Framework. Available at: http://vancouver.ca/files/cov/park-board-strategic-plan-presentation-20120627.pdf. Accessed: January 2017.

Vancouver Board of Parks and Recreation (Park Board). 2013. The Local Food Action Plan of the Vancouver Park Board. Available at: http://vancouver.ca/files/cov/Local-food-action-plan.pdf. Accessed: January 2017.

Vancouver Board of Parks and Recreation (Park Board). 2014. Rewilding Vancouver; From Sustaining to Flourishing. An Environmental Education and Stewardship Action Plan for the Vancouver Park Board. Available at: http://vancouver.ca/files/cov/enviromental-education-stewardship-action-plan.pdf. Accessed: January 2017.

Vancouver Board of Parks and Recreation (Park Board). 2015. Park Board Urban Agriculture Policy. Available at: http://vancouver.ca/files/cov/park-board-urban-agriculture-policy.pdf. Accessed: January 2017.

Vancouver Board of Parks and Recreation (Park Board). 2016a. Vancouver Board of Parks and Recreation Biodiversity Strategy. Available at: http://parkboardmeetings.vancouver.ca/2016/20160201/REPORT_BiodiversityStrategy20160201.pdf. Accessed: January 2017.

Vancouver Board of Parks and Recreation (Park Board). 2016b. Parks Provision Standard and Metrics Study, 2016. Vancouver Board of Parks and Recreation.

Vancouver School Board (VSB). 1996a. Policy Manual: FNA-R-2 Use of Facilities and Grounds for K - 12: Use of School Grounds for Creative Play Areas. Available at: http://www.vsb.bc.ca/district-policy/fna-r-2-use-facilities-and-grounds-k-12-use-school-grounds-creative-play-areas . Accessed: January 2017.

Vancouver School Board (VSB). 1996b. Policy Manual: FNA-R-3 Use of Facilities and Grounds for K-12: Use of School Grounds for Garden Plots. Available at: http://www.vsb.bc.ca/district-policy/fna-r-3-use-facilities-and-grounds-k-12-use-school-grounds-garden-plots. Accessed: January 2017.

Vancouver School Board (VSB). 2010. Sustainability Framework for the Vancouver School Board. Available at: http://www.vsb.bc.ca/sites/default/files/publications/SUSTAINABILITY%20FRAMEWORK%202.pdf. Accessed: January 2017.

Vancouver School Board (VSB). 2016. Vancouver School Board Strategic Plan 2016-2021. Available at: http://www.vsb.bc.ca/sites/default/files/publications/strategic-plan.pdf. Accessed: January 2017.

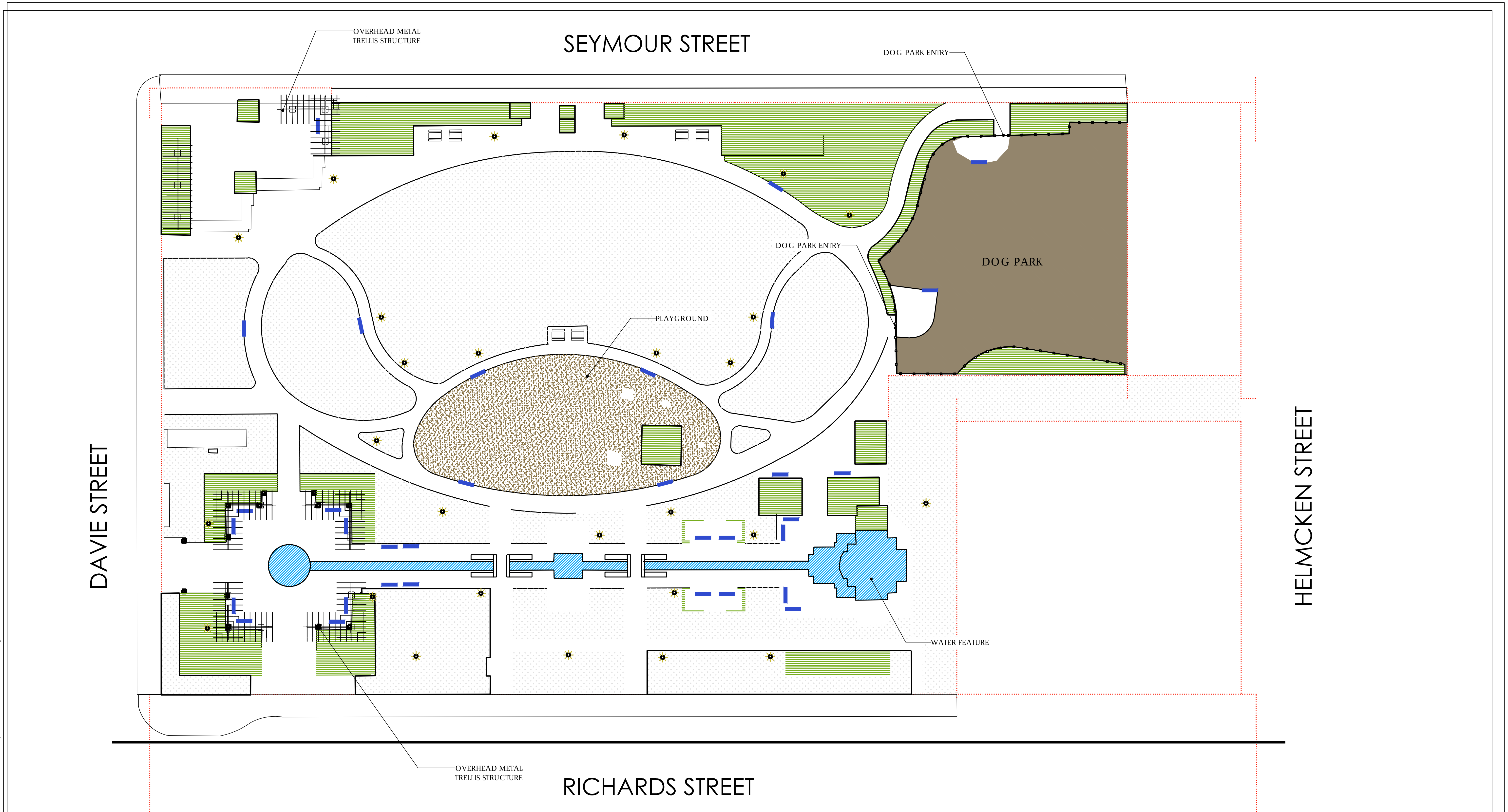
Vennesland, R.G. and R.W. Butler. 2004. Factors Influencing Great Blue Heron Nesting Productivity on the Pacific Coast of Canada from 1998 to 1999. Waterbirds 27(3): 289–296.

Verbeek, N.A. and R.W. Butler. 1999. Northwestern Crow (Corvus caurinus), The Birds of North America (P. G. Rodewald, Ed.). Ithaca: Cornell Lab of Ornithology. Available at: https://birdsna.org/Species-Account/bna/species/norcro. Accessed: January 2017.

WorkSafeBC .2009. WorkSafeBC OHS Regulation, Part 18: Traffic Control. Available at: https://www.worksafebc.com/en/law-policy/occupational-health-safety/searchable-ohs-regulation/ohs-regulation/part-18-traffic-control. Accessed: January 2017.

APPENDICES

APPENDIX A FIGURES



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ORIGINAL SHEET - ANSI B

February, 2017
123220785

Stantec

111 Dunsmuir Street
Vancouver, BC
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Legend/ Notes

GROSS AREA: 10,528 sq.m.
PARK AREA (BACK OF SIDEWALK TO BACK OF SIDEWALK): 9,408 sq.m.

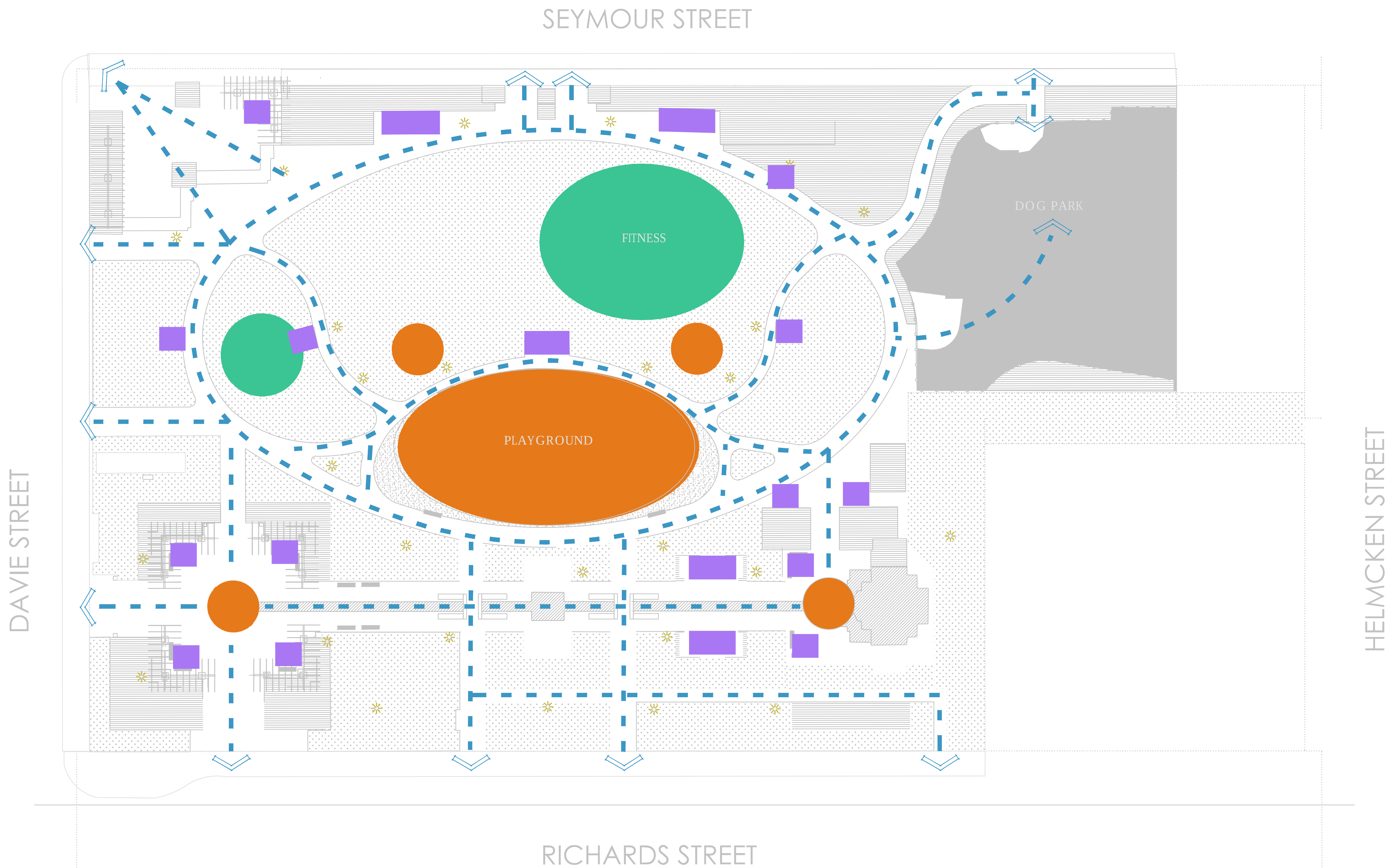
OPEN GRASSED AREA 3,988 sq.m.	RUBBER TILES (PLAYGROUND AREA) 567 sq.m.	METAL FENCE (DOG PARK) 94 l.m.
PLANTING BED 1,198 sq.m.	DIRT (DOG PARK) 850 sq.m.	PIC NIC TABLES 6
WATER FEATURE 199 sq.m.	CONCRETE PAVING (PARK) 2,660 sq.m.	BENCHES 33
		LAMP STANDARDS 28

Client/Project

BC Hydro SEED Program Study
EMERY BARNES PARK

Figure No.
A.1-1

Title
PARK INVENTORY



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Legend/ Notes

SITTING

PLAYING

FITNESS

WALKING/JOGGING

Client/Project

BC Hydro SEED Program Study
EMERY BARNES PARK

Figure No.

A.1-2

Title

PARK PROGRAMMING

\\10.1.152.28\workgroup\1169\active\11694_land_arch\other PC Projects\temp_BC_Hydro\05_drawings\05-01_current\figures\Emery Barnes Park\EBP_A.1-3_intensity_of_use.dwg
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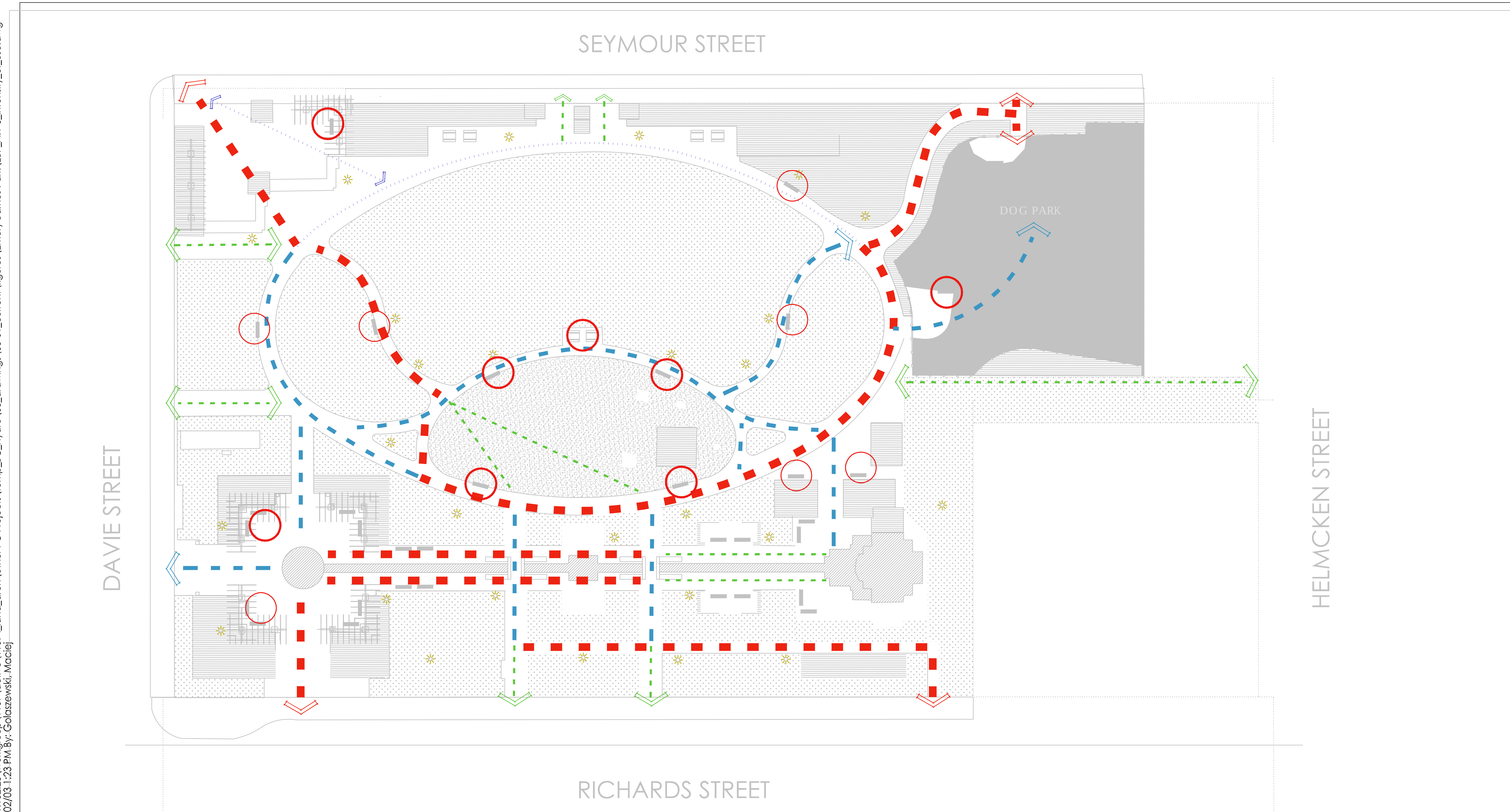

ORIGINAL SHEET - ANSI B

February, 2017
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Client/Project

BC Hydro SEED Program Study
EMERY BARNES PARK

Figure No.
A.1-3

Title
INTENSITY OF USE

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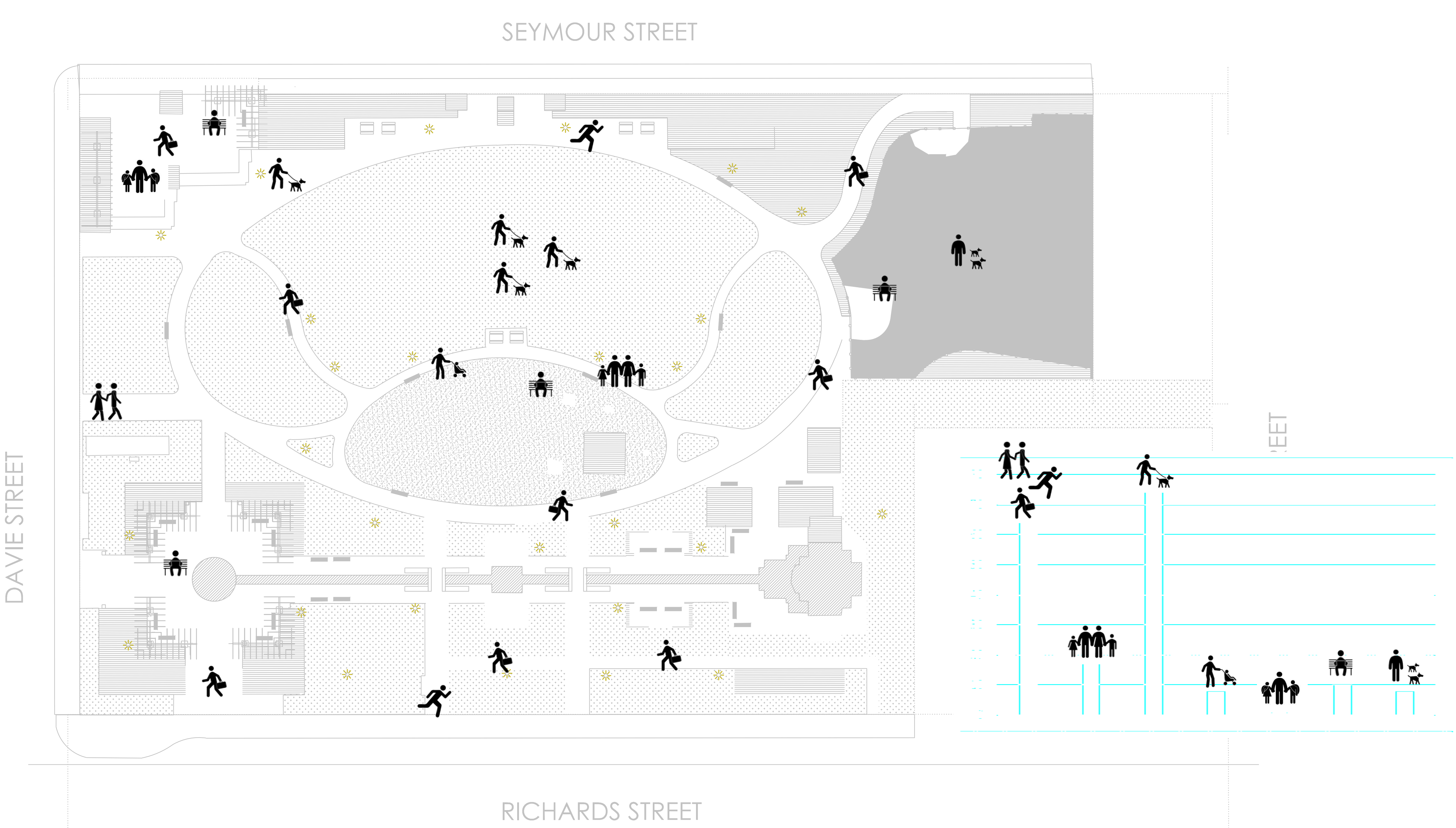
Legend/ Notes

- PRIMARY ROUTE OF TRAVEL
- SECOND FREQUENTED ROUTE OF TRAVEL
- THIRD FREQUENTED ROUTE OF TRAVEL
- CASUAL WALKING
- MOST FREQUENTED SITTING SPOT (BENCH SELECTED MORE OFTEN)
- MOST FREQUENTED SITTING SPOT (BENCH SELECTED LESS OFTEN)



ORIGINAL SHEET - ANSI B

February, 2017
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Legend/ Notes

- STROLLERS (MOM/DAD WITH STROLLER)
- COMMUTERS (FAST PEOPLE WALING TO WORK)
- DOG WALKERS (ONE PERSON WITH DOG ON A LEASH)
- BENCH DWELLLERS
- DOG PARK USERS
- SCHOOL WALKERS (PARENT & CHILD)
- CASUAL WALKER
- FAMILIES
- JOGGERS
- GARDEN TENDER

Client/Project

BC Hydro SEED Program Study
EMERY BARNES PARK

Figure No.
A.1-4

Title
TYPES OF USERS (WEEKDAYS)

ORIGINAL SHEET - ANSI B

February, 2017
123220785

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Legend/ Notes

- STROLLERS (MOM/DAD WITH STROLLER)
- COMMUTERS (FAST PEOPLE WALING TO WORK)
- DOG WALKERS (ONE PERSON WITH DOG ON A LEASH)
- BENCH DWELLLERS
- DOG PARK USERS
- SCHOOL WALKERS (PARENT & CHILD)
- CASUAL WALKER
- FAMILIES
- JOGGERS
- GARDEN TENDER

Client/Project
BC Hydro SEED Program Study
EMERY BARNES PARK

Figure No.
A.1-5

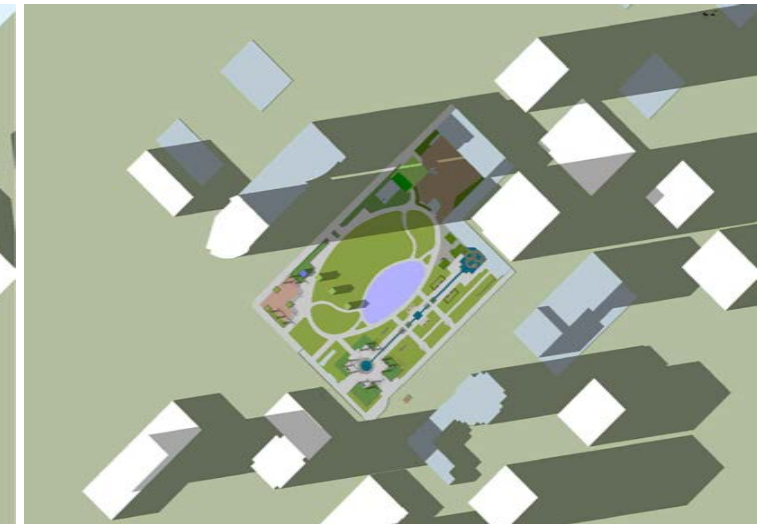
Title
TYPES OF USERS (WEEKENDS)

SUMMER TIME (June 21st):

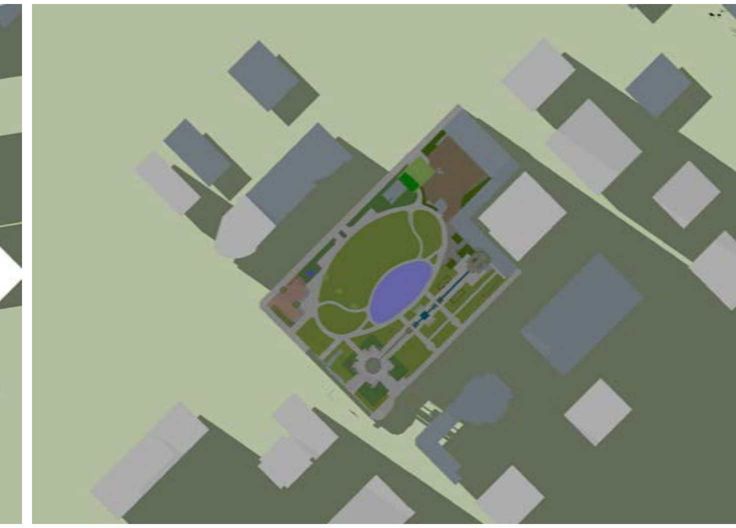
9 a.m.

12 p.m.

4 p.m.



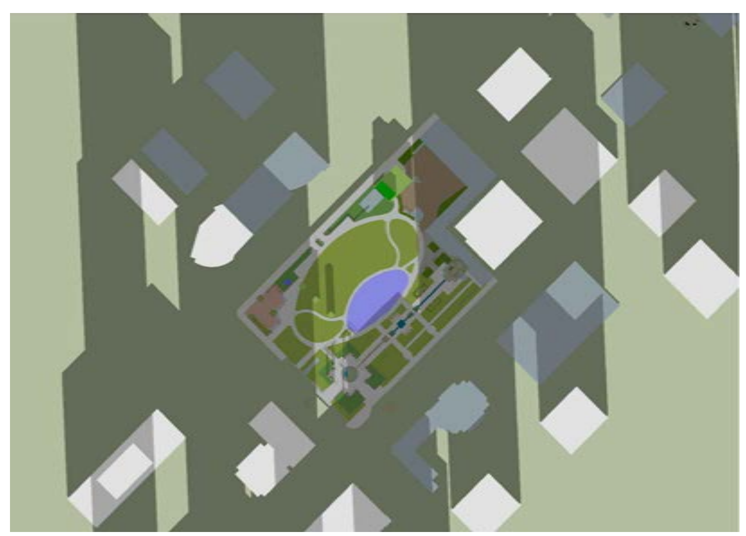
8 p.m.



WINTER TIME (December 22nd):

9 a.m.

12 p.m.



4 p.m.

TRUE NORTH

February, 2017
123220785

Legend/ Notes

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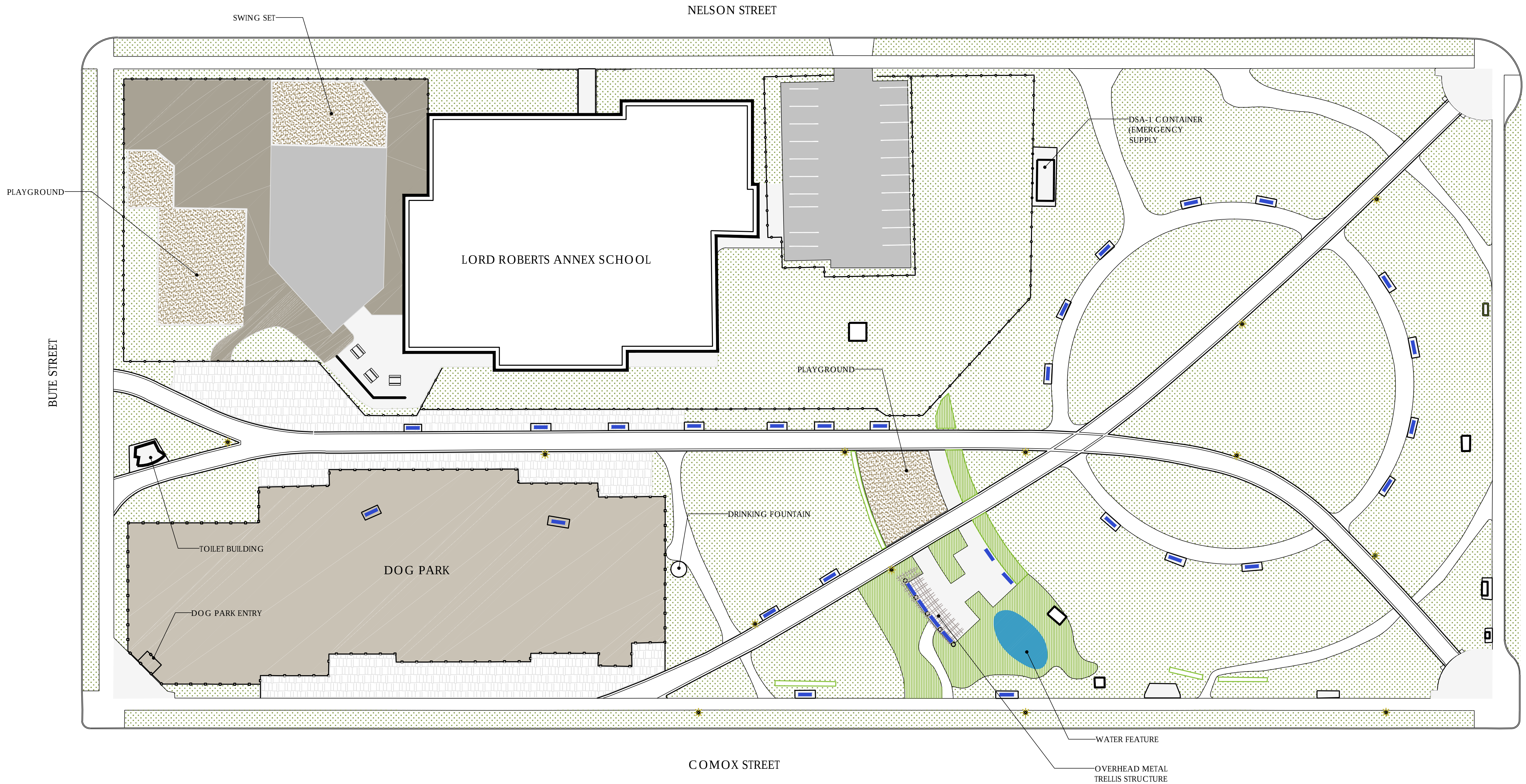
Client/Project

BC Hydro SEED Program Study
EMERY BARNES PARK

Figure No.
A.1-6

Title
SUN ANALYSIS



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2017/02/03 1:38 PM By: Golaszewski, Maciej

ORIGINAL SHEET - ANSI B

February, 2017
123220785

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Legend/ Notes

GROSS AREA: 21,617 sq.m.
PARK AREA (BACK OF SIDEWALK TO BACK OF SIDEWALK): 19,123 sq.m.

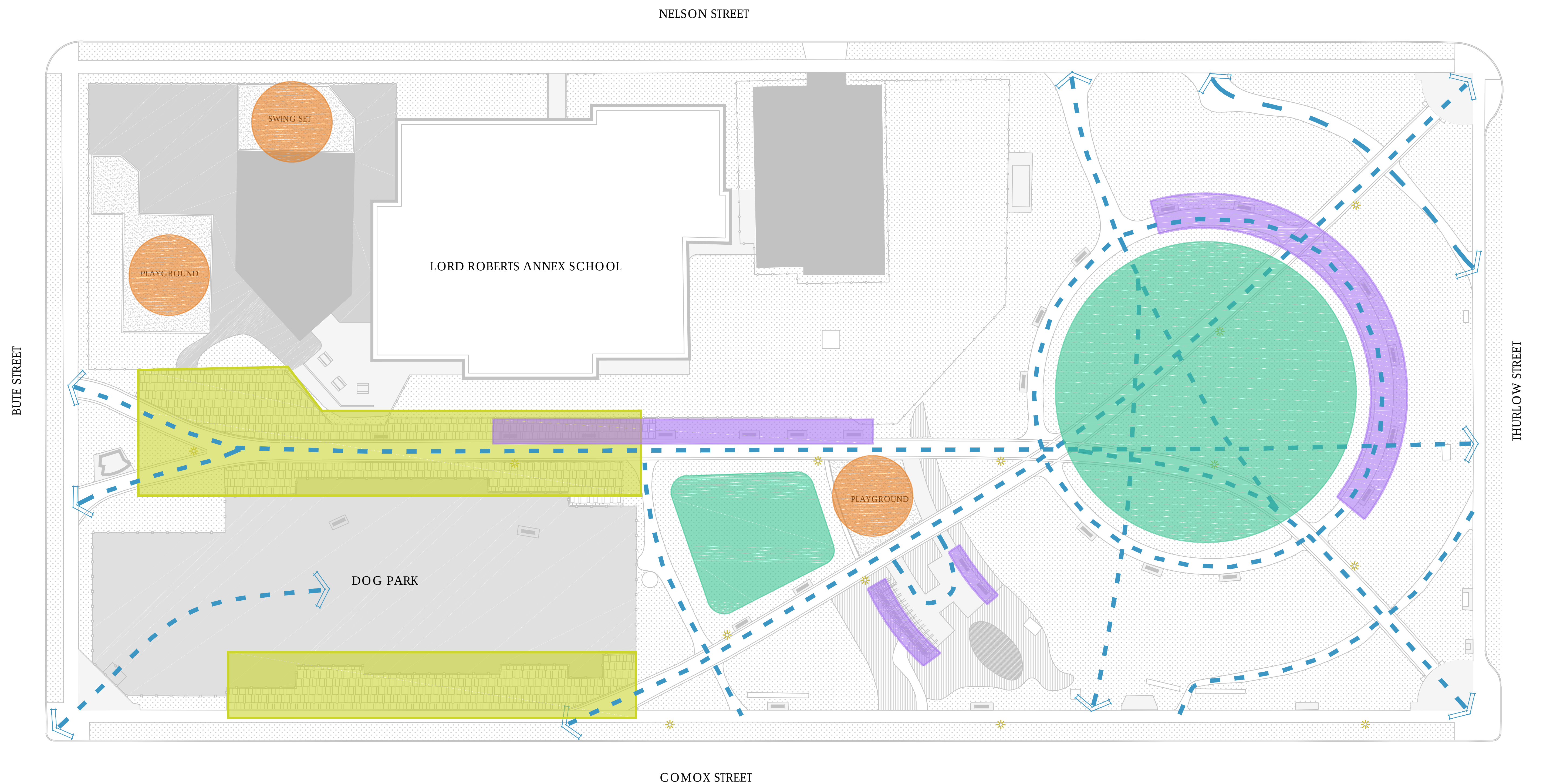
OPEN GRASSED AREA	9,638 sq.m.
PLANTING BED	383 sq.m.
AGRICULTURE PLOTS	868 sq.m.
SAND (PLAYGROUND AREA)	560 sq.m.
DIRT (DOG PARK)	2071 sq.m.
DIRT (SCHOOL GROUND)	503 sq.m.
CONCRETE PAVING	743 sq.m.
GRAVEL	1647 sq.m.
FENCE (CHAIN LINK)	386 l.m.
METAL FENCE (DOG PARK)	226 l.m.
POST AND RAIL	47 l.m.
PIC NIC TABLES	3 (each)
BENCHES	31 (each)
LAMP STANDARDS	13 (each)

Client/Project

BC Hydro SEED Program Study
NELSON PARK

Figure No.
A.1-1

Title
PARK INVENTORY



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2017/02/03 1:45 PM By: Golaszewski, Maciej

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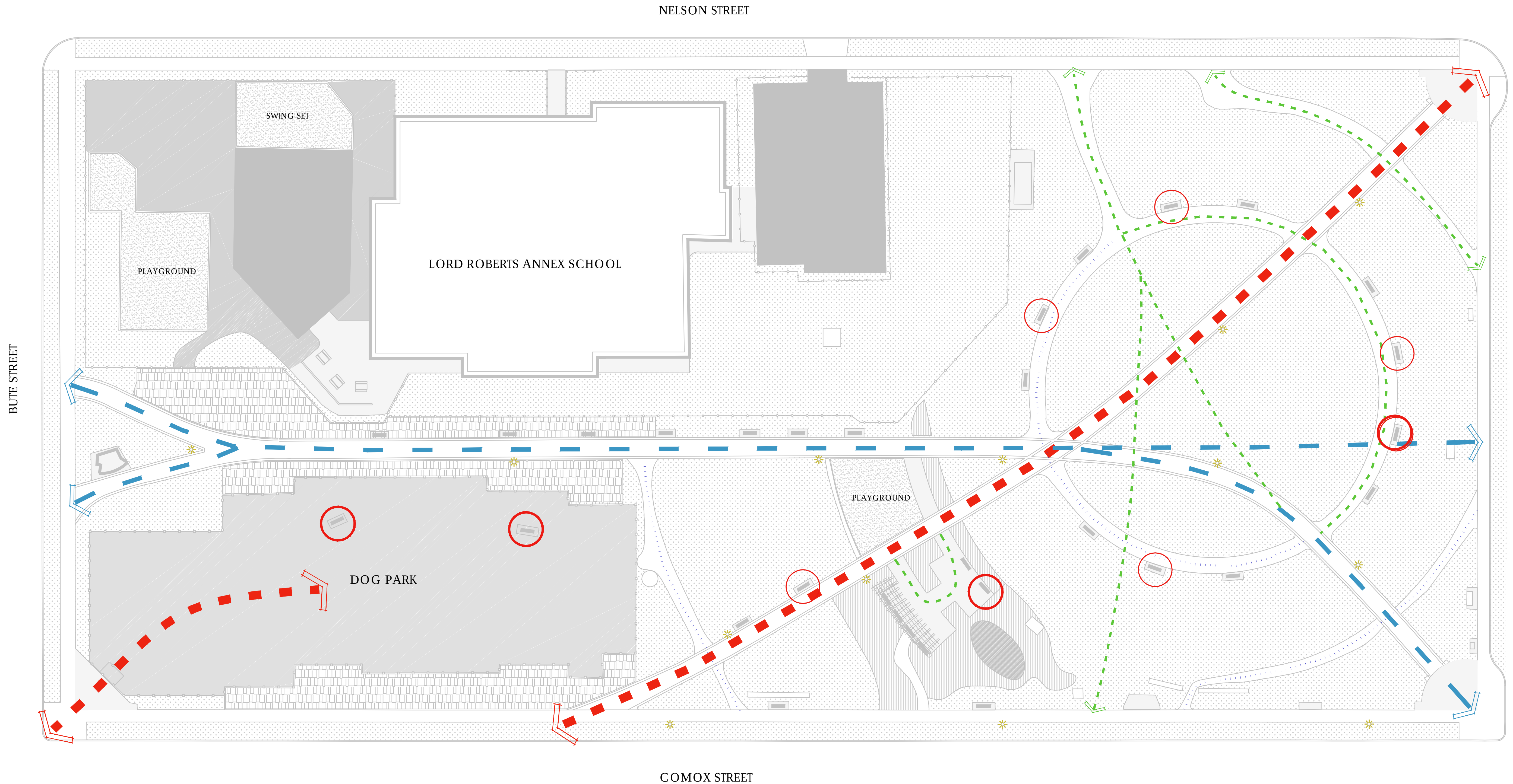
Legend/ Notes

- ACTIVE GARDENING
- SITTING
- PLAYING
- FITNESS
- WALKING/JOGGING

Client/Project
BC Hydro SEED Program Study
NELSON PARK

Figure No.
A.1-2

Title
PARK PROGRAMMING & USE



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2017/02/03 1:47 PM By: Golaszewski, Maciej

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Legend/ Notes

PRIMARY ROUTE OF TRAVEL

SECOND FREQUENTED ROUTE OF TRAVEL

THIRD FREQUENTED ROUTE OF TRAVEL

CASUAL WALKING

MOST FREQUENTED SITTING SPOT (BENCH SELECTED MORE OFTEN)

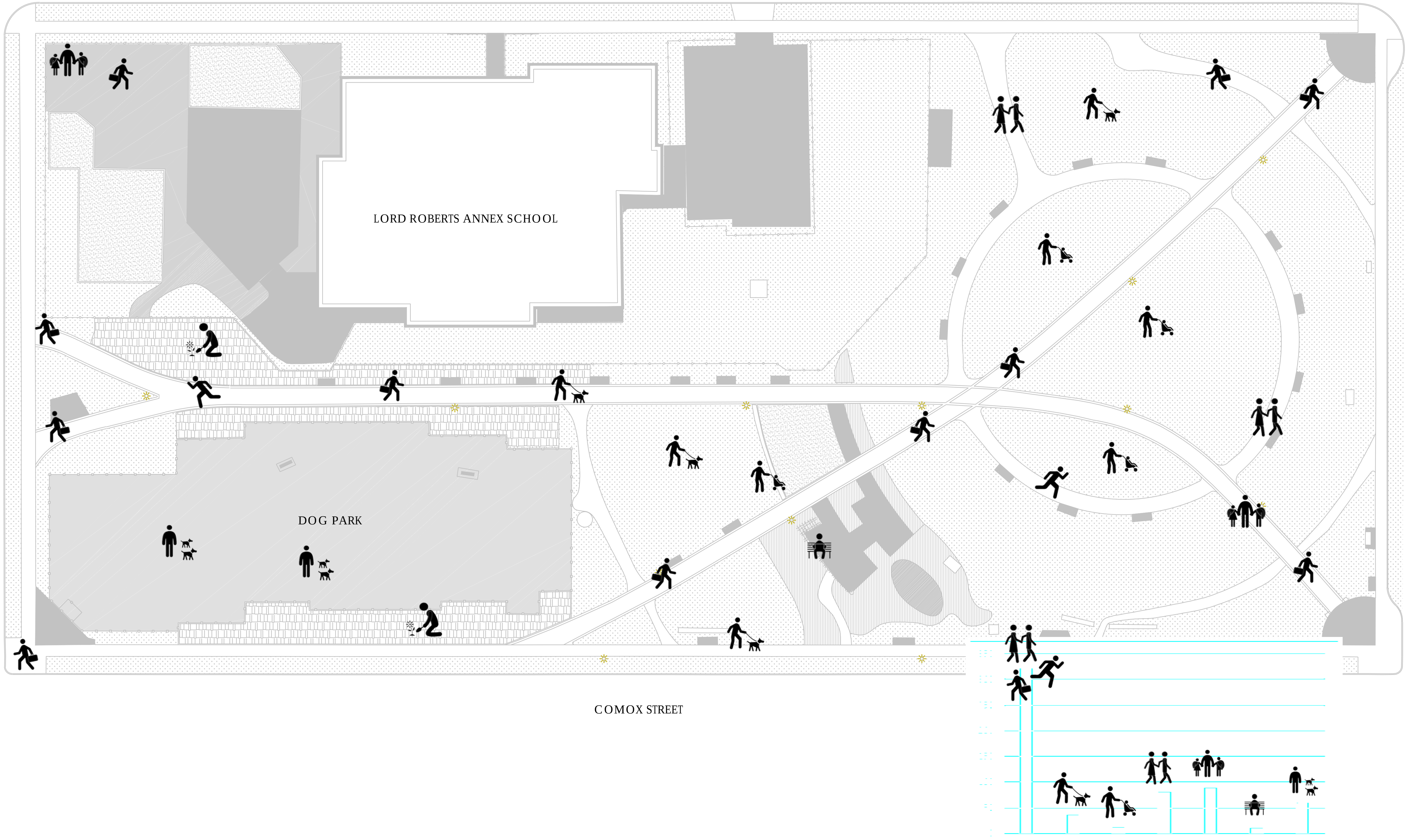
MOST FREQUENTED SITTING SPOT (BENCH SELECTED LESS OFTEN)

Client/Project

BC Hydro SEED Program Study
NELSON PARK

Figure No.
A.1-3

Title
INTENSITY OF USE



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February, 2017
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Legend/ Notes

- STROLLERS (MOM/DAD WITH STROLLER)
- COMMUTERS (FAST PEOPLE WALING TO WORK)
- DOG WALKERS (ONE PERSON WITH DOG ON A LEASH)
- BENCH DWELLLERS
- DOG PARK USERS
- SCHOOL WALKERS (PARENT & CHILD)
- CASUAL WALKER
- FAMILIES
- JOGGERS
- GARDEN TENDER

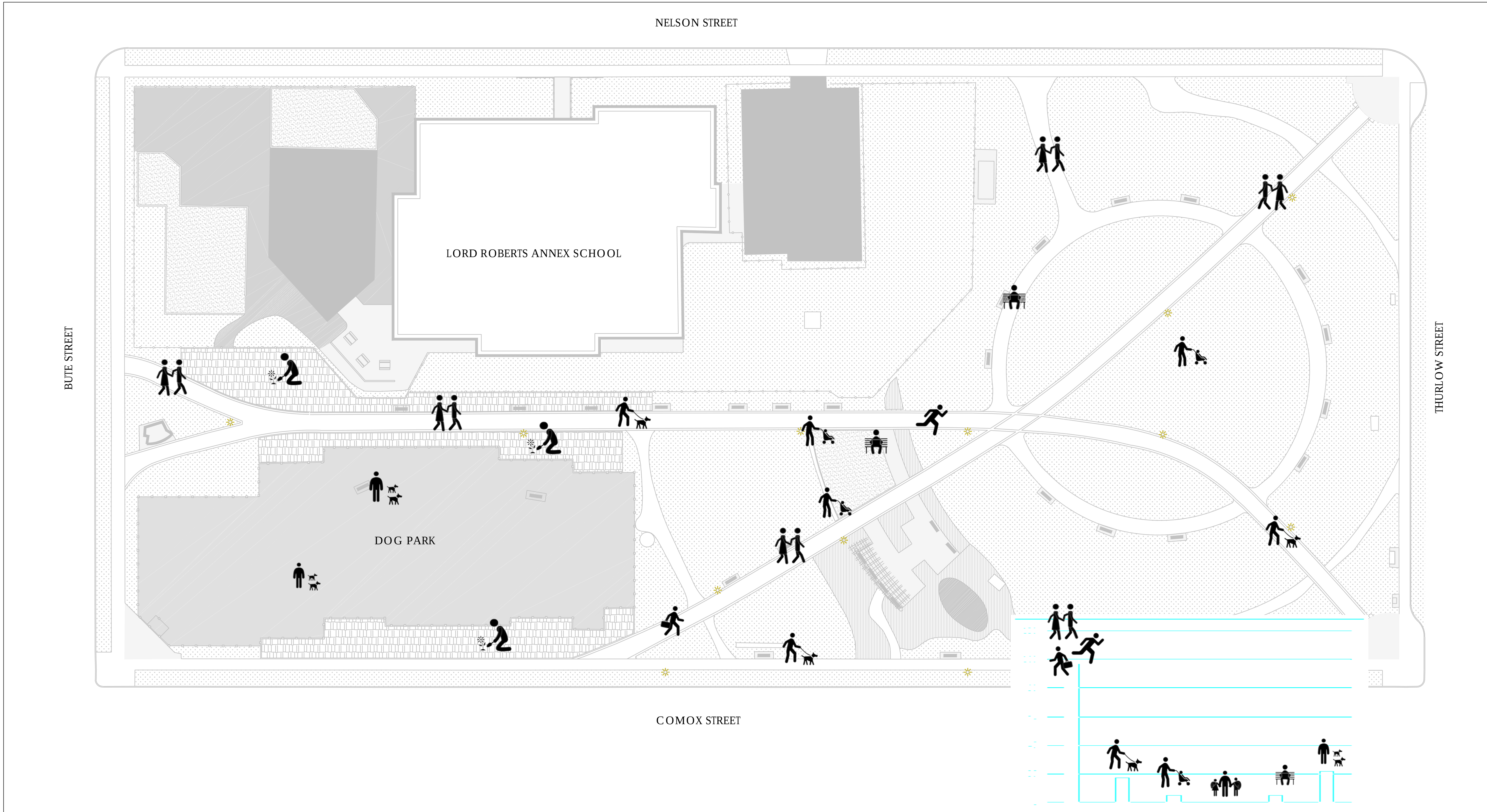
Client/Project

BC Hydro SEED Program Study
NELSON PARK

Figure No.
A.1-4

Title
TYPES OF USERS (WEEKDAYS)

\\10.1.152.28\workgroup\1169\active\11694_land_arch\other PC Projects\temp_BC_Hydro\05_drawings\05-01_current\figures\Nelson Park\NP_A.1-5_types Of Users_weekend.dwg
2017/02/03 1:55 PM By: Golaszewski, Maciej



ORIGINAL SHEET - ANSI B

February, 2017
123220785

Legend/ Notes

- STROLLERS (MOM/DAD WITH STROLLER)
- COMMUTERS (FAST PEOPLE WALING TO WORK)
- DOG WALKERS (ONE PERSON WITH DOG ON A LEASH)
- BENCH DWELLLERS
- DOG PARK USERS
- SCHOOL WALKERS (PARENT & CHILD)
- CASUAL WALKER
- FAMILIES
- JOGGERS
- GARDEN TENDER

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Client/Project
BC Hydro SEED Program Study
NELSON PARK

Figure No.
A.1-5

Title
TYPES OF USERS (WEEKEND)

SUMMER TIME (June 21st):

9 a.m.

12 p.m.

4 p.m.

8 p.m.

WINTER TIME (December 22nd):

9 a.m.

12 p.m.

4 p.m.

TRUE NORTH

ORIGINAL SHEET - ANSI B

February, 2017
123220785

Legend/ Notes

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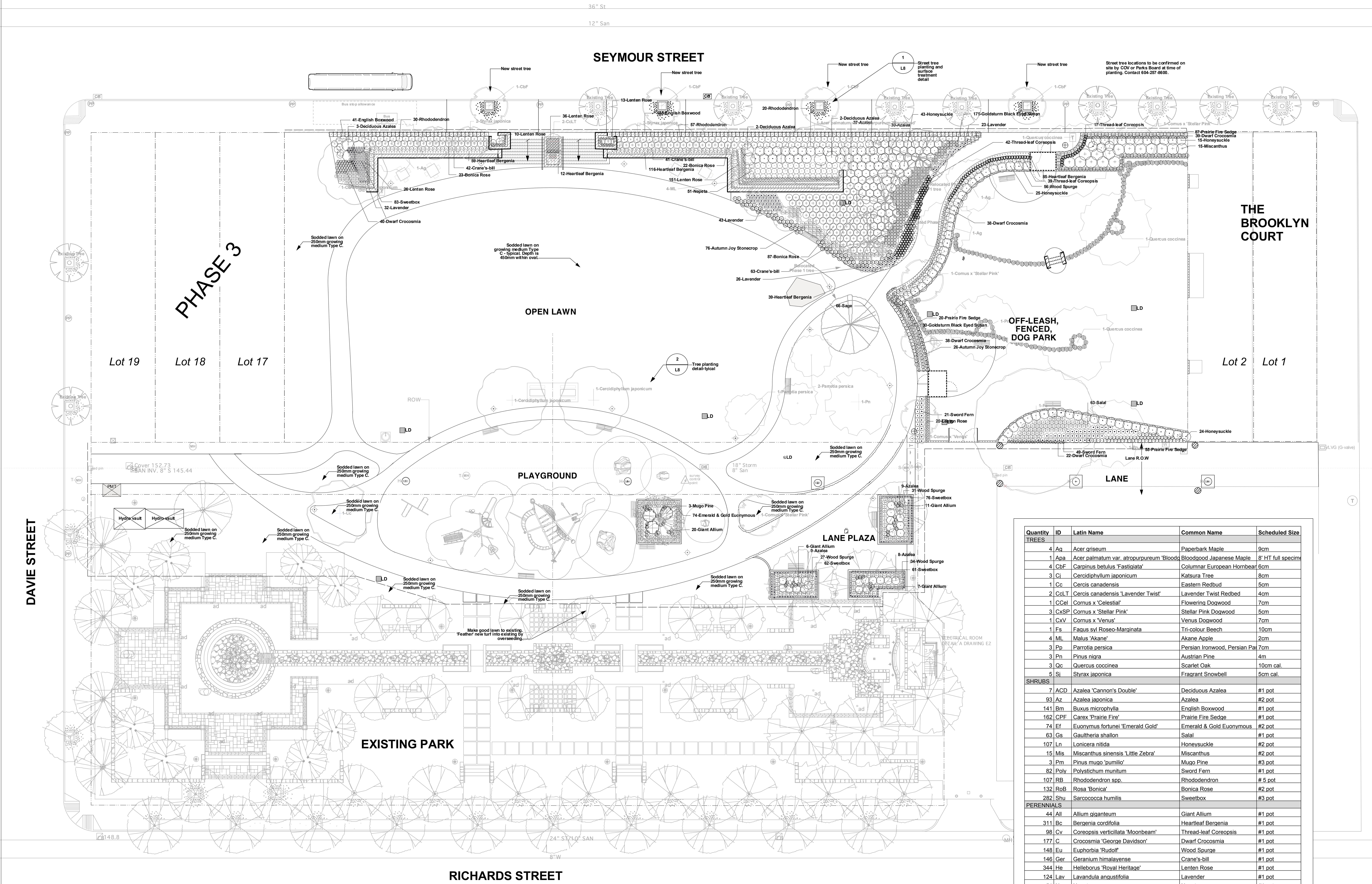
BC Hydro SEED Program Study
NELSON PARK

Figure No.
A.1-6

Title
SUN ANALYSIS

\\10.1.152.28\workgroup\1169\active\11694_land_arch\other PC Projects\temp_BC_Hydro\05_drawings\05-01_current\figures\Nelson Park\NP_A.1-6_Sun_analysis.dwg
2017/02/03 3:57 PM By: Golaszewski, Maciej



Quantity	ID	Latin Name	Common Name	Scheduled Size
TREES				
4	Ag	Acer griseum	Paperbark Maple	9cm
1	Apa	Acer palmatum var. atropurpureum 'Bloodg	Bloodgood Japanese Maple	8' HT full specime
4	CbF	Carpinus betulus 'Fastigiata'	Columnar European Hornbear	6cm
3	Cj	Cercidiphyllum japonicum	Katsura Tree	8cm
1	Cc	Cercis canadensis	Eastern Redbud	5cm
2	CcLT	Cercis canadensis 'Lavender Twist'	Lavender Twist Redbed	4cm
1	CCel	Cornus x 'Celestial'	Flowering Dogwood	7cm
3	CxSP	Cornus x 'Stellar Pink'	Stellar Pink Dogwood	5cm
1	CxV	Cornus x 'Venus'	Venus Dogwood	7cm
1	Fs	Fagus syl Roseo-Marginata	Tri-colour Beech	10cm
4	ML	Malus 'Akane'	Akane Apple	2cm
3	Pp	Parrotia persica	Persian Ironwood, Persian Par	7cm
3	Pn	Pinus nigra	Austrian Pine	4m
3	Qc	Quercus coccinea	Scarlet Oak	10cm cal.
5	Sj	Styrax japonica	Fragrant Snowbell	5cm cal.
SHRUBS				
7	ACD	Azalea 'Cannon's Double'	Deciduous Azalea	#1 pot
93	Az	Azalea japonica	Azalea	#2 pot
141	Bm	Buxus microphylla	English Boxwood	#1 pot
162	CPF	Carex 'Prairie Fire'	Prairie Fire Sedge	#1 pot
74	Ef	Euonymus fortunei 'Emerald Gold'	Emerald & Gold Euonymous	#2 pot
63	Gs	Gaultheria shallon	Salal	#1 pot
107	Ln	Lonicera nitida	Honeysuckle	#2 pot
15	Mis	Miscanthus sinensis 'Little Zebra'	Miscanthus	#2 pot
3	Pm	Pinus mugo 'pumilio'	Mugo Pine	#3 pot
82	Poly	Polystichum munitum	Sword Fern	#1 pot
107	RB	Rhododendron spp.	Rhododendron	# 5 pot
132	RoB	Rosa 'Bonica'	Bonica Rose	#2 pot
282	Shu	Sarcococca humilis	Sweetbox	#3 pot
PERENNIALS				
44	All	Allium giganteum	Giant Allium	#1 pot
311	Bc	Bergenia cordifolia	Heartleaf Bergenia	#1 pot
98	Cv	Coreopsis verticillata 'Moonbeam'	Thread-leaf Coreopsis	#1 pot
177	C	Crocosmia 'George Davidson'	Dwarf Crocosmia	#1 pot
148	Eu	Euphorbia 'Rudolf'	Wood Spurge	#1 pot
146	Ger	Geranium himalayense	Crane's-bill	#1 pot
344	He	Helleborus 'Royal Heritage'	Lenten Rose	#1 pot
124	Lav	Lavandula angustifolia	Lavender	#1 pot
51	N	Nepeta sp.	Nepeta	#1 pot
205	RfG	Rudbeckia fulgida 'Goldsturm'	Goldsturm Black Eyed Susan	#1 pot
66	S	Salvia sp.	Sage	#1 pot
102	Sed	Sedum 'Autumn Joy'	Autumn Joy Stonecrop	#2 pot

Contact COV at time of installation of street trees: 604-257-8600

Rhododendrons to be comprised of, and to be laid out on site:
50 Rhododendron Helensky University
27 Rhododendron Nova Zembla
13 Rhododendron Bruce Bretchbhill
17 Rhododendron Catabiense Album

Vancouver Board
of Parks and Recreation

2099 Beach Avenue
Vancouver B.C. V6G 1Z4
Tel: 604-257-8400

RECORD DRAWINGS
This record drawing has been prepared based upon information furnished by Cedar Crest Lands Ltd (the contractor). While the information is believed to be reliable, the Registered Professional does not assure or certify its accuracy, and thus is not responsible for the accuracy of this record drawing, or for any errors or omissions which may have been incorporated into it as a result. Those relying on this record drawing are advised to obtain independent verification of its accuracy before applying it for any purpose.
Date: July, 2010

Jonathan Losee Ltd.
Landscape Architecture

#102 - 1661 W. 2nd Avenue, Vancouver, B.C.
ph: 604-669-1003 fax: 604-669-0402

with:

DEC Design Ltd.
Mechanical Engineering
Suite 309 - 713 Columbia Street
New Westminster, B.C.
V3M 1B2

MMM Group
Electrical Engineering
Suite 215 - 3993 Henning Drive
Burnaby, B.C.
V5C 6P7

LUSH DESIGNS LTD.
Irrigation Consulting
Suite 317 - 9672 134 th Street
Surrey, B.C.
V3T 5L5

WEILER SMITH BOWERS
Structural Engineers
Suite 118 - 3855 Henning Drive
Burnaby, BC
V5C 6N3

Rev.No.	REVISION	DATE	NAME
	Issue for As-Built	July 6, 2010	KZ
7	Issue for Site Instruction SI-L11	Apr 14, 2010	KZ
6	Issue for Site Instruction SI-L09	Mar 17, 2010	KZ
5	Issue for Site Instruction SI-L07	Jan 21, 2010	KZ
4	Issue for CCO-L04	Jan 11, 2010	KZ
3	Issue for Site Instruction SI-6	Nov 04, 2009	KZ
2	Issue for C.C.O - L-01	Oct 07, 2009	KZ
	Issue for Construction	Sept 18, 2009	KZ
1	Issue for Addendum L4	April 28, 2009	KZ
	Issue for Tender	April 6, 2009	KZ
	For Client Review	Dec. 16 2008	KZ
	For Client Review	Oct. 30 2008	KZ
	For Consultant Review	Sept. 30 2008	KZ

PROJECT
Emery Barnes Park
Phase 2

TITLE
Planting Plan

DRAWING No. **L-3**

SCALE	PROJECT No.	DATE	REV.
1:200	2008-19	September 2008	
DESIGNED BY: JL	DRAWN BY: KZ	CHECKED BY:	

GROWING MEDIUM SPECIFICATION EXCERPT

(Refer to Growing Medium Specification 02920)

1.7 SUBMITTALS
1.7.1 Submit to the VPB Project Manager a copy of an analysis by an approved independent soil testing laboratory, (such as Pacific Soil Analysis; Mr. Bill Herman, #5 11720 Voyageur Way, Richmond B.C. Ph. 273-8226). The analysis shall be of tests done on the proposed growing medium and additives proposed for the work from samples taken at the supply source, within three weeks immediately prior to growing medium placement. Costs of the initial analysis, and subsequent tests to ensure compliance with the specification shall be borne by the Contractor. Failure to submit soils analysis is cause for immediate rejection of any placed growing medium. The Contractor is responsible for testing the on -site soil to determine its suitability for amendment to meet specifications of this Section to serve as the growing medium.

1.7.2 The analysis shall include a breakdown of the following components: total nitrogen by weight, available levels of phosphorous, potassium, calcium, magnesium, soluble salt content, organic matter by weight, and pH value. In addition, the analysis shall clearly indicate the Project Name, Date Tested and Contractor□s Name.

1.7.3 Submit with the above analysis, the testing laboratory's recommendations for amendments, fertilizers and other modifications to make the proposed growing medium meet the requirements of this specification.

1.7.4 Submit to the VPB Project Manager one composite sample of each type of proposed growing medium for each different application within the project (e.g. lawns, shrubs). Each sample shall be a composite of at least three samples from the proposed source and shall be at least one (1) litre in volume.

1.7.5 At the discretion of the VPB Project Manager, submit up to two additional samples, including samples of proposed additives to the growing medium from material delivered to the site as required to ascertain compliance with this specification. Results of these tests shall be submitted to the VPB Project Manager for approval.

1.7.6 After the completion of the soils analysis, a one litre sample of the completed/mixed growing medium, including all amendments shall be submitted at least twenty-one (21) days before placement of growing medium to allow for evaluation of samples and testing for noxious weed content by Vancouver Park Board. VPB will advise of test results.

1.9 PRODUCT HANDLING
1.9.1 DO NOT MOVE OR WORK GROWING MEDIUM OR ADDITIVES WHEN THEY ARE EXCESSIVELY WET, EXTREMELY DRY, OR FROZEN OR IN ANY MANNER WHICH WILL ADVERSELY AFFECT GROWING MEDIUM STRUCTURE. Growing medium whose structure has been destroyed by handling under these conditions will be rejected.

2.6 SAND/ORGANIC MIX (TYPE S/O)
2.6.1 This growing medium shall be a homogenous mix of approved sand and approved compost with the following composition BY DRY WEIGHT, AFTER MIXING:

For PLANTING BEDS growing medium shall consist of the following AFTER MIXING (% BY DRY WEIGHT):

75% round sand (>0.074mm-<2mm)	Nutrient Content :
0-5% max silt (>0.053mm - <0.063mm)	Nitrogen 0.2 - 0.6%
0-5% max clay (2 microns - 4 microns)	Phosphorus : 50 -150ppm
Total fines max. 5%	Potassium 50 - 300 ppm
15% organic matter	C/N ratio max 25 : 1
pH 5 .0 to 6.0	

For LAWN AREAS growing medium shall consist of the following AFTER MIXING (% BY DRY WEIGHT):

85% round sand (>0.05mm-<2mm)	Nutrient Content :
0-5% max silt (>0.053mm - <0.063mm)	Nitrogen 0.2 - 0.6%
0-5% max clay (2 microns - 4 microns)	Phosphorus : 50 -150ppm
Total fines max. 5%	Potassium 50 - 300 ppm
7-8% organic matter	C/N ratio max 25 : 1
pH 6 .0 to 6.5	

2.6.2 Provide a 1 litre sample and a particle size analysis of the sand proposed for use. Provide an additional 1 litre sample and particle size analysis from the third quarter volume of sand delivered to the site.

2.6.3 ALL GROWING MEDIUM TO BE PRE MIXED, TESTED AND APPROVED PRIOR TO DELIVERY ON SITE.

3.3 PLACING GROWING MEDIUM - ALL TYPES
3.3.1 Growing medium shall be moist(25% to 75% of field capacity) but not wet when placed. It shall not be handled in anyway if it is wet or frozen. Refer to 1.9.

3.3.2 Place all growing medium to the required finished grades. Except where drawings or details show otherwise, place to the following minimum depths and levels (measured after initial settling of growing medium):

Depths:
Tree Planting Areas on grade 600mm(24") minimum or depth of root ball, whichever is greater. For as large an area as possible around the base of each tree. Recommended 10m2 or twice the size of the root ball whichever greater. Refer to Section 02950

Shrub and Groundcover Areas on grade 450mm (18") minimum depth

Low or High Traffic Lawn
Areas on grade 150mm (6") minimum depth

PLANTING KEY ⚠1

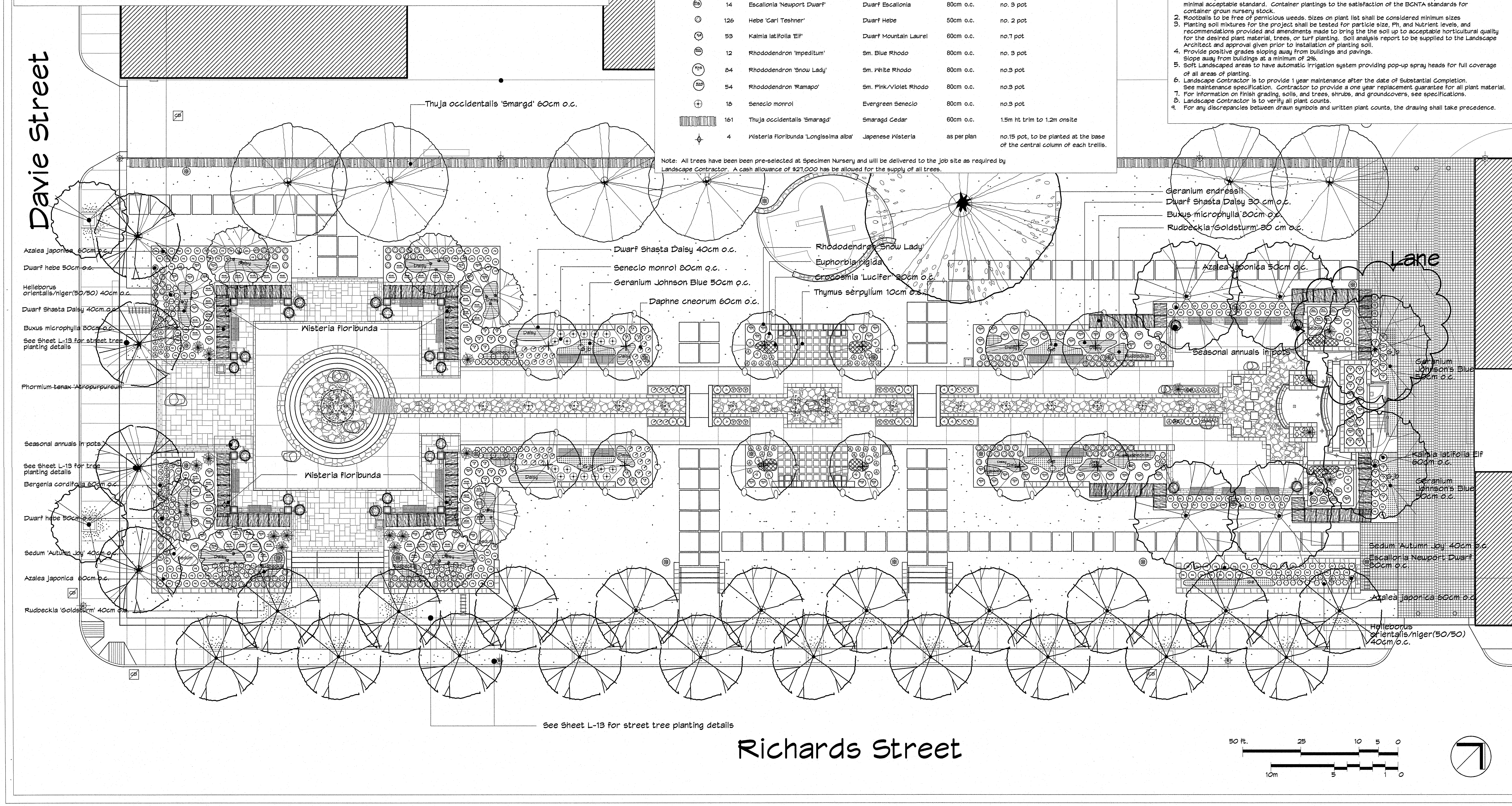
Symbol	Qty.	Botanical Name	Common Name	Spacing	Remarks
Trees					
	4	Prunus yedoensis 'Akebono'	Daybreak Cherry	as shown	48" WB, 14cm cal. Wt 1500lbs
	2	Prunus serrulata 'Kwanzan'	Kwanzan Cherry	as shown	WB, 6cm cal. min.
	20	Pyrus calleryana 'Chanticleer'	Chanticleer Pear	as shown	WB, 10cm cal.
	8	Acer palmatum spp.	Japanese Maple species	as shown	Multistemmed, 3.5m ht.
	6	Acer rubrum	Red Maple	as shown	WB, 12cm cal. Wt.1800 lbs
	6	Cercidiphyllum japonicum	Katsura Tree	as shown	WB, 10cm cal.
	12	Styrax japonicus	Japanese Snowbell	as shown	WB, 6cm cal.
	1	Quercus rubra	Red Oak	as shown	30cm cal., 12m ht, Wt. 16,000 lbs
Shrubs					
	200	Buxus microphylla 'Green Beauty'	Boxwood Hedge	80cm o.c.	no. 5 pot, 0.6m tall
Az	180	Azalea japonica 'Hino Crimson'	Dwarf Azalea	60cm o.c.	no.3 pot
	54	Daphne cneorum	Fragrant Daphne	60cm o.c.	no. 3 pot
Es	14	Escallonia 'Newport Dwarf'	Dwarf Escallonia	80cm o.c.	no. 3 pot
	126	Hebe 'Carl Teshner'	Dwarf Hebe	50cm o.c.	no. 2 pot
Ka	53	Kalmia latifolia 'Elf'	Dwarf Mountain Laurel	60cm o.c.	no.7 pot
RhI	12	Rhododendron 'Impeditum'	Sm. Blue Rhodo	80cm o.c.	no. 3 pot
RhS	84	Rhododendron 'Snow Lady'	Sm. White Rhodo	80cm o.c.	no.3 pot
RhR	54	Rhododendron 'Ramapo'	Sm. Pink/Violet Rhodo	80cm o.c.	no.3 pot
	18	Senecio monroi	Evergreen Senecio	80cm o.c.	no.3 pot
	161	Thuja occidentalis 'Smaragd'	Smaragd Cedar	60cm o.c.	1.5m ht trim to 1.2m onsite
	4	Wisteria floribunda 'Longissima alba'	Japenese Wisteria	as per plan	no.15 pot, to be planted at the base of the central column of each trellis.

Note: All trees have been been pre-selected at Specimen Nursery and will be delivered to the job site as required by Landscape Contractor. A cash allowance of $27,000 has be allowed for the supply of all trees.

PLANTING KEY ⚠1

Symbol	Qty.	Botanical Name	Common Name	Spacing	Remarks
Perennials and Grasses					
	88	Bergenia cordifolia 'Perfect'	Bergenia	50cm o.c.	no. 1 pot
	100	Crocosmia 'Lucifer'	Monbretia	30cm o.c.	no.1 pot
	40	Euphorbia rigida	Spurge	80cm o.c.	no.1 pot
	6	Euphorbia myrsinites	Spurge	40cm o.c.	no.1 pot
Gjb	80	Geranium Johnson's Blue	Johnson's Blue Geranium	50cm o.c.	no.1 pot
Ge	50	Geranium endressii	Pink Geranium	50cm o.c.	no.1 pot
	103	Helleborus orientalis/niger (50/50)	Christmas Rose	40cm o.c.	no.1 pot
	375	Leucantemum superbum	Dwarf Shasta Daisy	30cm o.c.	no.1 pot
	17	Phormium tenax 'Atropurpeum'	New Zealand Flax	1.0m o.c.	no.1 pot
	100	Rudbeckia fulgida 'Goldsturm'	Black Eyed Susan	40cm o.c.	10cm pot
	160	Sedum 'Autumn Joy'	Stonecrop	40cm o.c.	10cm pot
	1000	Thymus pseudolanuginosus	Woolly Thyme	10cm o.c.	10cm pot
	1415 sq. m.	Sodded Lawn			

1. All landscape construction to meet the current edition of the BCNTA/BCSLA Landscape Standards as a minimal acceptable standard. Container plantings to the satisfaction of the BCNTA standards for container grown nursery stock.
2. Rootballs to be free of pernicious weeds. Sizes on plant list shall be considered minimum sizes
3. Planting soil mixtures for the project shall be tested for particle size, Ph, and Nutrient levels, and recommendations provided and amendments made to bring the the soil up to acceptable horticultural quality for the desired plant material, trees, or turf planting. Soil analysis report to be supplied to the Landscape Architect and approval given prior to installation of planting soil.
4. Provide positive grades sloping away from buildings and pavings. Slope away from buildings at a minimum of 2%.
5. Soft Landscaped areas to have automatic irrigation system providing pop-up spray heads for full coverage of all areas of planting.
6. Landscape Contractor is to provide 1 year maintenance after the date of Substantial Completion. See maintenance specification. Contractor to provide a one year replacement guarantee for all plant material.
7. For information on finish grading, soils, and trees, shrubs, and groundcovers, see specifications.
8. Landscape Contractor is to verify all plant counts.
9. For any discrepancies between drawn symbols and written plant counts, the drawing shall take precedence.



Re-issued for As Built September 17, 2003

⚠1 Revised plant list	
Re-issued for Construction	August 22, 2002
Issued for Construction	June 18, 2002
Issued for Addendum (Plotted at 50%)	March 25, 2002
Issued for Tender	March 13, 2002
Issued for Review	February 21, 2002
Issued for Review	February 7, 2002
Issued for Review	January 11, 2002

Revisions

Consultants

Stevenson + Associates
LANDSCAPE ARCHITECTS
Suite 220 - 1000 Roosevelt Crescent
North Vancouver, British Columbia
Telephone 987 - 2477 Facsimile 987 - 2478

Project Title

Downtown South Park
Vancouver, BC

For

Vancouver Board of Parks and Recreation

Sheet Title

Planting Plan

Contract	0116
Drawn	rs/mh
Checked	
Date	November 9, 2001
Scale	1:125
Sheet Number	7

L-3.1

Revision	By	Appd.	YY.MM.DD

Issued	By	Appd.	YY.MM.DD

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Permit-Seal

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The Contractor shall verify and be responsible for all dimensions. DO NOT scale the drawing - any errors or omissions shall be reported to Stantec without delay.

Client/Project
BC HYDRO
DOWNTOWN VANCOUVER
ELECTRICITY SUPPLY (DVES)

File Name:

Dwn.	Chkd.	Dsgn.	YY.MM.DD

Title
CONCEPT PLAN
EMERY BARNES PARK SITE

Project No.	Scale
123220785	1:250

Figure No.	Sheet	Revision
A. 9-1		0

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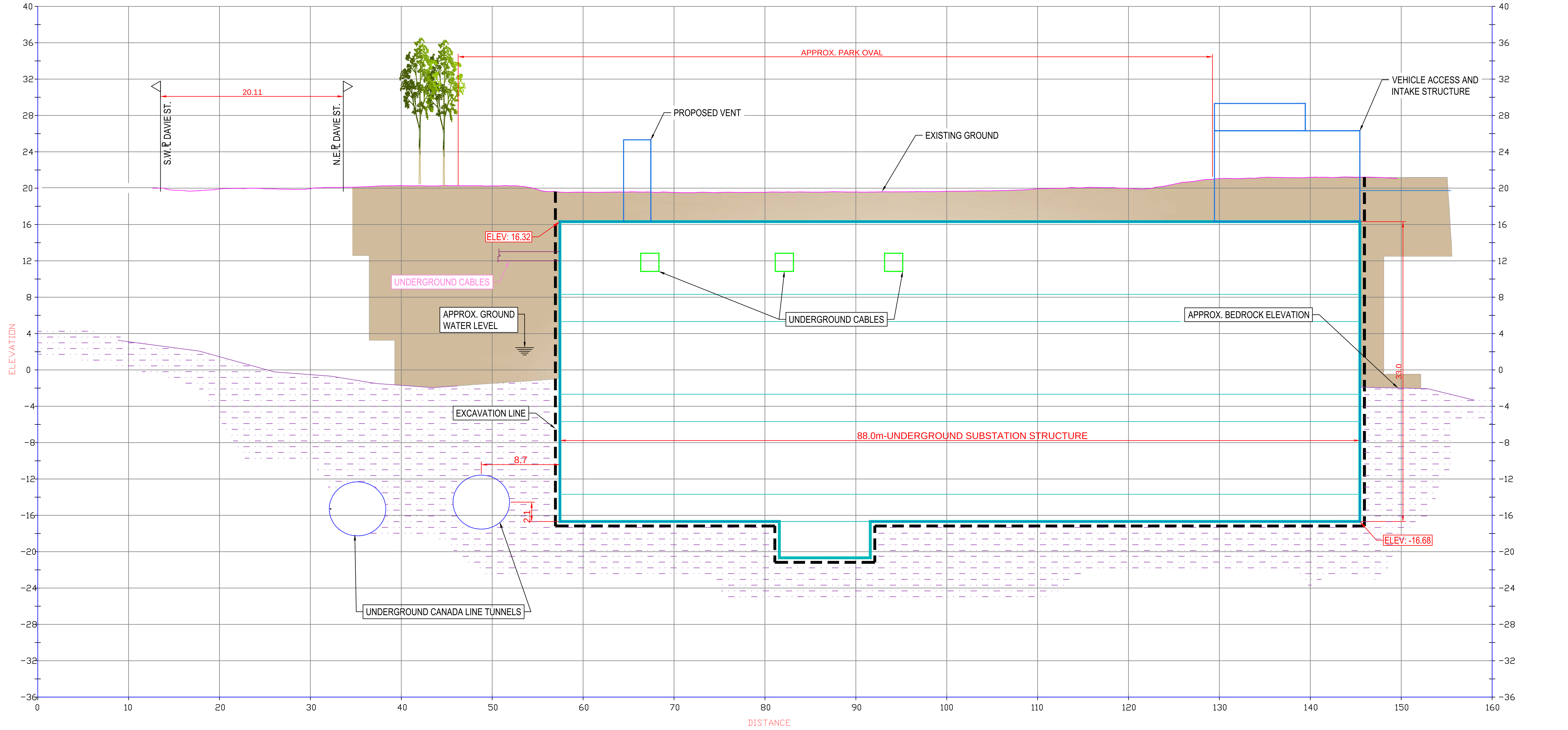
2017/02/01 9:18 AM By: Tirado, Joel

ORIGINAL SHEET - ISO A1



A-A
A. 9-1
SECTION
SCALE: 1:250 HORZ. 1:250 VERT.

FOR INFORMATION ONLY

Revision | By | Appd. | YY.MM.DD

Issued | By | Appd. | YY.MM.DD

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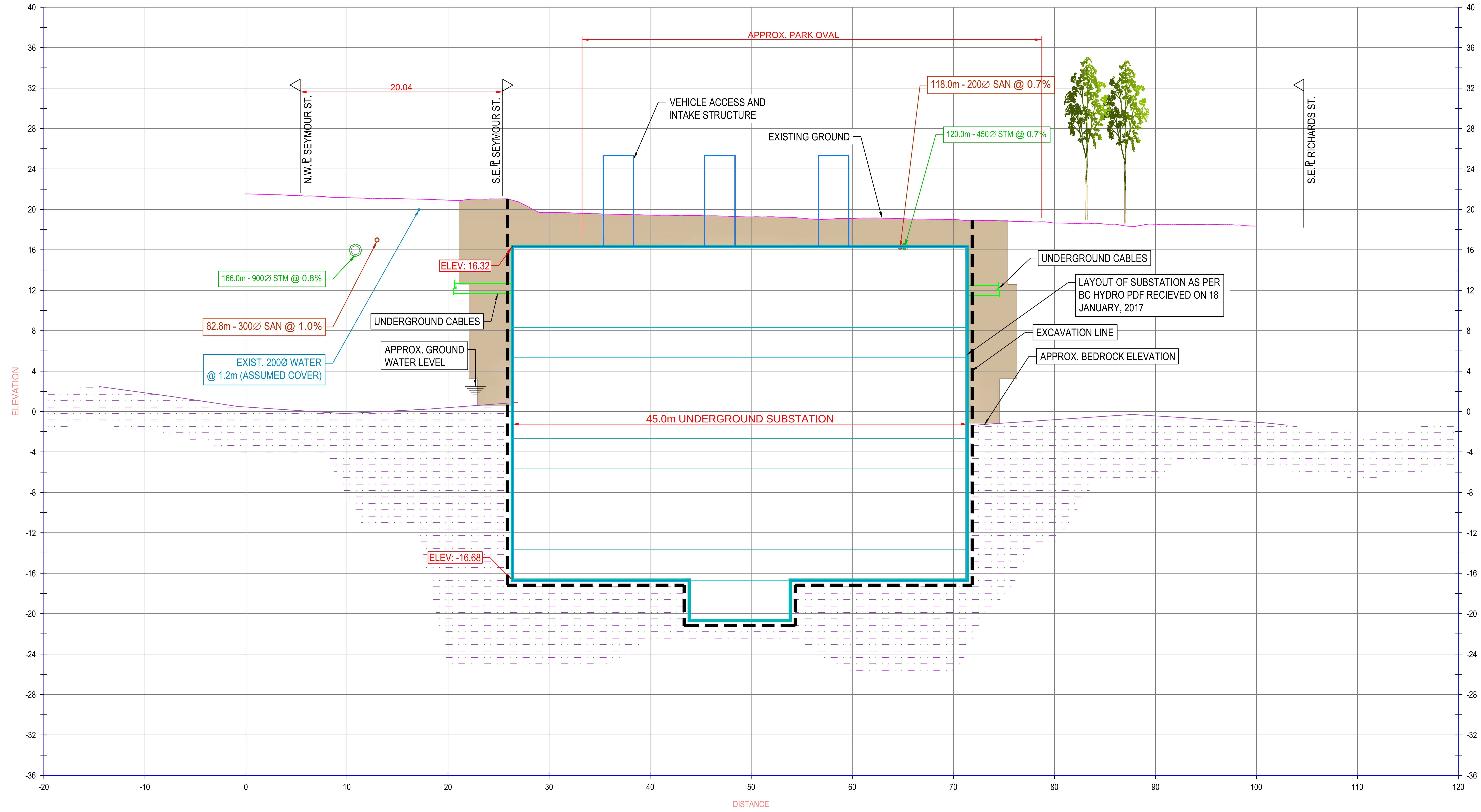
Client/Project
BC HYDRO
DOWNTOWN VANCOUVER
ELECTRICITY SUPPLY (DVES)

File Name: | Dwn. | Chkd. | Dsgn. | YY.MM.DD

Title
CONCEPT PLAN - SECTION
EMERY BARNES PARK SITE

Project No. 123220785
Scale 1:250 H 1:250 V
Figure No. A. 9-2
Sheet
Revision 0

ORIGINAL SHEET - ISO A1



B-B / A. 9-1 SECTION
SCALE: 1:250 HORZ. 1:250 VERT.

FOR INFORMATION ONLY

Revision	By	Appd.	YY.MM.DD

Issued	By	Appd.	YY.MM.DD

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Vancouver BC
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Client/Project
BC HYDRO
DOWNTOWN VANCOUVER

ELECTRICITY SUPPLY (DVES)

File Name: Dwn. Chkd. Dsgn. YY.MM.DD

Title
CONCEPT PLAN - SECTION
EMERY BARNES PARK SITE

Project No. 123220785
Scale 1:250 H 1:250 V

Figure No. A. 9-3
Sheet
Revision 0

ORIGINAL SHEET - ISO A1

Revision	By	Appd.	YY.MM.DD

Issued	By	Appd.	YY.MM.DD

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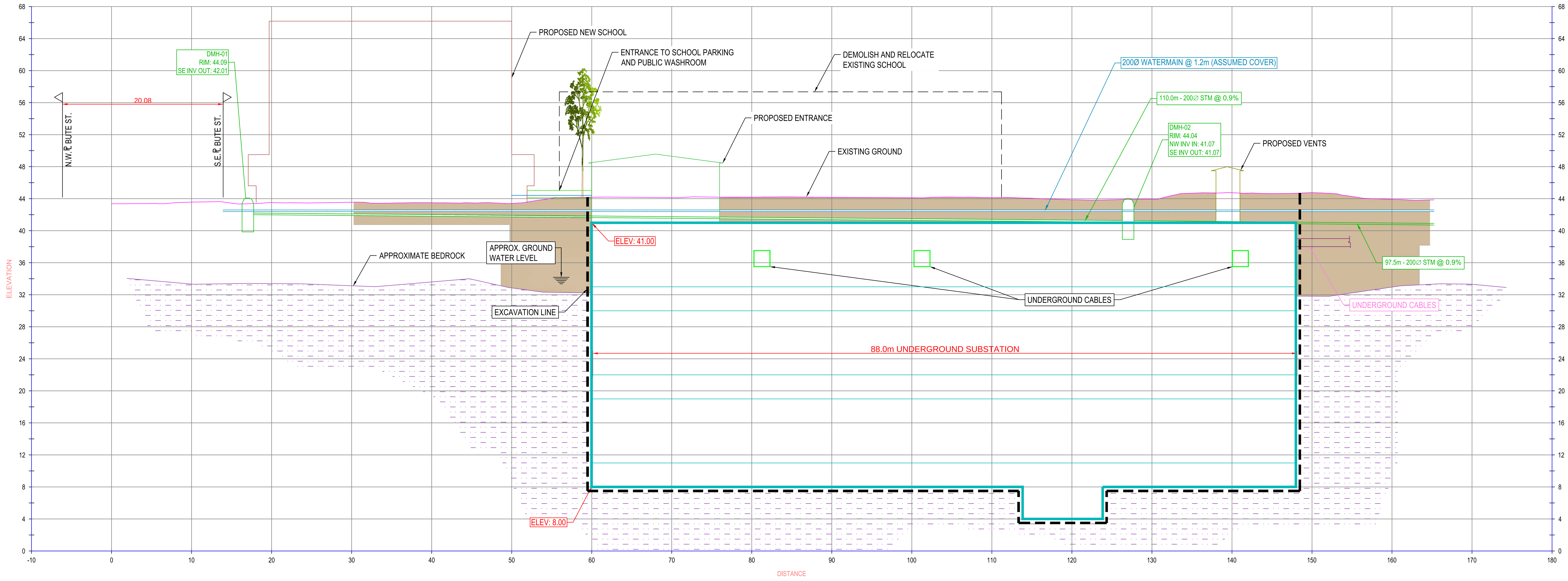
DOWNTOWN VANCOUVER
ELECTRICITY SUPPLY (DVES)

File Name: | Dwn. | Chkd. | Dsgn. | YY.MM.DD

Title
CONCEPT PLAN
NELSON PARK SITE

Project No. 123220785
Scale 1:250
Figure No. A. 9-4
Sheet
Revision 0

ORIGINAL SHEET - ISO A1



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FOR INFORMATION ONLY

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File Name: | Dwn. | Chkd. | Dsgn. | YY.MM.DD

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NELSON PARK SITE

Project No. 123220785
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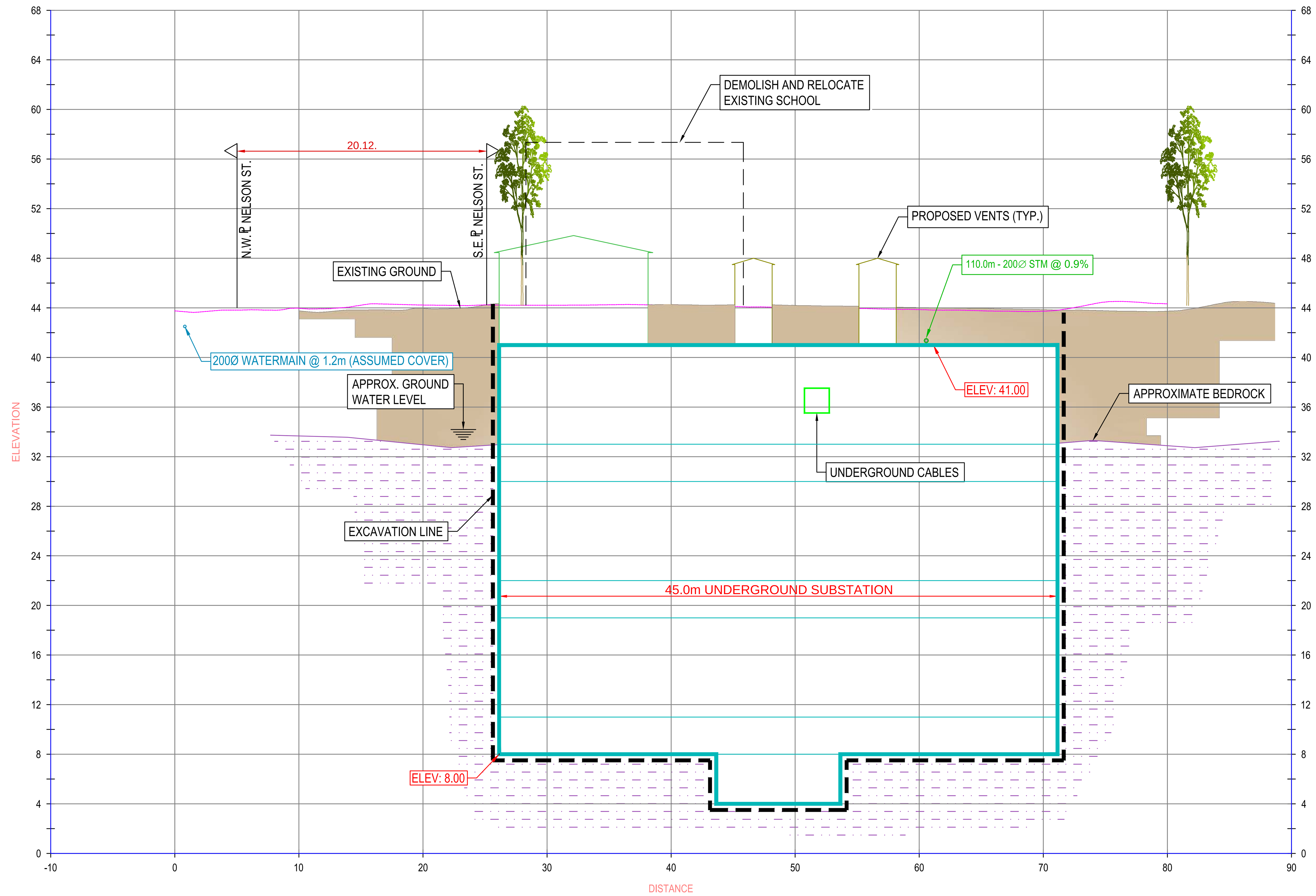

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SECTION

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File Name:

Dwn. Chkd. Dsgn. YY.MM.DD

Title
CONCEPT PLAN - SECTION
NELSON PARK SITE

Project No. 123220785
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Figure No. A. 9-6
Sheet
Revision 0

ORIGINAL SHEET - ISO A1

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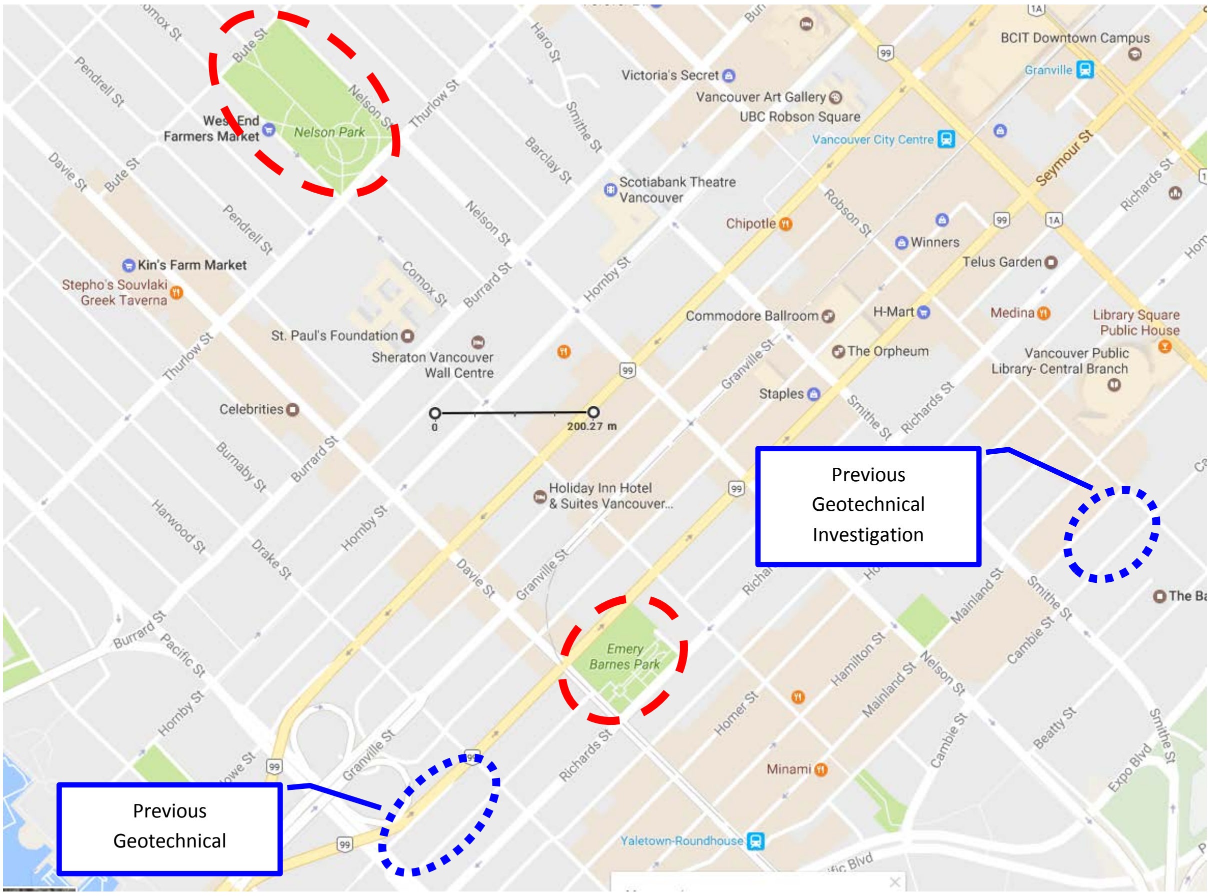

Emery Barnes Park

- Approximately 200 m from Seymour / Pacific Street boreholes
- Approximately 650 m from Cambie / Nelson Street boreholes

Nelson Park

- Approximately 900 m from Seymour / Pacific Street boreholes
- Approximately 1150 m from Cambie / Nelson Street boreholes

The Geological Survey of Canada map for Vancouver (Map 1486A) indicates the following:

- At the Nelson Park site bedrock is within 10 m or less of the surface
- At the Emery Barnes Park site bedrock is more than 10 m below the surface

<u>Cambie / Nelson Street boreholes</u>

- Drilled in June 2007
- Five (5) Sonic drilled boreholes advanced to 12.6 to 18.3 m below ground level (bgl)
- Monitoring wells installed in all boreholes

- Ground water strikes during drilled at 10.6 to 12.2 m bgl within the Till
- Ground water table elevations ranged from 4.4 to 8.3 m geodetic
- Observed ground water levels were recorded after an extended period of dry weather; it is expected levels will rise during periods of wetter weather
- Soil conditions:
    - 0.7 to 1.2 m fill material
    - Silt and Sand combinations – 0.8 to 1.8 m thickness
        - Medium dense to dense / stiff to very stiff
    - Weathered Till – 0.6 to 1.8 m thickness
        - Dense to very dense silty Sand with some gravel and occasional cobbles
    - Glacial Till – Depth to top of till varies from 2.1 to 3.8 m (Base not proven)
        - Very dense silty Sand with some gravel, cobbles and occasional boulders
        - Some clayey silt layers encountered

<u>Seymour / Pacific Street boreholes</u>

- Drilled in June 2010
- Three (3) mud-rotary drilled boreholes advanced to 15.2 to 18.3 m below ground level (bgl)
- Monitoring wells installed in two (2) boreholes
- Ground water strikes during drilled at 10.6 to 12.2 m bgl within the Till
- Ground water table elevations ranged from 8.3 to 14.2 m geodetic
    - Groundwater was monitored over a one month period with a 3.1 to 3.5 m drop in water level from January to February 2010
- The water levels measured in the standpipe piezometers are not considered to be a true representation of the regional groundwater table, but rather perched water flowing within the glaciated sand interlayers within the glacial till deposit
- Soil conditions:
    - 0.8 to 1.2 m fill material
    - Interlayered clayey Silt and Silt / Sand 1.1 to 1.75 m thickness
        - Compact to dense / stiff to hard
    - Glacial Till – Depth to top of till varies from 2.0 to 2.6 m (Base not proven)
        - Very dense silty Sand with some gravel, cobbles and occasional boulders

Groundwater Control

- We anticipate that seepage will be encountered from the walls of the excavation; therefore, weep holes and/or horizontal drains about 3 m (10 feet) long should be installed to dewater and depressurize the face. The majority of excavation dewatering will likely be limited to perimeter ditches connected to collection sumps. The collected water should be retained in the sumps for a sufficient length of time to allow precipitation of sediment before the water is pumped to the City storm sewer system. Alternatively a sediment collection system should be used prior to water disposal.

Construction Comments:

- At the Emery Barnes park site excavation of the native soils should be possible using conventional equipment
    - There is a risk that Sandstone / Siltstone rock floaters may be encountered which could require the use of heavy rock breaking equipment to remove
- At the Nelson park site excavation of surficial soil, including till, should be possible using conventional equipment
    - There is a risk that bedrock may be close to the surface which would require the use of hydraulic breakers or explosives to excavate
- Support of the excavation sides should be possible using conventional shotcrete and tie back anchors; however, depending on the performance of the native sand with the till deposit, hollow anchor bars may be needed
- For Nelson Park the existing school will require demolition prior to excavating for the substation. No other existing structures are present close to the proposed footprint area that may be affected by ground movements.
- For Emery Barnes Park, there is an existing two-storey structure with basement level/s approximately 10 m distance from the proposed substation excavation. Possible implications for this structure include:
    - Structural distress may occur due to ground movements associated with the substation excavation and ground water control activities
    - Excessive vibrations and noise may occur due to construction activities
    - Underpinning of the structure may be required if the proposed substation excavation depth is greater than the existing structure foundation depth. Further assessment is required
- As a precaution against a possible rise in the groundwater level, an under-slab drainage system should be installed. The under-slab drainage system should consist of a network of slotted or perforated rigid-wall pipe embedded within a layer of drain rock. The under-slab drainage system should discharge through non-perforated pipe to a sump-pump system in order to prevent the build-up of any water pressure under the slab.

APPENDIX B STRATEGIES AND INITIATIVES; SUPPLEMENTAL INFORMATION

SUMMARY OF GREENEST CITY 2020 ACTION PLAN GOALS AND TARGET

Table B.1 Summary of the City of Vancouver and Park Board Strategies Related to the Greenest City 2020 Action Plan Goals and Targets

Vancouver's Greenest City 2020 Action Plan (GCAP) Goals and Targets	Key Supporting Policies Initiatives, and/or Strategies
GOAL 1: CLIMATE CHANGE AND RENEWABLES – *Eliminate Vancouver's dependence on fossil fuels.*	
2020 TARGET 1: Reduce community-based greenhouse gas emissions by 33% from 2007 levels	• Renewable City Strategy (RCS): our future to 2050 • Neighbourhood Energy Strategy (NES) (2012) • Climate Adaptation Strategy (2012) • Zero-Emission Building Plan • Transportation 2040 Plan
2050 TARGET 1: Derive 100% of the energy used in Vancouver from renewable sources	
2050 TARGET 2: Reduce greenhouse gas emissions by 80% below 2007 levels	
GOAL 2: GREEN BUILDINGS: *Lead the world in green building design and construction.*	
2020 TARGET 1: Reduce energy use and GHG emissions in existing buildings by 20% over 2007 levels	*Not Applicable – Maintenance of existing buildings is not anticipated at either Emery Barnes Park, or Nelson Park / Lord Roberts Annex*
2020 TARGET 2: Require all buildings constructed from 2020 onward to be carbon neutral in operations	• Renewable City Strategies: our future to 2050 • Zero Emissions Building Plan • Green Building Policy for Rezonings • Vancouver's Building Bylaw (2013)
GOAL 3: GREEN TRANSPORTATION – *Make walking, cycling, and public transit preferred transportation options*	
2020 TARGET 1: Make the majority (over 50%) of trips by foot, bicycle, and public transit	• Renewable City Strategy: our future to 2050 • Transportation 2040 Plan
2020 TARGET 2: Reduce the average distance driven per resident by 20% from 2007 levels.	
2040 Target 1: Make at least two thirds of all trips by foot, bike and public transport	
GOAL 4: ZERO WASTE - *Create zero waste; diverting waste from the landfill is critical to solving today's climate crisis*	
2020 TARGET 1: Reduce solid waste going to the landfill or incinerator by 50% from 2008 levels	• Zero Waste Vancouver Strategy *(formal strategy document is under development)*.
GOAL 5: ACCESS TO NATURE - *Vancouver residents will enjoy incomparable access to green spaces, including the world's most spectacular urban forest.*	
2020 TARGET 1: All Vancouver residents live within a five-minute walk of a park, greenway or other green space	• Healthy City for All Action Plan • Rewilding Vancouver: An Environmental Education and Stewardship Action Plan • Biodiversity Strategy
2020 TARGET 2: Plant 150,000 trees by 2020.	• Urban Forest Strategy Framework

Table B.1 Summary of the City of Vancouver and Park Board Strategies Related to the Greenest City 2020 Action Plan Goals and Targets

Vancouver's Greenest City 2020 Action Plan (GCAP) Goals and Targets	Key Supporting Policies Initiatives, and/or Strategies
2020 TARGET 3: Biodiversity; To restore or enhance 25 hectares (ha) of natural areas between 2010 and 2025	• Rewilding Vancouver: An Environmental Education and Stewardship Action Plan • The Vancouver Bird Strategy • Biodiversity Strategy
2050 TARGET 4: Increase Vancouver's tree canopy cover to 22%	• Urban Forest Strategy Framework
GOAL 6: CLEAN WATER –*Vancouverites will have the best drinking water of any city in the world*	
2020 TARGET 1: Meet or beat the strongest of British Columbian, Canadian, or appropriate international drinking water quality standards and guidelines.	• Healthy City for All Action Plan
2020 TARGET 2: Reduce per capita water consumption by 33% from 2006 levels.	
GOAL 7: LOCAL FOOD- *Vancouver will become a global leader in urban food systems*	
2020 TARGET 1: Increase city-wide and neighbourhood food assets by a minimum of 50% over 2010 levels	• Vancouver Food Strategy • Parks Board Local Food Action Plan • Parks Board Urban Agricultural Policy • Healthy City for All Action Plan
GOAL 8: CLEAN AIR: *Breathe the cleanest air of any major city in the world*	
2020 TARGET: Always meet or beat the most stringent air quality guidelines from Metro Vancouver, British Columbia, Canada, and the World Health Organization	• Healthy City for All Action Plan
GOAL 9: GREEN ECONOMY – *Secure Vancouver's International Reputation as a mecca of green enterprise.*	
2020 TARGET 1: Double the number of green jobs over 2010 levels (green jobs)	• Renewable City Strategy: our future to 2050. • Neighbourhood Energy Strategy
2020 TARGET 2: Double the number of companies that are actively engaged in greening their operations over 2011 levels (green businesses)	
GOAL 10: Lighter Footprint – *ACHIEVE A ONE-PLANET ECOLOGICAL FOOTPRINT*	
2020 TARGET 1: Reduce Vancouver's ecological footprint by 33% over 2006 levels	• Renewable City Strategy: our future to 2050. • Neighbourhood Energy Strategy • Transportation 2040 • Park Board Strategic Framework • Green Operations Plan
SOURCE: City of Vancouver, 2016	

ADDITIONAL PLANS THAT SUPPORT THE RENEWABLE CITY STRATEGY GOALS FOR ZERO-EMISSION BUILDINGS

Zero-emissions Building Plan: The Zero Emissions Building Plan was approved by Vancouver City Council in July, 2016. The action plan establishes targets and four action strategies which require that the majority of new buildings in Vancouver use 100% renewable energy and have no operational greenhouse gas emissions by 2025 and that all new buildings achieve these outcomes by 2030. The phased approach aims to reduce emissions from newly permitted buildings by 70% by 2020 and 90% by 2025. These plan mandates that all new buildings constructed produce little to no GHG emissions by either: being built to a zero emission standard (e.g., Passive House Standard); or connecting to a neighbourhood energy system (Green Building Manager 2016).

Green Buildings Policy for Rezonings: The Green Buildings Policy for Rezonings was approved in July, 2010, and required all applicable developments applying for rezoning to achieve the LEED standards. The revised version requires meeting LEED Gold with additional energy reductions.

Vancouver Neighbourhood Energy Strategy and Energy Centre Guidelines: As energy used by buildings generates 55% of Vancouver's GHG emissions, the GCAP prioritized use of Neighbourhood Energy Systems (NES) for high-density, mixed use-use neighbourhoods, including Vancouver's downtown area. Neighbourhood Energy Systems (NES) are shared infrastructure platforms that provide heating and/or cooling infrastructure for multiple buildings, and eliminate the need for boilers in individual buildings (General Manager of Engineering Services, 2012) The *Neighbourhood Energy Strategy* was developed in 2012 to provide a strategic approach to neighbourhood energy policy including the need and results of stakeholder engagement, geo-spatial analysis to identify target areas for NES, tailored strategies for target areas, and enabling, supportive policy (General Manager of Engineering Services, 2012).

Vancouver's Building By-laws: The Vancouver Building By-law required the use of ASHRA 90.1 to improve the energy efficiency performance of commercial and industrial buildings.

Transportation 2040 Plan: Transportation 2040: Provides the strategic vision for Vancouver to guide transportation and land use decisions. The plan sets long-term targets and includes both high-level policies and specific actions to support a multi-modal city with more transportation choices for people living in, working in, or visiting Vancouver. Many of the goals, targets, and policies are shared by the Greenest City 2020 Action Plan. A "hierarchy of modes" is established to ensure that each group of road users is sequential considered when the City's transportation decisions are made. Opportunities for walking are prioritized, followed by cycling, transit, taxi/commercial transit/shared vehicles, and private automobiles (City of Vancouver 2012).

REFERENCES

City of Vancouver. 2012. Transportation 2040 – Plan as adopted by Vancouver city Council on October 31, 2012. Available at: http://vancouver.ca/files/cov/Transportation_2040_Plan_as_adopted_by_Council.pdf. Accessed: January, 2017.

City of Vancouver. 2016. Greenest City 2020 Action Plan Part Two: 2015-2020. Available at: http://vancouver.ca/files/cov/greenest-city-2020-action-plan-2015-2020.pdf. Accessed: January 2017.

General Manager of Engineering Services, 2012. Policy Report to the Standing Committee on Planning, Transportation and Environment; Vancouver Neighbourhood Energy Strategy and Energy Centre Guidelines. Available at: http://vancouver.ca/files/cov/neighbourhood-energy-strategy-and-energy-centre-guidelines-committee-report.pdf. Accessed: January, 2017.

Green Building Manager, Sustainability Group (Green Building Manager). 2016. Development and Building Policy Report – Zero Emissions Building Plan. Available at: http://council.vancouver.ca/20160712/documents/rr2.pdf. Accessed: January, 2017.

City of Vancouver. 2012. Transportation 2040; Moving Forward. Available: http://vancouver.ca/files/cov/transportation-2040-plan.pdf. Accessed: January 2017.

APPENDIX C EMERY BARNS PARK ARBORIST REPORT

Emery Barnes Park Arborist Report

Certified Arborist Report

Prepared for:
BC Hydro

Prepared by:
Stantec Consulting Ltd.

February 16, 2017

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1.0 INTRODUCTION

BC Hydro is exploring the feasibility of building an underground substation and supporting infrastructure (including above ground substation entrance, vents and public washrooms, and underground 25 kV and 230 kV cables) at Emery Barnes Park (the Project). Emery Barnes Park is located between Seymour, Davie and Richards Streets, in the Downtown neighbourhood.
The park is 0.85 ha and was created in three phases, between 2003 and 2012 (City of Vancouver 2017a).

1.1 OBJECTIVE

The objectives of this study and report are to inventory the trees within Emery Barnes Park to assess the potential impacts of construction and plan impact mitigation measures. To support these objectives, the following tasks were completed:

- An inventory to document the location, species, diameter at breast height (DBH), and general condition of each tree within Emery Barnes Park and adjacent street trees
- Provision of recommended environmental protection measures during- and following-construction, including recommendations for tree-replacement

Relevant legislation (including bylaws), policies, regulations, and strategic planning sources have been reviewed to guide the scope of this report, along with input received from the Vancouver Parks Board. The City of Vancouver's Protection of Trees Bylaw 9958 indicates that trees greater than 20 cm DBH on private property are protected (City of Vancouver 2017b). Although Emery Barnes Park is located on city-owned land where this bylaw does not apply, the bylaw has been used as a guide for the field survey and subsequent recommendations.

Vancouver has developed an Urban Forest Strategy, which indicates that 18% of the city's area is covered by tree canopy (City of Vancouver 2014). The Urban Forest Strategy and Greenest City Action Plan include a goal of planting 150,000 trees by 2020 and increasing the city's canopy cover to 22% by 2050 (City of Vancouver 2014; City of Vancouver 2015). As of January 2017, 47,495 trees have been planted since 2010 (City of Vancouver 2017c). The Downtown neighbourhood has a canopy closure of 8.3% according to the Urban Forest Strategy (City of Vancouver 2014). The Greenest City Action Plan also includes a goal of having all of Vancouver residents living within a five-minute talk from a green space (i.e., park, greenway or other green space; City of Vancouver 2015).

1.2 PROJECT AREA

The Project area includes the portions of Emery Barnes Park that intersect the footprint of the underground substation, associated infrastructure, and temporary workspace (Figure 1).

2.0 METHODS

The arborist survey was conducted on January 18 and 27, 2017. The survey was completed by Stantec's ISA Certified Arborist and a second vegetation ecologist.

The arborist survey focused within the proposed footprint of the Project; however, since the Project is in a preliminary design stage, all of Emery Barnes Park and adjacent street trees were inventoried. Trees that were rooted in the Project footprint or whose dripline of their canopy intersected with the Project footprint were noted.

The following information was collected during the survey:

- Tree species or genus
- DBH was measured, following guidelines in the Protection of Trees Bylaw for trees with multiple stems
- GPS location
- Photos
- General condition of the tree using the following scale:
  - 1 = good, no signs of damage or disease
  - 2 = fair, some signs of damage or disease
  - 3 = poor, tree is badly damaged or diseased
  - 4 = dead, potential wildlife tree.

Due to the timing of the survey in mid-January, not all deciduous trees could be identified to species due to the lack of leaves, flowers, of fruiting structures. Where possible, trees were identified to genus, but this was not possible in a few cases.

3.0 RESULTS

A total of 111 trees were measured and recorded during the survey (Table 1; Figure 1). Thirty-three (33) of the 111 trees surveyed are ≥20 cm DBH. Of the 111 trees surveyed, 59 are located within the Project footprint.

Fifty-nine (59) trees would be removed from Emery Barnes Park and adjacent streets, 15 of which are ≥ 20 cm DBH.

Most of the trees were rated as being in good condition, with only a few rated as being in fair condition (Table 1). None of the surveyed trees were in poor condition or dead.

Photos of some of the trees can be found in Attachment A of this report.

Table 1 Tree Inventory Results

Tree ID#	Common Name	Scientific Name	Diameter at breast height (cm)	≥20 cm DBH (Y/N)	Tree Requires Removal (Y/N)	Condition	Comments
Tree no. 01	American sweetgum	*Liquidambar styraciflua*	15	N	Y	1	
Tree no. 02	American sweetgum	*Liquidambar styraciflua*	15	N	Y	1	
Tree no. 03	unknown	unknown	8	N	Y	1	
Tree no. 04	katsura	*Cercidiphyllum japonicum*	22	Y	Y	1	
Tree no. 05	paperbark maple	*Acer griceum*	15	N	Y	1	
Tree no. 06	Japanese snowball	*Styrax japonicus*	6	N	Y	1	
Tree no. 07	Japanese snowball	*Styrax japonicus*	9	N	Y	1	
Tree no. 08	eastern redbud (weeping)	*Cercis canadensis*	10	N	Y	1	
Tree no. 09	eastern redbud (weeping)	*Cercis canadensis*	8	N	Y	1	
Tree no. 10	dogwood	*Cornus sp.*	2	N	Y	1	
Tree no. 11	Japanese snowball	*Styrax japonicus*	10	N	Y	1	
Tree no. 12	Japanese snowball	*Styrax japonicus*	7	N	Y	1	
Tree no. 13	Japanese snowball	*Styrax japonicus*	7	N	Y	1	
Tree no. 14	apple	*Malus* sp.	11	N	Y	1	
Tree no. 15	apple	*Malus* sp.	12	N	Y	1	
Tree no. 16	apple	*Malus* sp.	11	N	Y	1	
Tree no. 17	apple	*Malus sp.*	7	N	Y	1	
Tree no. 18	American sweetgum	*Liquidambar styraciflua*	26	Y	Y	1	
Tree no. 19	American sweetgum	*Liquidambar styraciflua*	22	Y	Y	2	topped
Tree no. 20	American sweetgum	*Liquidambar styraciflua*	25	Y	Y	1	

Results
February 16, 2017

Tree ID#	Common Name	Scientific Name	Diameter at breast height (cm)	≥20 cm DBH (Y/N)	Tree Requires Removal (Y/N)	Condition	Comments
Tree no. 21	American sweetgum	*Liquidambar styraciflua*	21	Y	Y	1	
Tree no. 22	pine	*Pinus* sp.	16	N	Y	1	
Tree no. 23	American sweetgum	*Liquidambar styraciflua*	23	Y	Y	1	
Tree no. 24	dogwood	*Cornus* sp.	9	N	Y	1	
Tree no. 25	unknown	*unknown*	7	N	Y	1	
Tree no. 26	Persian ironwood	*Parrotia persicaria*	7	N	Y	2	Damaged trunk
Tree no. 27	pin oak	*Quercus palustris*	35	Y	Y	1	
Tree no. 28	katsura	*Cercidiphyllum japonicum*	12	N	Y	1	
Tree no. 29	katsura	*Cercidiphyllum japonicum*	11	N	Y	1	
Tree no. 30	Persian ironwood	*Parrotia persicaria*	12	N	Y	1	
Tree no. 31	giant sequoia	*Sequoiadendron giganteum*	24	Y	Y	1	
Tree no. 32	unknown	*unknown*	13	N	Y	1	
Tree no. 33	American sweetgum	*Liquidambar styraciflua*	12	N	Y	1	
Tree no. 34	American sweetgum	*Liquidambar styraciflua*	26	Y	Y	2	damaged trunk
Tree no. 35	dawn redwood	*Metasequoia glyptostroboides*	16	N	Y	1	
Tree no. 36	cherry	*Prunus* sp.	12	N	N	1	
Tree no. 37	Japanese snowball	*Styrax japonicus*	13	N	Y	1	
Tree no. 38	Japanese snowball	*Styrax japonicus*	19	N	Y	1	
Tree no. 39	Callery pear	*Pyrus calleryana*	17	N	Y	1	
Tree no. 40	American sweetgum	*Liquidambar styraciflua*	16	N	Y	1	

Results
February 16, 2017

Tree ID#	Common Name	Scientific Name	Diameter at breast height (cm)	≥20 cm DBH (Y/N)	Tree Requires Removal (Y/N)	Condition	Comments
Tree no. 41	beech	*Fagus* sp.	33	Y	Y	1	
Tree no. 42	little-leaf linden	*Tilia cordata*	31	Y	Y	1	
Tree no. 43	beech	*Fagus* sp.	14	N	N	1	
Tree no. 44	little-leaf linden	*Tilia cordata*	37	Y	N	1	
Tree no. 45	Beech	*Fagus* sp.	23	Y	N	1	
Tree no. 46	little-leaf linden	*Tilia cordata*	28	Y	N	1	
Tree no. 47	beech	*Fagus* sp.	27	Y	N	1	
Tree no. 48	beech	*Fagus* sp.	24	Y	N	1	
Tree no. 49	little-leaf linden	*Tilia cordata*	26	Y	N	1	
Tree no. 50	little-leaf linden	*Tilia cordata*	21	Y	N	1	
Tree no. 51	dogwood	*Cornus* sp.	7	N	Y	1	
Tree no. 52	oak	*Quercus* sp.	16	N	Y	1	
Tree no. 53	black pine	*Pinus nigra*	13	N	Y	1	
Tree no. 54	paperbark maple	*Acer griseum*	11	N	Y	1	
Tree no. 55	paperbark maple	*Acer griseum*	11	N	Y	1	
Tree no. 56	paperbark maple	*Acer griseum*	16	N	Y	1	
Tree no. 57	dogwood	*Cornus* sp.	11	N	Y	1	
Tree no. 58	dogwood	*Cornus* sp.	9	N	Y	1	
Tree no. 59	dogwood	*Cornus* sp.	7	N	Y	1	
Tree no. 60[a]	red maple	*Acer rubrum*	28	Y	N	1	
Tree no. 61[a]	red maple	*Acer rubrum*	28	Y	N	1	

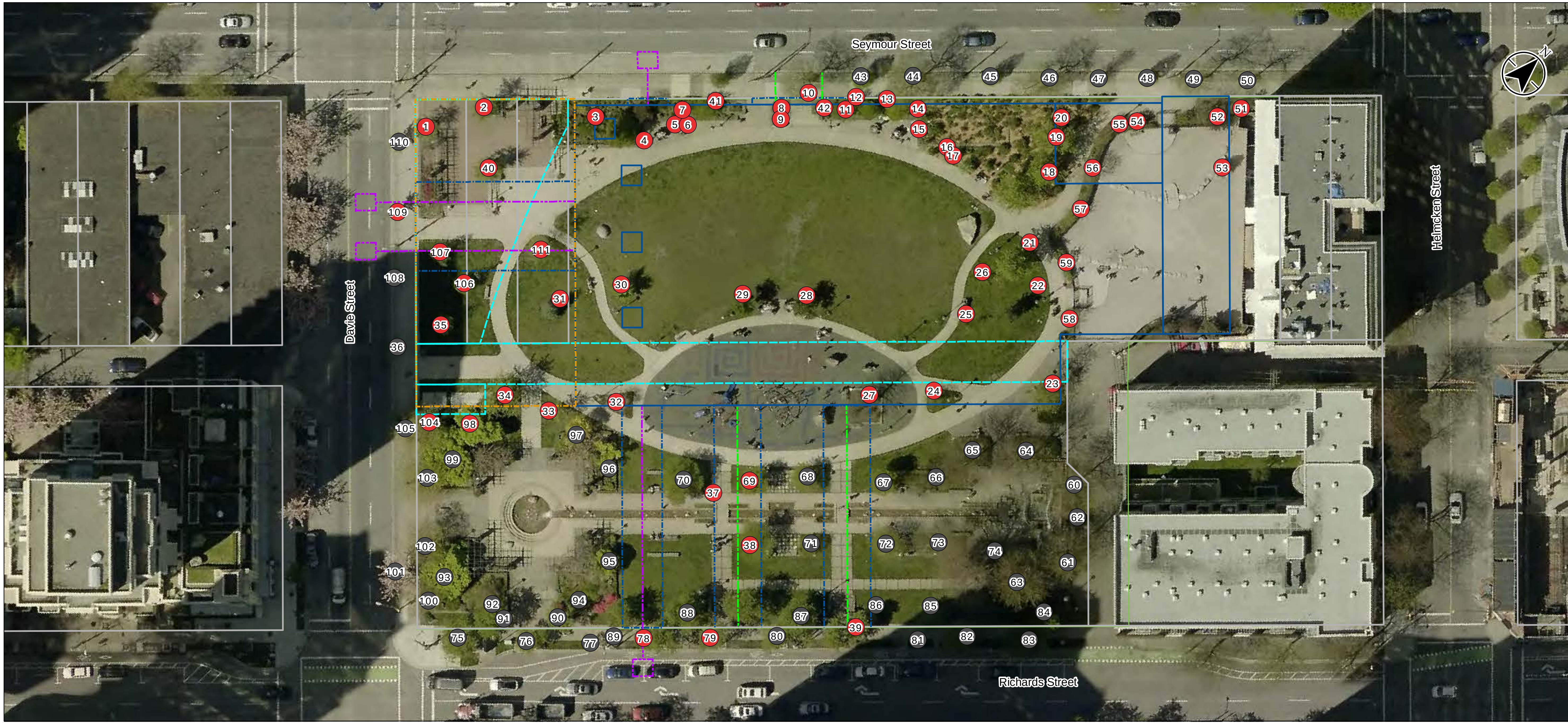
Tree ID#	Common Name	Scientific Name	Diameter at breast height (cm)	≥20 cm DBH (Y/N)	Tree Requires Removal (Y/N)	Condition	Comments
Tree no. 62[b]	Unknown	*unknown*	-	-	N	1	
Tree no. 63	red maple	*Acer rubrum*	31	Y	N	1	
Tree no. 64	red maple	*Acer rubrum*	33	Y	N	1	
Tree no. 65	red maple	*Acer rubrum*	33	Y	N	1	
Tree no. 66	Japanese snowbell	*Styrax japonicus*	15	N	N	1	
Tree no. 67	Japanese snowbell	*Styrax japonicus*	17	N	N	1	
Tree no. 68	Japanese snowbell	*Styrax japonicus*	13	N	Y	1	
Tree no. 69	Japanese snowbell	*Styrax japonicus*	13	N	Y	1	
Tree no. 70	Japanese snowbell	*Styrax japonicus*	18	N	N	1	
Tree no. 71	Japanese snowbell	*Styrax japonicus*	9	N	N	1	
Tree no. 72	Japanese snowbell	*Styrax japonicus*	19	N	N	1	
Tree no. 73	Japanese snowbell	*Styrax japonicus*	13	N	N	1	
Tree no. 74	red maple	*Acer rubrum*	39	Y	N	1	
Tree no. 75	Callery pear	*Pyrus calleryana*	18	N	N	1	
Tree no. 76	Callery pear	*Pyrus calleryana*	14	N	N	1	
Tree no. 77	Callery pear	*Pyrus calleryana*	13	N	N	1	
Tree no. 78	Callery pear	*Pyrus calleryana*	17	N	Y	1	
Tree no. 79	Callery pear	*Pyrus calleryana*	14	N	Y	1	
Tree no. 80	Callery pear	*Pyrus calleryana*	15	N	N	1	
Tree no. 81	apple	*Malus* sp.	8	N	N	1	
Tree no. 82	Callery pear	*Pyrus calleryana*	18	N	N	1	
Tree no. 83	Callery pear	*Pyrus calleryana*	18	N	N	1	

Tree ID#	Common Name	Scientific Name	Diameter at breast height (cm)	≥20 cm DBH (Y/N)	Tree Requires Removal (Y/N)	Condition	Comments
Tree no. 84	Callery pear	*Pyrus calleryana*	13	N	N	1	
Tree no. 85	Callery pear	*Pyrus calleryana*	13	N	N	1	
Tree no. 86	Callery pear	*Pyrus calleryana*	13	N	N	1	
Tree no. 87	Callery pear	*Pyrus calleryana*	18	N	N	1	
Tree no. 88	Callery pear	*Pyrus calleryana*	18	N	N	1	
Tree no. 89	Callery pear	*Pyrus calleryana*	15	N	N	1	
Tree no. 90	Callery pear	*Pyrus calleryana*	15	N	N	1	
Tree no. 91	Callery pear	*Pyrus calleryana*	18	N	N	1	
Tree no. 92	Japanese snowbell	*Styrax japonicus*	11	N	N	1	
Tree no. 93	Japanese maple	*Acer palmatum*	40	Y	N	1	
Tree no. 94	Japanese snowbell	*Styrax japonicus*	10	N	N	1	
Tree no. 95	Japanese maple	*Acer palmatum*	19	N	N	1	
Tree no. 96	Japanese maple	*Acer palmatum*	23	Y	N	1	
Tree no. 97	Japanese maple	*Acer palmatum*	26	Y	N	1	
Tree no. 98	Japanese maple	*Acer palmatum*	37	Y	Y	1	
Tree no. 99	Japanese maple	*Acer palmatum*	50	Y	N	1	
Tree no. 100	cherry	*Prunus* sp.	19	N	N	1	
Tree no. 101	cherry	*Prunus* sp.	22	Y	N	1	
Tree no. 102	cherry	*Prunus* sp.	20	Y	N	1	
Tree no. 103	cherry	*Prunus* sp.	27	Y	N	1	

Results
February 16, 2017

Tree ID#	Common Name	Scientific Name	Diameter at breast height (cm)	≥20 cm DBH (Y/N)	Tree Requires Removal (Y/N)	Condition	Comments
Tree no. 104	cherry	*Prunus* sp.	25	Y	Y	1	
Tree no. 105	cherry	*Prunus* sp.	7	N	N	2	Lots of pruning, poor branch structure
Tree no. 106	dawn redwood	*Metasequoia glyptostroboides*	17	N	Y	1	
Tree no. 107	dawn redwood	*Metasequoia glyptostroboides*	19	N	Y	1	
Tree no. 108	cherry	*Prunus* sp.	12	N	N	1	
Tree no. 109	cherry	*Prunus* sp.	17	N	Y	1	
Tree no. 110	cherry	*Prunus* sp.	17	N	N	1	
Tree no. 111	unknown	*unknown*	14	N	Y	1	

NOTES:
[a] The DBH of these trees was estimated because they were behind tree protection barriers for construction in the adjacent lot to the north.
[b] This is a small, weeping tree on the top of the water feature. It was unsafe to measure the DBH.



- Statutory Right Of Way
- Proposed Statutory Right Of Way
- Temporary Work Area
- Proposed Distribution Duct
- Proposed Transmission Duct
- Proposed Substation
- Property Boundary

- Surveyed Tree
- Surveyed Tree to be Removed

0 10 20 metres

1:600 (At original document size of 11x17)

Stantec

Project Location: Vancouver, BC

123220737
Prepared by L. Trudell 2017-02-16
Requested by C. Lion on 2017-02-16
Reviewed by M. Ramsay 2017-02-16

Client/Project
Emery Barnes Park
Arborist Report
BC Hydro SEED Program Study

Figure No.
1

Title
Emery Barnes Park
Arborist Survey Results

Notes
1. Coordinate System: NAD 1983 UTM Zone 10N
2. Base features: DataBC, Government of British Columbia (GovBC); Surrey History National Topographic System, GovBC; CanVec v12,Government of Canada (GC)
3. Orthoimagery: City of Vancouver Open Data catalogue 2015

4.0 RECOMMENDED ENVIRONMENTAL PROTECTION MEASURES

4.1 PRE-CONSTRUCTION

During the design phase, the construction footprints and trenching areas for underground cables should be reduced as much as possible to avoid trees. Ideally, temporary work space and construction access should be planned and staged within the permanent footprint. Relocating smaller trees to other areas of the park or nearby parks or streets may be feasible, and would reduce the number of replacement trees that may be required. Technical specifications from the City of Vancouver (number 32 96 43) should be followed if trees are to be relocated (PWL Partnership Landscape Architects Inc. 2015).

Prior to construction, trees to be removed should be clearly flagged to avoid unnecessarily removing trees that could be preserved. A tree protection barrier of six times the diameter of the tree (i.e., a 20 cm DBH tree would have a tree protection barrier of 1.2 m from the trunk) should be installed before any construction activities take place around trees to be retained. Tree protection barriers should be installed for each retention tree located in the Park, on adjacent property within 2 m of the boundary of the site, and on streets adjacent to the site (City of Vancouver 2017b). Standards for installing the tree protection barrier should follow technical specification number 32 01 56 (PWL Partnership Landscape Architects Inc. 2015).

4.2 CONSTRUCTION

Tree protection barriers must be maintained during construction, and regular inspections by an ISA Certified Arborist must be completed throughout the construction phase (City of Vancouver 2017b).

Materials may not be stored in the tree protection barrier at any time.

Trees that are adjacent to the footprint, but will not be removed, may require root pruning by an ISA Certified Arborist so that the roots are not crushed or ripped, but are cleanly cut.

5.0 REPLACEMENT TREES

Based on the current design footprint of the Project, 59 trees will be removed. These trees and/or their equivalent canopy area will require replacement. BC Hydro will work with the Vancouver Park Board to replace the number of trees required by the City of Vancouver to offset the loss of trees due to the Project.

Although the Protection of Trees Bylaw does not apply to City lands, as a point of reference it indicates that one or two replacement trees should be replanted for each tree that is removed. According to this bylaw, the number of trees required to be planted depends on the size of trees to be replanted (City of Vancouver 2017b).

Ideally, replacement trees should be of the same species and replanted within Emery Barnes Park where possible in accordance with future designs for the park following construction of the Project; however, if this is not an option, replanting trees within the same neighbourhood (i.e., Downtown) would be ideal to maintain the canopy cover of the neighborhood and support the Urban Forest Strategy and Greenest City Action Plan objectives of the city.

It is unlikely that large trees can be planted above the underground substation and infrastructure due to concerns about root damage to the concrete structure, or risks to the infrastructure in the event of windthrow. However, tree species with relatively smaller mature height and diameter (e.g. the crab apples, pears, Japanese snowbells, and Japanese maples) could be replaced in-kind and on-site once Emery Barnes Park is restored following construction. Depending on the details of post-construction park design and engineering constraints, some additional tree species may also be accommodated on-site with the use of raised planter boxes and beds such as are presently featured in the park. Additional tree replacement could be located off-site.

To reduce the temporary loss of canopy cover due to Project construction, it may be beneficial to plant fewer, larger trees either elsewhere on-site, or off-site (i.e., trees identified in Part 2 of Schedule D of the Protection of Trees Bylaw [City of Vancouver 2017b]). The temporal loss of urban canopy could also be minimized by implementing tree replacement measures concurrent-with Project construction, or prior-to commencing construction, if feasible.

All trees should be replanted following the Vancouver Board of Parks and Recreation Park Development Standards (PWL Partnership Landscape Architects Inc. 2015).

6.0 SUMMARY

The removal of 59 trees during construction represents a temporary loss of the urban canopy that can be replaced in the long-term, once replacement trees achieve similar stature. A landscape design of Emery Barnes Park will be prepared that considers the constraints of the Project and any resulting changes in future programming of the Park, which will aim to replace trees on-site and in-kind, to the extent possible. BC Hydro will work with the Vancouver Park Board to replace the number of trees required by the City of Vancouver to offset the loss of trees due to the Project. These measures will maintain or improve the net canopy cover of the Downtown neighbourhood, mitigate losses associated with the Project, and support the city's management objectives for the Urban Forest Strategy and Greenest City Action Plan.

7.0 CLOSURE

We trust the information provided in this report is sufficient for your needs at this time. If you have any questions or require further information, please do not hesitate to contact the undersigned.

Regards,

STANTEC CONSULTING LTD.

Prepared by:

Christine Lion, B.Sc., R.P.Bio, ISA Certified Arborist
Environmental Scientist
Phone: (604) 412-2972
Christine.Lion@stantec.com

Reviewed by:

Matthew Ramsay, M.Sc., P.Ag.
Restoration/Vegetation Ecologist
Phone: (778) 328-1033
Matthew.Ramsay@stantec.com

8.0 REFERENCES

City of Vancouver. 2017a. Emery Barnes Park. Available at: http://covapp.vancouver.ca/parkfinder/parkdetail.aspx?inparkid=20. Accessed: January 2017.

City of Vancouver. 2017b. Protection of Trees Bylaw 9958. Available at: http://vancouver.ca/your-government/protection-of-trees-bylaw.aspx. Accessed: January 2017.

City of Vancouver. 2017c. Developing Vancouver's Urban Forest Strategy. Available at: http://vancouver.ca/home-property-development/urban-forest-strategy.aspx. Accessed: January 2017.

City of Vancouver. 2014. City of Vancouver Urban Forest Strategy. Available at: http://vancouver.ca/files/cov/Urban-Forest-Strategy-Draft.pdf. Accessed: January 2017.

City of Vancouver. 2015. Greenest City: 2020 Action Plan. Part Two: 2015 – 2020. Available at: http://vancouver.ca/files/cov/greenest-city-2020-action-plan-2015-2020.pdf. Accessed: January 2017.

PWL Partnership Landscape Architects Inc. 2015. Vancouver Board of Parks and Recreation Park Development Standards. Prepared for Vancouver Board of Parks and Recreation. Available at: http://vancouver.ca/files/cov/VPB_Design_Standards_20150515.pdf. Accessed: January 2017.

ATTACHMENT A
PHOTOS

ATTACHMENT A PHOTOS

Photo 1 Pin Oak (Tree No. 27) near Water Feature and Playground in Emery Barnes Park

Photo 2 **Playground and Grassy Area in Emery Barnes Park with Tree No. 32 in the Background and Tree No. 35 in the Foreground**

Photo 3 Weeping Eastern Redbud (Tree No. 8)

Photo 4 Paperbark Maple (Tree No. 54)

Photo 5 **Red Maple Trees (Tree No. 60; left, and Tree No. 61; right) and Unknown Weeping Tree (centre; Tree No. 62)**

APPENDIX D NELSON PARK/LORD ROBERTS SCHOOL ANNEX ARBORIST REPORT

Lord Roberts School Annex/ Nelson Park

Certified Arborist Report

Prepared for:
BC Hydro

Prepared by:
Stantec Consulting Ltd.

February 14, 2017

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1.0 INTRODUCTION

BC Hydro is exploring the feasibility of building an underground substation and supporting infrastructure (including above ground substation entrance, above ground vents, underground 25 kV and 230 kV cables and public washrooms), at Lord Roberts School Annex and Nelson Park. In addition, the Vancouver School Board would replace the existing Lord Roberts School Annex with a new urban elementary school at this same location. Both undertakings constitute 'the Project', for the purposes of this report. Lord Roberts School Annex and Nelson Park are located between Bute, Thurlow, Nelson and Comox Streets in the West End neighbourhood of Vancouver. The park is 1.16 ha and was redeveloped in 2007 (City of Vancouver 2017a).

1.1 OBJECTIVES

The objectives of this study and report are to inventory and assess the trees within the Lord Roberts School Annex and Nelson Park to inform the assessment of potential impacts on existing trees due to the Project's construction and plan impact mitigation measures. To support these objectives, the following tasks were completed:

- An inventory to document the location, species, diameter at breast height (DBH), and general condition of each tree within the Lord Roberts Annex School grounds, Nelson Park, and adjacent street trees.
- Provision of recommended environmental protection measures during- and after-construction, including recommendations for tree-replacement

Relevant legislation (including bylaws), policies, regulations, and strategic planning sources have been reviewed to guide the scope of this report, along with input received from the Vancouver School Board and Parks Board. The City of Vancouver's Protection of Trees Bylaw 9958 indicates that trees greater than 20 cm DBH on private property are protected (City of Vancouver 2017b). Although Lord Roberts School Annex and Nelson Park are located on city-owned land where this bylaw does not apply, the bylaw has been used as a guide for the field survey and subsequent recommendations.

Vancouver has developed an Urban Forest Strategy, which indicates that 18% of the city's area is covered by tree canopy (City of Vancouver 2014). The Urban Forest Strategy and Greenest City Action Plan include a goal of planting 150,000 trees by 2020 and increasing the city's canopy cover to 22% by 2050 (City of Vancouver 2014; City of Vancouver 2015). As of January 2017, 47,495 trees have been planted since 2010 (City of Vancouver 2017c). The West End neighbourhood has a canopy closure of 18.6% according to the Urban Forest Strategy (City of Vancouver 2014). The Greenest City Action Plan also includes a goal of having all of Vancouver residents living within a five-minute talk from a green space (i.e., park, greenway or other green space; City of Vancouver 2015).

1.2 PROJECT AREA

The Project area includes the area within the fenceline of the existing Lord Roberts School Annex (the proposed location of the underground substation and proposed new elementary school) plus the footprint of underground transmission or distribution cables in Nelson Park, and temporary work space.

2.0 METHODS

The arborist survey was conducted on January 18 and 27, 2017. The survey was completed by Stantec's ISA Certified Arborist and a second vegetation ecologist.

The arborist survey focused within the proposed footprint of the Project (substation, supporting infrastructure and new school); however, since the Project is in a preliminary design stage, the entire Lord Roberts School Annex and Nelson Park were inventoried. Street trees adjacent to the Project site were included among the inventory for the park. Trees that were rooted in the Project footprint or whose dripline of their canopy intersected with the Project footprint were noted.

The following information was collected during the survey:

- Tree species or genus
- DBH was measured, following guidelines in the Protection of Trees Bylaw for trees with multiple stems
- GPS location
- Photos
- General condition of the tree using the following scale:
  - 1 = good, no signs of damage or disease
  - 2 = fair, some signs of damage or disease
  - 3 = poor, tree is badly damaged or diseased
  - 4 = dead, potential wildlife tree.

Due to the timing of the survey in mid-January, not all deciduous trees could be identified to species due to the lack of leaves, flowers, of fruiting structures. Where possible, trees were identified to genus, but this was not possible in a few cases.

3.0 RESULTS

A total of 166 trees were measured and recorded during the survey within the park, school grounds, and along adjacent streets (Table 1; Figure 1). Of the 166 surveyed trees, 136 are greater than 20 cm DBH.

Five (5) trees would be removed from Nelson Park due to the Project, three of which are ≥20 cm DBH. Thirty-seven (37) trees would be removed from Lord Roberts School Annex grounds, 36 of which are ≥20 cm DBH.

Most of the surveyed trees were rated as being in good condition, with only a few rated as being in fair condition (Table 1). None of the surveyed trees were in poor condition or dead.

Photos of some of the surveyed trees can be found in Attachment A of this report.

Table 1 Tree Inventory Results

Tree ID#	Common Name	Scientific Name	Diameter at breast height (cm)	≥20 cm DBH (Y/N)	Tree Requires Removal (Y/N)	Condition	Comments
Tree no. 01	beech	*Fagus* sp.	47	Y	Y	1	
Tree no. 02	black pine	*Pinus nigra*	44	Y	Y	1	Squirrel nest present
Tree no. 03	black pine	*Pinus nigra*	40	Y	Y	1	
Tree no. 04	black pine	*Pinus nigra*	99	Y	Y	1	Multi-stemmed
Tree no. 05	Japanese snowbell	*Styrax japonicus*	9	N	Y	1	Newly planted
Tree no. 06	western redcedar	*Thuja plicata*	33	Y	N	1	
Tree no. 07	cherry	*Prunus* sp.	50	Y	N	2	Cleft in trunk; surface roots are exposed
Tree no. 08	western redcedar	*Thuja plicata*	44	Y	Y	1	
Tree no. 09	western redcedar	*Thuja plicata*	27	Y	Y	1	
Tree no. 10	cherry	*Prunus* sp.	63	Y	Y	1	
Tree no. 11	western redcedar	*Thuja plicata*	56	Y	Y	1	
Tree no. 12	maple	*Acer* sp.	44	Y	Y	1	Stick nest present
Tree no. 13	cherry	*Prunus* sp.	41	Y	Y	1	
Tree no. 14	cherry	*Prunus* sp.	63	Y	Y	1	
Tree no. 15	dogwood	*Cornus* sp.	20	Y	Y	1	
Tree no. 16	Turkish hazelnut	*Corylus colurna*	29	Y	N	1	
Tree no. 17	cherry	*Prunus* sp.	46	Y	Y	1	
Tree no. 18	maple	*Acer* sp.	47	Y	N	1	
Tree no. 19	cherry	*Prunus* sp.	43	Y	Y	1	
Tree no. 20	Turkish hazelnut	*Corylus colurna*	14	N	N	1	

Table 1 Tree Inventory Results

Tree ID#	Common Name	Scientific Name	Diameter at breast height (cm)	≥20 cm DBH (Y/N)	Tree Requires Removal (Y/N)	Condition	Comments
Tree no. 21	cherry	*Prunus* sp.	43	Y	Y	1	
Tree no. 22	cherry	*Prunus* sp.	26	Y	Y	1	
Tree no. 23	maple	*Acer* sp.	107	Y	N	1	
Tree no. 24	black pine	*Pinus nigra*	41	Y	Y	1	
Tree no. 25	cherry	*Prunus* sp.	40	Y	Y	1	
Tree no. 26	black pine	*Pinus nigra*	60	Y	Y	1	
Tree no. 27	cherry	*Prunus* sp.	45	Y	Y	1	
Tree no. 28	cherry	*Prunus* sp.	35	Y	Y	1	
Tree no. 29	Turkish hazelnut	*Corylus colurna*	21	Y	Y	1	
Tree no. 30	beech	*Fagus* sp.	80	Y	Y	1	
Tree no. 31	beech	*Fagus* sp.	20	Y	Y	1	Multi-stemmed
Tree no. 32	Turkish hazelnut	*Corylus colurna*	18	N	N	1	
Tree no. 33	Turkish hazelnut	*Corylus colurna*	23	Y	N	1	
Tree no. 34	beech	*Fagus* sp.	44	Y	Y	1	Multi-stemmed
Tree no. 35	black pine	*Pinus nigra*	42	Y	Y	1	
Tree no. 36	black pine	*Pinus nigra*	56	Y	Y	1	
Tree no. 37	black pine	*Pinus nigra*	48	Y	Y	1	
Tree no. 38	red maple	*Acer rubra*	10	N	N	1	
Tree no. 39	unknown deciduous	unknown	31	Y	Y	1	
Tree no. 40	red maple	*Acer rubrum*	25	Y	N	1	
Tree no. 41	red maple	*Acer rubrum*	26	Y	N	1	

Table 1 Tree Inventory Results

Tree ID#	Common Name	Scientific Name	Diameter at breast height (cm)	≥20 cm DBH (Y/N)	Tree Requires Removal (Y/N)	Condition	Comments
Tree no. 42	unknown deciduous	unknown	24	Y	N	1	
Tree no. 43	little-leaf linden	*Tilia cordata*	34	Y	Y	1	
Tree no. 44	cherry	*Prunus* sp.	40	Y	N	1	Multi-stemmed
Tree no. 45	maple	*Acer* sp.	100	Y	N	2	Topped/pruned back; cavities present
Tree no. 46	cherry	*Prunus* sp.	39	Y	N	1	
Tree no. 47	cherry	*Prunus* sp.	71	Y	N	1	
Tree no. 48	cherry	*Prunus sp.*	55	Y	N	1	
Tree no. 49	unknown deciduous	*unknown*	33	Y	N	1	
Tree no. 50	maple	*Acer* sp.	79	Y	Y	1	
Tree no. 51	western redcedar	*Thuja plicata*	45	Y	Y	1	
Tree no. 52	little-leaf linden	*Tilia cordata*	34	Y	Y	1	
Tree no. 53	Deodar cedar	*Cedrus deodara*	45	Y	Y	1	
Tree no. 54	unknown deciduous	*unknown*	34	Y	Y	1	
Tree no. 55	unknown deciduous	*unknown*	35	Y	Y	1	
Tree no. 56	beech	*Fagus* sp.	37	Y	Y	1	
Tree no. 57	unknown deciduous	*unknown*	46	Y	Y	1	
Tree no. 58	oak	*Quercus* sp.	27	Y	N	1	

Table 1 Tree Inventory Results

Tree ID#	Common Name	Scientific Name	Diameter at breast height (cm)	≥20 cm DBH (Y/N)	Tree Requires Removal (Y/N)	Condition	Comments
Tree no. 59	oak	*Quercus* sp.	51	Y	N	1	
Tree no. 60	southern magnolia	*Magnolia grandiflora*	13	N	N	1	
Tree no. 61	little-leaf linden	*Tilia cordata*	30	N	N	1	
Tree no. 62	beech	*Fagus* sp.	79	Y	N	1	Stick nest present
Tree no. 63	beech	*Fagus* sp.	52	Y	N	1	
Tree no. 64	English hawthorne	*Crataegus oxyacantha*	32	Y	N	1	
Tree no. 65	English hawthorne	*Crataegus oxyacantha*	20	Y	N	1	
Tree no. 66	American sweetgum	*Liquidambar styraciflua*	17	N	N	1	
Tree no. 67	English hawthorne	*Crataegus oxyacantha*	26	Y	N	1	
Tree no. 68	English hawthorne	*Crataegus oxyacantha*	19	N	N	1	
Tree no. 69	English hawthorne	*Crataegus oxyacantha*	43	Y	N	1	
Tree no. 70	English hawthorne	*Crataegus oxyacantha*	24	Y	N	1	
Tree no. 71	English hawthorne	*Crataegus oxyacantha*	17	N	N	1	
Tree no. 72	English hawthorne	*Crataegus oxyacantha*	29	Y	N	1	
Tree no. 73	English hawthorne	*Crataegus oxyacantha*	31	Y	N	1	
Tree no. 74	English hawthorne	*Crataegus oxyacantha*	20	Y	N	1	
Tree no. 75	English hawthorne	*Crataegus oxyacantha*	25	Y	N	1	
Tree no. 76	English hawthorne	*Crataegus oxyacantha*	25	Y	N	1	
Tree no. 77	English hawthorne	*Crataegus oxyacantha*	23	Y	N	1	
Tree no. 78	English hawthorne	*Crataegus oxyacantha*	20	Y	N	1	
Tree no. 79	English hawthorne	*Crataegus oxyacantha*	22	Y	N	1	

Table 1 Tree Inventory Results

Tree ID#	Common Name	Scientific Name	Diameter at breast height (cm)	≥20 cm DBH (Y/N)	Tree Requires Removal (Y/N)	Condition	Comments
Tree no. 80	English hawthorne	*Crataegus oxyacantha*	25	Y	N	1	
Tree no. 81	English hawthorne	*Crataegus oxyacantha*	21	Y	N	1	
Tree no. 82	English hawthorne	*Crataegus oxyacantha*	34	Y	N	1	
Tree no. 83	cherry	*Prunus* sp.	11	N	N	1	
Tree no. 84	cherry	*Prunus* sp.	7	N	N	1	
Tree no. 85	cherry	*Prunus* sp.	37	Y	N	1	
Tree no. 86	cherry	*Prunus* sp.	64	Y	N	1	
Tree no. 87	cherry	*Prunus* sp.	44	Y	N	2	
Tree no. 88	Raywood ash	*Fraxinus oxycarpa*	18	N	N	1	
Tree no. 89	Raywood ash	*Fraxinus oxycarpa*	18	N	N	1	
Tree no. 90	Raywood ash	*Fraxinus oxycarpa*	13	N	N	1	
Tree no. 91	cherry	*Prunus* sp.	39	Y	N	1	
Tree no. 92	Raywood ash	*Fraxinus oxycarpa*	14	N	N	1	
Tree no. 93	Raywood ash	*Fraxinus oxycarpa*	13	N	N	1	
Tree no. 94	oak	*Quercus* sp.	58	Y	N	1	
Tree no. 95	oak	*Quercus* sp.	39	Y	N	1	
Tree no. 96	oak	*Quercus* sp.	40	Y	N	1	
Tree no. 97	cherry	*Prunus* sp.	61	Y	N	1	
Tree no. 98	little-leaf linden	*Tilia cordata*	30	Y	N	1	
Tree no. 99	giant sequoia	*Sequoiadendron giganteum*	66	Y	N	1	
Tree no. 100	ponderosa pine	*Pinus ponderosa*	44	Y	N	1	

Table 1 Tree Inventory Results

Tree ID#	Common Name	Scientific Name	Diameter at breast height (cm)	≥20 cm DBH (Y/N)	Tree Requires Removal (Y/N)	Condition	Comments
Tree no. 101	beech	*Fagus* sp.	42	Y	N	1	
Tree no. 102	beech	*Fagus* sp.	44	Y	N	1	
Tree no. 103	tulip tree	*Liriodendron tulipifera*	27	Y	N	1	
Tree no. 104	beech	*Fagus* sp.	25	Y	N	1	
Tree no. 105	Deodar cedar	*Cedrus deodora*	44	Y	N	1	
Tree no. 106	beech	*Fagus* sp.	35	Y	N	1	
Tree no. 107	unknown	*unknown*	15	N	N	1	
Tree no. 108	monkey puzzle tree	*Araucaria araucana*	18	N	Y	1	
Tree no. 109	cherry	*Prunus* sp.	10	N	N	1	
Tree no. 110	cherry	*Prunus* sp.	13	N	N	2	
Tree no. 111	shore pine	*Pinus contorta*	13	N	N	1	
Tree no. 112	maple	*Acer* sp.	58	Y	N	1	
Tree no. 113	Japanese maple	*Acer palmatum*	5	N	N	1	
Tree no. 114	cherry	*Prunus* sp.	21	Y	N	1	
Tree no. 115	magnolia	*Magnolia* sp.	14	N	N	1	
Tree no. 116	southern magnolia	*Magnolia grandiflora*	11	N	N	1	
Tree no. 117	paperbark maple	*Acer griseum*	8	N	N	1	
Tree no. 118	paperbark maple	*Acer griseum*	10	N	Y	1	
Tree no. 119	little-leaf linden	*Tilia cordata*	34	Y	N	1	
Tree no. 120	little-leaf linden	*Tilia cordata*	38	Y	N	1	
Tree no. 121	little-leaf linden	*Tilia cordata*	32	Y	N	1	
Tree no. 122	little-leaf linden	*Tilia cordata*	28	Y	N	1	

Table 1 Tree Inventory Results

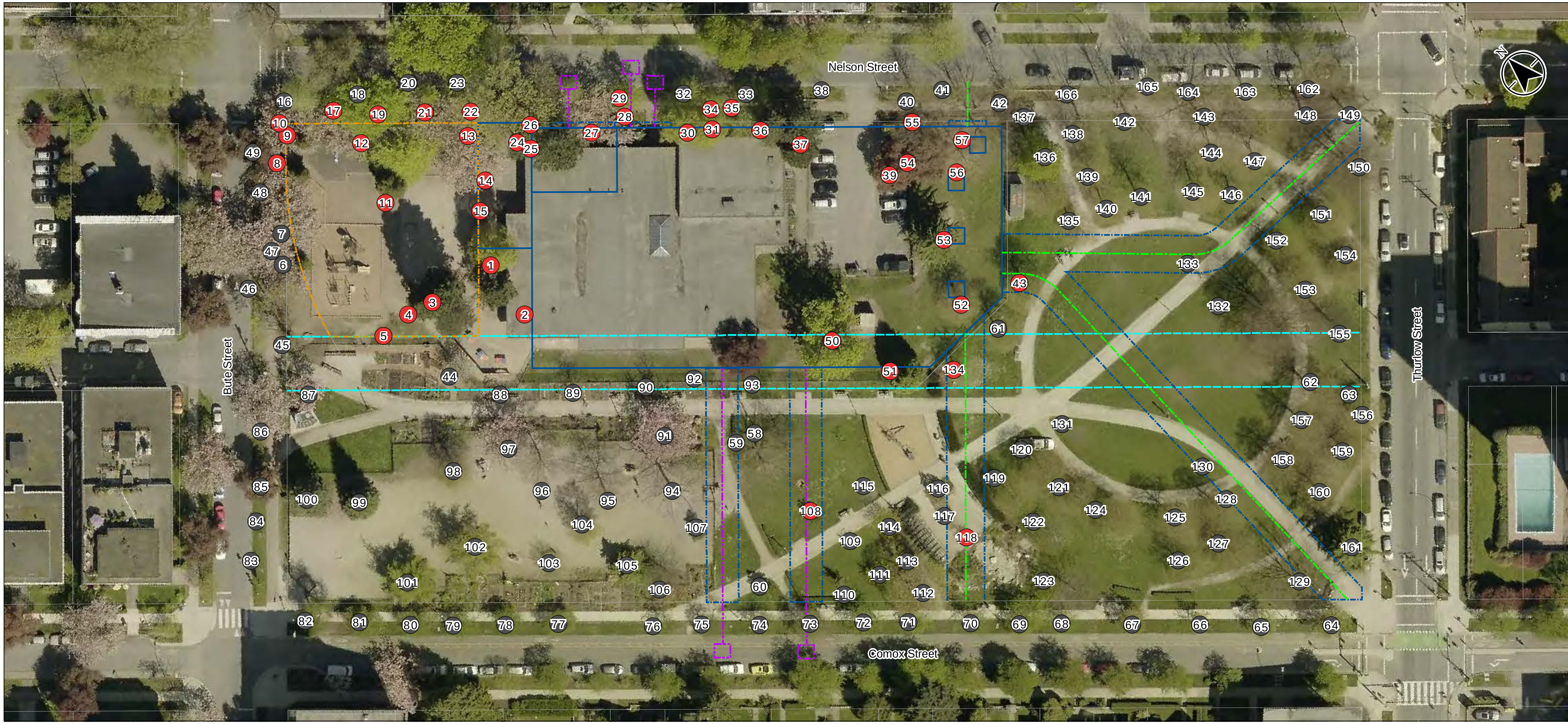
Tree ID#	Common Name	Scientific Name	Diameter at breast height (cm)	≥20 cm DBH (Y/N)	Tree Requires Removal (Y/N)	Condition	Comments
Tree no. 123	oak	*Quercus* sp.	33	Y	N	1	
Tree no. 124	little-leaf linden	*Tilia cordata*	36	Y	N	1	
Tree no. 125	little-leaf linden	*Tilia cordata*	36	Y	N	1	Scarring on trunk
Tree no. 126	little-leaf linden	*Tilia cordata*	28	Y	N	1	
Tree no. 127	little-leaf linden	*Tilia cordata*	32	Y	N	1	
Tree no. 128	little-leaf linden	*Tilia cordata*	34	Y	N	2	Scarring on trunk
Tree no. 129	oak	*Quercus* sp.	58	Y	N	1	
Tree no. 130	magnolia	*Magnolia* sp.	10	N	N	1	
Tree no. 131	magnolia	*Magnolia* sp.	11	N	N	1	
Tree no. 132	southern magnolia	*Magnolia grandiflora*	13	N	N	1	
Tree no. 133	southern magnolia	*Magnolia grandiflora*	7	N	N	1	
Tree no. 134	little-leaf linden	*Tilia cordata*	21	Y	Y	1	
Tree no. 135	little-leaf linden	*Tilia cordata*	34	Y	N	1	
Tree no. 136	little-leaf linden	*Tilia cordata*	34	Y	N	1	
Tree no. 137	horse-chestnut	*Aesculus hippocastanum*	54	Y	N	1	
Tree no. 138	oak	*Quercus* sp.	44	Y	N	1	
Tree no. 139	little-leaf linden	*Tilia cordata*	34	Y	N	1	
Tree no. 140	little-leaf linden	*Tilia cordata*	34	Y	N	1	
Tree no. 141	little-leaf linden	*Tilia cordata*	27	Y	N	1	
Tree no. 142	oak	*Quercus* sp.	39	Y	N	1	
Tree no. 143	oak	*Quercus* sp.	57	Y	N	1	

Table 1 Tree Inventory Results

Tree ID#	Common Name	Scientific Name	Diameter at breast height (cm)	≥20 cm DBH (Y/N)	Tree Requires Removal (Y/N)	Condition	Comments
Tree no. 144	little-leaf linden	*Tilia cordata*	30	Y	N	1	Stick nest (corvid)
Tree no. 145	little-leaf linden	*Tilia cordata*	30	Y	N	1	
Tree no. 146	little-leaf linden	*Tilia cordata*	28	Y	N	1	
Tree no. 147	little-leaf linden	*Tilia cordata*	31	Y	N	2	
Tree no. 148	beech	*Fagus* sp.	51	Y	N	1	
Tree no. 149	beech	*Fagus* sp.	44	Y	N	1	
Tree no. 150	beech	*Fagus* sp.	64	Y	N	1	
Tree no. 151	little-leaf linden	*Tilia cordata*	40	Y	N	1	
Tree no. 152	little-leaf linden	*Tilia cordata*	34	Y	N	1	
Tree no. 153	little-leaf linden	*Tilia cordata*	37	Y	N	1	
Tree no. 154	little-leaf linden	*Tilia cordata*	33	Y	N	1	
Tree no. 155	little-leaf linden	*Tilia cordata*	37	Y	N	1	
Tree no. 156	little-leaf linden	*Tilia cordata*	35	Y	N	1	
Tree no. 157	little-leaf linden	*Tilia cordata*	35	Y	N	1	
Tree no. 158	little-leaf linden	*Tilia cordata*	35	Y	N	1	
Tree no. 159	little-leaf linden	*Tilia cordata*	35	Y	N	1	
Tree no. 160	little-leaf linden	*Tilia cordata*	39	Y	N	1	
Tree no. 161	Deodar cedar	*Cedrus deodora*	54	Y	N	1	
Tree no. 162	red maple	*Acer rubrum*	37	Y	N	1	
Tree no. 163	red maple	*Acer rubrum*	30	Y	N	1	
Tree no. 164	red maple	*Acer rubrum*	32	Y	N	1	
Tree no. 165	red maple	*Acer rubrum*	25	Y	N	2	Scarring on trunk

Table 1 Tree Inventory Results

Tree ID#	Common Name	Scientific Name	Diameter at breast height (cm)	≥20 cm DBH (Y/N)	Tree Requires Removal (Y/N)	Condition	Comments
Tree no. 166	red maple	*Acer rubrum*	19	N	N	1	



- Statutory Right Of Way
- Proposed Statutory Right Of Way
- Temporary Work Area
- Proposed Distribution Duct
- Proposed Transmission Duct
- Proposed Substation
- Property Line

- Surveyed Tree
- Surveyed Tree to be Removed

0 10 20 metres

1:750 (At original document size of 11x17)

Stantec

Project Location: Vancouver, BC

123220737
Prepared by L. Trudell 2017-02-17
Requested by C. Lion on 2017-02-17
Reviewed by M. Ramsay 2017-02-17

Client/Project
Lord Roberts School Annex / Nelson Park
Arborist Report
BC Hydro SEED Program Study

Figure No.
1

Title
Lord Roberts School Annex / Nelson Park
Arborist Survey Results

Notes

1. Coordinate System: NAD 1983 UTM Zone 10N
2. Base features: DataBC, Government of British Columbia (GovBC); Surrey History National Topographic System, GovBC; CanVec v12,Government of Canada (GC)
3. Orthoimagery: City of Vancouver Open Data catalogue 2015

4.0 RECOMMENDED ENVIRONMENTAL PROTECTION MEASURES

4.1 PRE-CONSTRUCTION

Construction footprints and trenching areas for the underground cables have been through an initial optimization review to reduce and avoid tree removal. During the detailed design phase, additional adjustments may be made to further reduce potential impacts to trees in and adjacent to the footprint. Ideally, temporary work space and construction access should be planned and staged within the permanent footprint. Relocating smaller trees to other areas of the park or nearby parks or streets may be feasible, and would reduce the number of replacement trees that may be required. Technical specifications from the City of Vancouver (number 32 96 43) should be followed if trees are to be relocated (PWL Partnership Landscape Architects Inc. 2015).

Prior to construction, trees to be removed should be clearly flagged to avoid unnecessarily removing trees that could be retained. A tree protection barrier of six times the diameter of the tree (i.e., a 20 cm DBH tree would have a tree protection barrier of 1.2 m from the trunk) should be installed before any construction activities take place. Tree protection barriers should be installed for each retention tree located in the Park, on adjacent property within 2 m of the boundary of the site, and on streets adjacent to the site (City of Vancouver 2017b). Standards for installing the tree protection barrier should follow technical specification number 32 01 56 (PWL Partnership Landscape Architects Inc. 2015).

4.2 CONSTRUCTION

Tree protection barriers must be maintained during construction, and regular inspections by an ISA Certified Arborist must be completed throughout the construction phase (City of Vancouver 2017b).

Materials may not be stored in the tree protection barrier at any time.

Trees that are adjacent to the footprint, but will not be removed, may require root pruning by an ISA Certified Arborist so that the roots are not crushed or ripped, but are cleanly cut.

5.0 REPLACEMENT TREES

Based on the current design footprint of the Project, five trees would be removed from Nelson Park and 37 trees would be removed from Lord Roberts School Annex grounds. These trees and/or their equivalent canopy area will require replacement. BC Hydro will work with the Vancouver Park Board and Vancouver School Board to replace the number of trees required by the City of Vancouver to offset the loss of trees due to the Project.

Although the Protection of Trees Bylaw does not apply to City lands, as a point of reference it indicates that one or two replacement trees should be replanted for each tree that is removed. According to this bylaw, the number of trees required to be planted depends on the size of trees to be replanted (City of Vancouver 2017b).

Where feasible, replacement trees ideally should be of the same species and replanted within Nelson Park and/or the new school grounds in accordance with future designs for the park and school following construction of the Project; however, if this is not an option, replanting trees within the same neighbourhood (i.e., West End) would be ideal to maintain the canopy cover of the neighborhood and support the Urban Forest Strategy and Greenest City Action Plan objectives of the city.

It is unlikely that large or deep-rooted trees can be planted above the underground substation and infrastructure due to concerns about root damage to the concrete structure, or risks to the infrastructure in the event of windthrow. However, depending on the details of post-construction park design and engineering constraints, smaller trees (i.e., <5 m mature height and <15 cm mature DBH) could possibly be planted above portions of the underground infrastructure. Additional tree replacement could be located off-site.

To reduce the temporal loss of canopy cover due to Project construction, it may be beneficial to plant fewer, larger trees either elsewhere on-site, or off-site (i.e., trees identified in Part 2 of Schedule D of the Protection of Trees Bylaw [City of Vancouver 2017b]). The temporal loss of urban canopy could also be minimized by implementing tree replacement measures concurrent-with Project construction, or prior-to commencing construction, if feasible.

All trees should be replanted following the Vancouver Board of Parks and Recreation Park Development Standards (PWL Partnership Landscape Architects Inc. 2015).

6.0 SUMMARY

The removal of five trees from Nelson Park and 37 trees from Lord Roberts School Annex grounds during construction represents a temporary loss of the urban canopy that can be replaced in the long-term, once replacement trees achieve similar stature. A landscape design of Nelson Park and the new school grounds will be prepared that considers the constraints of the Project and any resulting changes in future programming of the Park or school. The landscape design for both areas will aim to replace trees on-site and in-kind, where feasible. BC Hydro will work with the Vancouver Park Board to replace the number of trees required by the City of Vancouver to offset the loss of trees due to the Project. These measures will maintain or improve the net canopy cover of the West End neighbourhood, mitigate losses associated with the Project, and support the city's management objectives for the Urban Forest Strategy and Greenest City Action Plan.

7.0 CLOSURE

We trust the information provided in this report is sufficient for your needs at this time. If you have any questions or require further information, please do not hesitate to contact the undersigned.

Regards,

STANTEC CONSULTING LTD.

Prepared by:

Christine Lion, B.Sc., R.P.Bio., ISA Certified Arborist
Environmental Scientist
Phone: (604) 412-2972
Christine.Lion@stantec.com

Reviewed by:

Matthew Ramsay, M.Sc., P.Ag.
Restoration/Vegetation Ecologist
Phone: (778) 328-1033
Matthew.Ramsay@stantec.com

8.0 REFERENCES

City of Vancouver. 2017a. Nelson Park. Available at: http://covapp.vancouver.ca/parkfinder/parkdetail.aspx?inparkid=203. Accessed: January 2017.

City of Vancouver. 2017b. Protection of Trees Bylaw 9958. Available at: http://vancouver.ca/your-government/protection-of-trees-bylaw.aspx. Accessed: January 2017.

City of Vancouver. 2017c. Developing Vancouver's Urban Forest Strategy. Available at: http://vancouver.ca/home-property-development/urban-forest-strategy.aspx. Accessed: January 2017.

City of Vancouver. 2015. Greenest City: 2020 Action Plan. Part Two: 2015 – 2020. Available at: http://vancouver.ca/files/cov/greenest-city-2020-action-plan-2015-2020.pdf. Accessed: January 2017.

City of Vancouver. 2014. City of Vancouver Urban Forest Strategy. Available at: http://vancouver.ca/files/cov/Urban-Forest-Strategy-Draft.pdf. Accessed: January 2017.

PWL Partnership Landscape Architects Inc. 2015. Vancouver Board of Parks and Recreation Park Development Standards. Prepared for Vancouver Board of Parks and Recreation. Available at: http://vancouver.ca/files/cov/VPB_Design_Standards_20150515.pdf. Accessed: January 2017.

ATTACHMENT A
PHOTOS

ATTACHMENT A PHOTOS

Photo 1 **Black Pine and Lord Roberts School Annex Playground (Trees No. 4 and 3, left to right)**

Photo 2 **Large Maple Tree along Nelson Street, North Side of Nelson Park (Tree No. 23)**

Photo 3 **Beech Tree with Stick Nest on East Side of Nelson Park along Thurlow Street (Tree no. 62)**

Photo 4 **Maple on West Side of Nelson Park, along Bute Street Showing Condition Class 2 due to Topped Pruning and Epicormic Shoot Sprouting (Tree no. 45)**

Photo 5 **Trees along the South Side of Nelson Street Looking East**

Photo 6 Trees along the North Side of Lord Roberts School Annex Playground

Photo 7 **Trees along the South Side of Nelson Street, Looking West**

Photo 8 Trees in Lord Roberts School Annex Parking Lot, looking South

Photo 9 Trees South of the Lord Roberts School Annex Parking Lot, Looking North

APPENDIX E ELECTRIC AND MAGNETIC FIELDS REPORT

February 17, 2017 Report No. ST170101

Mr. Neal Cormack
Stantec
1100-11 Dunsmuir Street
Vancouver, BC
V5B 6A3

Re: Desktop Review of Electric and Magnetic Field Human Health Risk for Proposed Underground Substations at Emery Barnes Park and Nelson Park/Lord Roberts Annex

Dear Mr. Cormack,

Further to your request on January 19, 2017, Aura Health and Safety Corporation (Aura) conducted a desk top review of electric and magnetic field exposure risk to humans for the proposed underground substations at Emery Barnes and Nelson Park/Lord Roberts Annex. It is Aura's understanding that the request was made in preparation of a BC Hydro Seed Program Effects and Benefits Study.

CLOSURE

This letter was prepared for the exclusive use of the Stantec. Any use which a third party makes of this letter, or any reliance on or decisions to be made based on it, are the responsibility of the third party.

We trust that this information is sufficient for your requirements at the present time. Should you have any questions, please do not hesitate to contact the undersigned at 778-242-8138.

Yours truly,

Aura Health and Safety Corporation

Prepared by:

Mona Shum, MSc, CIH
Principal Industrial Hygienist

Appendix: Appendix I – Statement of Limitations

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ELECTRIC AND MAGNETIC FIELDS

INTRODUCTION

Electricity transmission produces electric and magnetic fields (EMF), which are invisible fields of energy. Both proposed underground substations will produce EMF. BC Hydro understands that some members of the public are concerned about EMF. This desktop study reviews studies of similar BC Hydro projects, comparing the EMF levels to international guidelines.

Electric fields are produced by voltage of a wire measured in volts per meter (V/m), and magnetic fields are produced by electric current flowing through a wire and are measured in gauss (G) or tesla (T). In North America, the power frequency is 60 hertz (Hz). EMF levels are highest at the source and decrease rapidly with distance. Electric fields are easily blocked by obstacles such as vegetation, soil, and buildings whereas magnetic fields are not as significantly affected. As electric fields will be blocked by the ground above the underground substations and most interest around health effects of EMF is related to magnetic fields, this desktop review will focus on magnetic field data.

EMF AND HEALTH EFFECTS

There are established biological effects from acute exposure at high levels (well above 2000 mG) that are explained by recognized biophysical mechanisms. Very high levels of magnetic fields can induce electric fields and currents in the body which cause nerve and muscle stimulation.

As for long-term effects, much of the scientific literature is based on magnetic fields and childhood leukemia. In 2002, the International Agency for Research on Cancer (IARC) classified magnetic fields as "possibly carcinogenic to humans", which is in the same category as caffeic acid found in coffee and aloe vera extract (Table 1). This classification indicates that there is limited evidence of carcinogenicity in humans and less than sufficient evidence for carcinogenicity in experimental animals. However, there are methodological problems with the evidence that weaken it. There are also no accepted biophysical mechanisms that have been identified to explain the association and animal studies have largely been negative. Therefore, on review of all available evidence, the association with childhood leukemia is not strong enough to show causation (WHO, 2007). More recent evidence also indicates a decreased association between childhood leukemia and living near transmission lines. One of the most cited studies conducted by Draper et al., 2005 that had indicated an association was later updated by the same study team (Bunch et al., 2014) indicating that the association had decreased to be non-statistically significant. Authors indicated that the excess risk was only observed in the 1970s and possibly 1980s but did not extend to the later decades.

Table 1: IARC classifications (IARC, 2017)

Group	Description	Number of agents	Examples
Group 1	Carcinogenic to humans	119	Alcoholic beverages, UV light, diesel exhaust
Group 2A	Probably carcinogenic to humans	81	Hot beverages (>65 degrees C), perchloroethylene (used in dry-cleaning)
Group 2B	Possibly carcinogenic to humans	292	Power frequency EMF, caffeic acid (in coffee and other foods), pickled vegetables (Asian), aloe vera extract
Group 3	Not classifiable as to its carcinogenicity to humans	505	Caffeine, benzoyl peroxide
Group 4	Probably not carcinogenic to humans	1	Caprolactam

The evidence is even weaker for other childhood cancers, cancers in adults, depression, suicide, cardiovascular disorders, reproductive dysfunction, developmental disorders, immunological modifications, neurobehavioural effects and neurodegenerative disease (WHO, 2007).

Both Health Canada and World Health Organization conclude that current evidence does not confirm the existence of any health consequences from exposure to low level electromagnetic fields such as those from power lines. However, both agencies indicate that there are gaps in knowledge and that more research is needed (Health Canada, 2016; WHO, 2017). A recent review of the literature from 2012-2016 does not provide new evidence to alter this conclusion (Exponent, 2017).

INTERNATIONAL EXPOSURE GUIDELINES

There are no Health Canada guidelines on EMF levels but both Health Canada and World Health Organization (WHO) refer to the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines that indicate that for 60 Hz, the reference magnetic field level is 2,000 mG for the general public and 10,000 mG for workers (ICNIRP, 2010).

BASELINE DATA

Baseline magnetic field levels were measured by BC Hydro at Nelson Park, around Lord Roberts Annex, and at Emery Barnes Park during non-peak hours on Saturday, January 21, 2017 in the afternoon.

Nelson Park

Currently, 12 kV and lower voltage distribution lines are buried along and within the park. Measurements were conducted by BC Hydro at approximately 1.5 m above the 12 kV distribution line along Bute Street, and ranged from 3.4 to 11.2 mG; the highest measurement above this cable (11.2 mG) was likely influenced by an adjacent pole-top transformer. The highest measured magnetic field level for the entire park was 25.7 mG likely influenced by a mount transformer.

Lord Roberts Annex

Baseline measurements could not be taken within the Lord Roberts Annex site due to a security fence, but at the southwest perimeter fence, levels ranged from 0.4 to 9 mG with the highest reading occurring above the 12 kV distribution line.

Emery Barnes Park

At Emery Barnes Park, the highest magnetic field level was 4.6 mG likely influenced by an existing distribution transformer down stepping 12 kV to household voltage. There is also a 230 kV underground cable under Richards Street, but measurements were not taken at street level.

METHODS

A BC Hydro Engineering Report No. TD2017-000.605 (January 2017) was reviewed to determine the expected magnetic fields levels above ground at Emery Barnes Park, Nelson Park, and the proposed Lord Roberts Annex. A search of the literature was conducted to find other studies on EMF levels at or near substations, particularly of underground substations.

International guidelines and reports on EMF were reviewed to compare predicted exposures with guideline levels and to determine exposure risk to humans.

From the exposure and health guideline information, risk categories were assigned. Categories were selected based on two criteria: predicted approximate exposures to human populations, and predicted perceived risk to human populations. Each distinct area (i.e., Emery Barnes Park, Nelson Park, and Lord Roberts Annex) were considered separately to determine the risk category.

DISCUSSION ON IMPACTS

As the specifics of the two proposed substations are not known yet, the magnetic field levels were predicted based on those in and above the underground substation at Cathedral Square taken on Friday, January 13, 2017 during peak use hours (expected to be similar to the proposed substations) in the preliminary BC Hydro Engineering Report No. TD2017-000.605.

The highest magnetic field levels in substations are produced by the transmission lines going in and out of the substation rather than the substation equipment itself (SMEC, 2010). Above ground (at approximately 1.5 m) at Cathedral Square the highest peak level of magnetic field of 100 mG occurred in the alleyway where the three 230 kV transmission lines enter the park along the alleyway between Homer and Richards Street. All other measurements not taken directly above transmission lines were below 15 mG. It is predicted that in contingency conditions when one of the three cables is out of service, that the highest magnetic field levels may reach 200 mG, but that for the vast majority (over 95%) of the time, the levels would be below 25 mG.

Levels above the 12 kV distribution lines were below 13 mG at Cathedral Square.

Predicted EMF Levels

As currently no engineering designs are available for the two proposed substations, measurements from Cathedral Square were utilized to predict EMF levels.

Nelson Park

The proposed substation will have three 230 kV transmission underground cables near the south corner of the park near Comox and Thurlow. It is expected that the highest levels of magnetic fields will occur at this corner right above each of the 230 kV cables, but should be less than the peak levels (i.e., 100 mG) measured at Cathedral Square where currently three 230 kV transmission cables enter the square.

Lord Roberts Annex

The Lord Roberts Annex is expected to be moved from the current site to the west of the underground substation where no transmission or distribution lines are expected to be under the Annex. The levels above ground are not expected to vary much from the current baseline values where distribution lines already exist near the proposed site.

Emery Barnes Park

The proposed substation will have two 230 kV transmission underground cables entering into the park from Richards Street and two from Seymour Street. The transmission cable on Richards Street is existing and will be there regardless of the substation plan. The substation is proposed to have distribution cables entering from Seymour, Davie and Richards Streets. The highest levels of magnetic fields are expected to be above the transmission cables but well below the ICNIRP guideline value of 2000 mG and the levels above the distribution lines are expected to be much lower.

MITIGATION STRATEGIES

Various mitigation strategies to reduce the magnetic fields from underground transmission cables can be utilized such as burying the cables deeper, adding metal plates around the ducts for shielding, and optimizing the conductor spacing and phasing arrangement. These mitigation strategies have been modelled to decrease magnetic field levels substantially (eg., potentially 75 to 90% reduction). These strategies will further reduce magnetic field levels below the ICNIRP guideline value of 2000 mG.

CONCLUSIONS

As indicated by measurements taken by BC Hydro at Cathedral Square, which is expected to be similar to the two proposed substations, magnetic field levels will be well below ICNIRP public guideline levels. The highest levels of magnetic fields are expected above the 230 kV transmission cables entering into the parks. The Lord Annex site will not be situated above any transmission or distribution cables and therefore magnetic field levels are not expected to differ much from current baseline conditions. Therefore, from an exposure perspective, neither substation nor their associated underground cables are expected to produce exposures of concern to the general public (Table 2). However, due to proximity of human populations, the perceived risk may be of concern.

Table 2: Comparison of Potential Risk for Electric and Magnetic Field Issues

Potential Issues	Mitigation Measures	Route A	
		Risk Rating	Rationale
Proximity to Nelson Park Transmission Cables	Low risk to health related to EMF, thus no mitigation measures required. Public may perceive health risk to be higher than actual. Communication and engagement may help to alleviate concerns. Mitigation strategies such as burying the line deeper, using metal plates for shielding, or optimally phasing the circuits, may further mitigate perceived risk.	Low	Highest level of magnetic fields is expected immediately above the 230 kV transmission cable, which is expected to be significantly below the guideline level. Depending on what is placed directly above the cable, public may perceive a risk.
Proximity of Lord Roberts Annex to substation	Low risk to health related to EMF, thus no mitigation measures required. Information sharing and communications in regards to the actual health risks related to EMF may relieve any public perception of risk.	Low	Magnetic field levels are expected to be low and near current levels. Due to the sensitivity of having a school near a substation, the public may perceive a risk.
Proximity to Emery Barnes Transmission Cables	Low risk to health related to EMF, thus no mitigation measures required. Public may perceive health risk to be higher than actual. Communication and engagement may help to alleviate concerns. Mitigation strategies such as burying the line deeper, using metal plates for shielding, or optimally phasing the circuits, may further mitigate perceived risk.	Low	Highest level of magnetic fields is expected immediately above the 230 kV transmission cable, which is expected to be significantly below the guideline level. Depending on what is placed directly above the cable, public may perceive a risk.

RECOMMENDATIONS FOR FUTURE STUDY

When engineering designs for the proposed substations become available, the EMF levels should be modelled for the substations and surrounding parks and Annex for the project.

REFERENCES

BC Hydro (2017). Inter-office memo "Emery Barnes Park and Nelson Park, Magnetic Field Measurement Results" dated January 24, 2017.

BC Hydro (2017). "Estimation of Magnetic Field Levels for the Proposed Substations in Downtown Vancouver" Report No. TD2017-000.605. January 2017.

Bunch KJ, Keegan TJ, Swanson J, Vincent TJ, Murphy MF. Residential distance at birth from overhead high-voltage powerlines: childhood cancer risk in Britain 1962-2008. Br J Cancer 2014; 110(5): 1402-1408.

Draper G, Vincent T, Kroll ME, Swanson J. Childhood cancer in relation to distance from high voltage power lines in England and Wales: a case-control study. BMJ 2005; 330(7503): 1290-1292.

Exponent, Inc. (2017). Electric and Magnetic Fields and Health: Review of the Scientific Research from March 1, 2012 to December 31, 2016. February 14, 2017.

Health Canada (2016). Electric and magnetic fields from power lines and electrical appliances. Available at http://healthycanadians.gc.ca/healthy-living-vie-saine/environment-environnement/home-maison/emf-cem-eng.php. Accessed January 2017.

International Agency for Research on Cancer. Agents classified by the IARC monographs, volumes 1–117. Lyon: IARC; last update January 26, 2017. Available at http://monographs.iarc.fr/ENG/Classification/index.php.

International Commission on Non-Ionizing Radiation Protection (2010). ICNIRP Guidelines for Limiting Exposure to Time-Varying Electric and Magnetic Fields (1 Hz - 100 kHz). Health Physics 99(6):818-836.

SMEC. 2010. Independent Review (EMF) of the North Sydney Substation Project. Appendix G – Independent EMF Review. For Department of Planning. Available at https://www.ausgrid.com.au/~/media/Files/Network/Network%20Projects/Sydney%20North/North%20Sydney%20EA/Appendix%20G%20PPR%20%20Independent%20EMF%20Review1.pdf. Accessed January 2017.

World Health Organization (2007). Electromagnetic fields and Public Health - Exposure to extremely low frequency fields. Available at http://www.who.int/peh-emf/publications/facts/fs322/en/ Accessed January 2017

World Health Organization (2017). Electromagnetic fields. What are electromagnetic fields? Available at http://www.who.int/peh-emf/about/WhatisEMF/en/index1.html. Accessed January 2017

APPENDIX I - STATEMENT OF LIMITATIONS

The work performed in this report was carried out in accordance with the Standard Terms of Conditions made part of our contract. The conclusions presented herein are based solely upon the scope of services and time and budgetary limitations described by this contract.

The report has been prepared in accordance with generally accepted industrial hygiene and/or health and safety practices. No other warranties, either expressed or implied, are made as to the professional services provided under the terms of our contract and included in this report.

The research performed herein relies on information supplied by others, such as BC Hydro. No attempt has been made to independently verify the accuracy of such information, unless specifically noted in our report.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it are the responsibility of such third parties. Aura health and Safety accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this report.

APPENDIX F REAL ESTATE VALUES REPORT

Consulting Report
Value Impact Review – Proposed Underground Substations
Emery Barnes Park and Nelson Park/Lord Roberts Annex

Prepared for:

Mr. Neal Cormack
Stantec

Prepared by:

Altus Group Limited

Value Impact Review

Proposed Underground Substations
Downtown Vancouver, BC

Effective Date: February, 2017

February 14, 2017 Project No.: 11120.101344.000

Mr. Neal Cormack, P.Eng., ENV SP
Regional Leader
Stantec
1100-111 Dunsmuir Street
Vancouver, BC V6B 6A3

Dear Mr. Cormack:

Re: Value Impact Review – Proposed Underground Substations
Emery Barnes Park and Nelson Park/Lord Roberts Annex, Vancouver, BC

Further to your request, we have undertaken an analysis as described in the Terms of Reference in the attached report.

The purpose of this Consulting Report has been to conduct a review of literature relating to the impact of the construction of underground electrical substations on the value of properties in the surrounding area. As will be seen, no studies were found relating to this specific topic; as a result, our review has focussed on studies relating to the impact on value of electrical and other infrastructure. While there are differences between those types of facilities – which are located above ground - and the proposed underground substations, our goal has been to ascertain how the conclusions of those studies might apply in the circumstances described in this report.

Our report has been undertaken in accordance with the Consulting Standard of the Canadian Uniform Standards of Professional Appraisal Practice (CUSPAP), the RICS Valuation-Professional Standards and the International Valuation Standards. The report is subject to the limitations on scope and the Extraordinary Limiting Conditions described herein.

Respectfully submitted,
Altus Group Limited

Altus Group

Table of Contents

Terms of Reference

Background

BC Hydro is proposing to construct underground substations beneath Emery Barnes Park and Nelson Park/Lord Nelson Annex. Stantec has been commissioned by BC Hydro:

> "…to study the potential effects of the proposed Projects at Emery Barnes Park and Nelson Park/Lord Roberts Annex based on conceptual designs. This report includes a brief overview of baseline conditions, potential Project impacts, key mitigation measures and recommendations for future studies. The studies are also intended to support consultation with the public and other stakeholders prior to the joint decision making process by BC Hydro, the Vancouver Park Board and Vancouver School Board at the end of March 2017 whether to proceed with the next phase of planning, community consultation and development."
>
> *Stantec - BC Hydro SEED: Technical, Environmental and Socio-Economic Study (Draft Feb 3, 2017)*

The draft report referred to above (the "Stantec Report") identifies a number of potential environmental impacts both during construction and in the operational phase. The report makes reference to two other reports:

1. "Estimation of Magnetic Field Levels for the Proposed Underground Substations in Downtown Vancouver" – *BC Hydro January 2017 (Referred to herein as the "BC Hydro Report")*
2. "Desktop Review of Electric and Magnetic Field Human Health Risk for Proposed Underground Substations at Emery Barnes Park and Nelson Park/Lord Roberts Annex" – *Aura Health and Safety, January 31, 2017. (Referred to herein as the "Aura Report")*

These two reports provide further context for a review of available literature to identify real estate value implications (other than compensation for the interests to be acquired by BC Hydro) for lands in the vicinity of the proposed substations. Stantec, as our client, has asked us to undertake this review to assist in the preparation of their report.

It is important to note that our review is intended to be at a high level and has involved no empirical research by us.

The assumptions on which our review has been based are summarized below.

Purpose and Intended Use

The purpose of this consulting report has been to conduct a review of available literature relating to the impact of underground substations or similar infrastructure on property values in the areas surrounding the facilities.

The intended use of the report is to assist Stantec and the parties to whom they are reporting in supporting the decision-making process and additional public consultation regarding the proposed projects. The intended users are therefore solely Stantec, BC Hydro, the Vancouver School Board, the City of Vancouver and others involved in the decision-making process. No other uses or users are intended.

Assumptions and Limiting Conditions

The following assumptions have been made in preparing this report;

1. The proposed substations will be designed and constructed as described in the Stantec Report. While the Report points out that the current design is conceptual and preliminary at this stage, 3D renderings from the Stantec Report provide some indication of the two schemes:

   Emery Barnes Park Project

Nelson Park/Lord Roberts Annex Project

The Nelson Park project is anticipated to comprise mainly Transmission and Distribution lines to transfer power to, into and out of the substation, construction of which is anticipated to be primarily on the Lord Roberts Annex property.

In both cases the Report describes the substations as being 99% underground. Above ground components consist of of an elevator and vent shafts.

2. Construction of each substation is expected to take around 3 years. The Emery Barnes is anticipated to start in 2036; the Nelson Park/Lord Roberts Annex in 2020. Any comments regarding value-related issues in our report relate to those which might be observed at the time of construction and after completion.

3. With respect to potential value impacts, from our review of the Stantec Report we have identified four possible areas of concern:
   - Air Quality
   - Noise
   - Vibration
   - Health-related issues associated with EMF

   For the first three factors, the Report identifies the construction phase as being the main period of potential impact. Because vibration and air-quality effects were not considered to be an issue during the operational phase, the Stantec Report did not address these. For the purpose of our report we have therefore assumed that issues relating to air quality and vibration during the operational phases of the projects would have no value impacts.

4. Potential noise impacts are addressed in the Stantec Report by comparing existing noise levels at the two locations on site (the "Baseline Noise Measurement") with that projected for both the construction and operational phases. At Emery Barnes Park, the operational noise levels measured at the site perimeter (between 10 and 22m from the sound source) were predicted to be above the Baseline Noise Measurements, but below the noise limits specified in the Noise Control By-Law. At Nelson Park, operational noise levels 14 to 23 metres from the sound source were predicted to be below Baseline Noise Measurements, and also below the noise limits specified in the Noise Control By-Law.

   In the absence of more specific information, we have assumed that the predicted operational noise levels would not be sufficient to be of concern.

5. During construction, the highest noise levels are identified in the Stantec Report as being caused by piling and jack-hammering. At both locations, noise levels for these activities are projected by Stantec to exceed the limits of the Noise Control By-Law. They also conclude: "…the noise effects are expected to be noticeable for indoor occupants during certain activities (i.e. piling, excavation). The perceptibility of construction noise could result in annoyance. Mitigation measures will be required to reduce the annoyance effects during construction."

   This conclusion is assumed to be correct.

6. With respect to potential health concerns resulting from exposure to EMF, the BC Hydro Report measured Magnetic Flux Density at the Cathedral Square substation. Their findings can be summarized as follows:

   - Field tests as well as simulations were conducted which provided very comparable results. The tests found peak levels of magnetic fields of 100 mG directly above the point where three 230 kV transmission lines enter the park. The MF level decreases with distance from this point, as shown in the following chart:

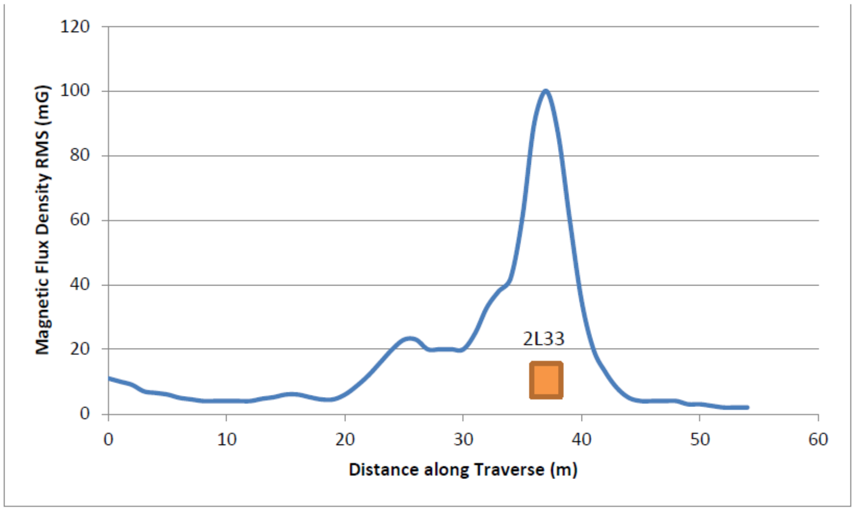

Figure 6: Measured magnetic flux density norm as a function of distance along TRV#1.

Source: BC Hydro

- A maximum potential magnetic field level was anticipated to be 200 mG in the event that one circuit went out of service. It was noted in the report that the probability of this occurrence is very low.
- Recommended maximum exposure levels are summarized in the BC Hydro Report as follows:

Table 1: Recommended Limits for Magnetic Field Exposure (1mG = 0.1µT).

	IEEE [5]	ICNIRP [6]	ACGIH [7]
General Public	9,000 mG (head and torso)	2,000 mG	-
Occupational	27,000 mG (head and torso)	10,000 mG	10,000 mG

- The conclusion of the BC Hydro Report is stated to be: "Based on the findings of this report and comparing the measured and simulated values with the reference levels in Table 1, the MF levels produced by the proposed West End Substation and the new Dal Grauer Substation (NDG) are expected to be well below these guidelines. Engineering techniques were proposed to minimize the MF levels produced by underground cables. Further analysis is required to evaluate the applicability of the proposed techniques."

This conclusion is assumed to be correct.

7. The Aura Report was undertaken as a "desk top review of electric and magnetic field exposure risk to humans and animals for the proposed underground substations at Emery Barnes and Nelson Park/Lord Roberts Annex." The report concluded:

   "As indicated by measurements taken by BC Hydro at Cathedral Square, which is expected to be similar to the two proposed substations, magnetic field levels will be well below ICNIRP public guideline levels. The highest levels of magnetic fields are expected above the 230 kV transmission cables entering into the parks. The Lord Roberts Annex site will not be situated above any transmission cables and therefore magnetic field levels are not expected to differ much from current baseline conditions. Therefore, from an exposure perspective, neither substation nor their associated underground cables are expected to produce exposures of concern to the general public (Table 1). However, due to proximity of human populations, the perceived risk may be of concern."

   We have assumed these conclusions to be correct.

8. The analysis in our report has been undertaken in a limited timeframe and is therefore subject to the extraordinary limiting condition that the conclusions reached are based on, and limited to, the research we have been able to undertake within the time available. Further analysis will be required to provide more definitive conclusions.

Scope of Work

- Discussion of the terms of reference.
- Review of the following reports in order to identify the nature of the proposed construction and, in particular the potential deleterious impacts (including EMF) and the measures to be taken to mitigate them.
  - The BC Hydro Report
  - The Aura Report
  - The Stantec Report
- Review of published and unpublished material relating to the effect of electrical and similar infrastructure on property values in the surrounding area;
- Identification of conclusions from the literature and their relevance to the proposed infrastructure.
- Review of material relating to the impact of noise on property value.
- External inspection of the subject properties and surrounding area.
- Report preparation.

Date of Review

The research and analysis for this report was undertaken in February 2017.

Literature Review

Introduction

While the impact of electrical infrastructure on property value has been the subject of numerous studies over many years, our review has focused on the more current source material – primarily that published since 2000. It should be noted, however, that we found no material relating specifically to the question of value impacts resulting from construction of underground substations. This review has therefore identified material relating to electrical infrastructure (such as High Voltage transmission Lines – HVOTL) and telecommunication facilities. In both these cases it was observed that the principal factors affecting values are: visual intrusion, perception of health risks (resulting from exposure to EMF) and concern over resale value. Our approach has therefore been to identify what conclusions were reached by those studies with respect to the elements of potential value impact most similar to those applicable to the subject properties. The material reviewed has been summarized in Appendix A.

In that regard, our review of the Stantec Report and Aura Report indicates that the issues which might be considered as having potential for value impacts are: noise during construction and the existence of low-level EMF. The material reviewed for this report has therefore been reviewed with the conclusions of those two reports in mind. The first part of this section of our report refers to studies relating to electrical and communication infrastructure; the second part addresses the issue of noise.

Studies Relating to Electrical and Communication Infrastructure.

The results of our review are broken down into two parts:

1. Studies describing questionnaire results
2. Transaction based analysis where conclusions are based on analysis if market data.

1. <u>Questionnaire based Studies</u>

a) Bond and Wang (2006) – Christchurch, New Zealand

The study examined both the perceived discounts and actual sales data associated with four residential neighbourhoods affected by Cell Phone Base Stations (CPBS) in Christchurch, New Zealand. These neighbourhoods had CPBS that were visible to 46% of residents. The study polled residents living within affected neighbourhoods (Case Study Group) as well as residents located over 1 km away (Control Group).

The results of the questionnaire–based component are summarized as follows:

- 74% of the Case Study Group respondents indicated that they would have gone ahead with their home purchase or rental regardless of knowing that the CPBS would be constructed.
- 51.4% of the Case Study respondents indicated that the proximity to the CPBS did not impact the price they were willing to pay for the property.
- Only 10% of the Case Study respondents indicated the impact the CPBS had on the price/rent they were willing to pay for the property, with one-third indicating it would decrease the price/rent by 1% to 9%.
- 45% of the Control Group, located at least 1 km from a CPBS, indicated they would pay substantially less for a property with a CPBS located nearby. 38% of the Control Group respondents felt that being within close proximity to a CPBS would decrease price/rent by more than 20%. An additional 36% of respondents felt a decrease of 10% to 19% would be warranted.
- The results indicated that respondents located further away from the CPBS (Control Group) were more concerned with the possibility of harmful health effects, stigma, effect on future property values and aesthetics than respondents located within close proximity to the CPBS.
- The report goes on to state that "even buyers who believe that there are no adverse health effects from cell phone base stations, knowing that other buyers might think the reverse, will probably seek a price discount for a property located near a cell phone base station."
- "Research to date reports no clearly established health effects from radio frequency emissions of CPBSs operated at or below the current safety standards, yet recent media reports indicate that people still perceive that CPBSs have harmful effects. Thus, whether or not CPBSs are proven to be free from health risks is only relevant to the extent that buyers of properties near CPBSs perceive this to be true."

b) National Institute for Science, Law and Public Policy (NISLAPP)

The 2014 Study surveyed residents of the United States and abroad on how cell towers and antennas impact a property's desirability.

- 94% of respondents indicated that a nearby cell tower or group of antennas would negatively impact their interest in a property or the price they would be willing to pay for it. 79% indicated that they would not purchase or rent a property within a few blocks of a cell tower or antennas under any circumstances.

- 89% indicated they were concerned about the increasing number of cell towers and antennas in their residential neighbourhood.
- The study also indicated that 57% of the respondents believed they had previously experienced cognitive effects from radiation and 63% indicated they believed they had previously experienced physical effects.

c) Sims and Dent (2004) – Cumbernauld, Scotland

This was a comprehensive study relating to value impacts resulting from proximity to HVOTLs. There were two parts to the study: a questionnaire based component and an analysis of transactional data. The questionnaire component surveyed real estate valuers and estate agents and concluded:

- Overall average responses indicated that HVOTLs have a negative impact on value of around 5% to 10%.
- Valuers' opinions clustered around 5% to 15% and agents' opinions were more varied.
- The largest perceived negative effect on value and marketing was indicated as health concerns, followed by visual impact and concerns over future value.

2. Transaction Based Studies

a) Tatos, Glick and Lunt (2016) – Salt Lake county, Utah

Using a hedonic regression model, this comprehensive study analyzed almost all single-family home sales between 2001 and 2014 within Salt-Lake County, Utah. The study analyzed over 125,000 transactions and 450 home characteristics to examine the effects of various types of transmission lines and substations. The analysis considered the effects of different types of HVOTLs (from 46KV to 345KV) on property values at varying distances from the infrastructure. It also considered the value impact of substations. The main conclusions reached can be summarized as follows:

- Homes within 50 metres of 138 kV transmission lines showed an average 5.1% decrease in value. Between 50 to 100 metres, homes had an average decrease of 2.9%. The decrease dropped below 1% after 400 metres.
- Homes within 50 metres of 46 kV lines showed no decrease in value. However, homes within 50 to 100 metres of 46 kV lines had an average decrease of 2.5%, with the decrease dropping to zero after 200 metres.
- The study suggests this decrease may be due to the lines being more visible from a distance of 50 to 100 metres.

- Homes within 50 metres of a substation experienced an average value decrease of 2.9%. The decrease in value diminished to 0.38% at a distance of 50 to 100 metres.
- Homes Adjacent to 345 kV transmission lines experienced mixed results due to being adjacent to corridors which often benefit from open space unavailable to other homes.
- The decrease associated with homes within 50 metres of 138 kV and 345 kV transmission lines was noted to be strongest in the 2012 to 2014 period. However, the study also notes that this period experienced fewer sales than the previous periods studied.

b) Bond and Wang (2006) – Christchurch, New Zealand

As part of the study referred to previously, the authors analyzed transactional data from four neighbourhoods in Christchurch New Zealand before and after the installation of a CPBS. The conclusions reached were:

- Two of the neighbourhoods had CPBSs installed in 2000 and showed similar property value decreases of 20.7% to 21%.
- The two remaining neighbourhoods had CPBSs installed in 1994. One neighbourhood showed no significant change in value and the other showed a 12% increase after the installation of the CPBS.
- The reason for the variance between neighbourhoods was indicated to have potentially been due to the media publicity resulting from two legal cases related to CPBS in Christchurch, occurring in 1996 and 1999. The neighbourhoods which had CPBSs installed in 2000, after the legal cases, showed 20.7% to 21% decreases in property value.

c) Bond (2004) – Florida, USA

As part of the study referred to previously, the authors analyzed transactional data from four neighbourhoods in Christchurch New Zealand before and after the installation of a CPBS.

The study of transactional data was conducted in northeast Orange County, Florida, and measured the effect of cell phone tower proximity on residential property prices. Sales of 5,783 single-family, residential properties were analyzed which were located close to twenty chosen cell towers. The conclusions of the study indicate:

- Property prices in the transactions analyzed decreased by just over 2%, on average, after a cell phone tower was constructed. The amount of the decrease diminished with distance and was almost non-existent after approximately 656 feet.
- The author presents a potential explanation for the variance between the results of this study and the study conducted in Christchurch, NZ, suggesting that the United States

has a higher proportion of large structures, such as HVOTLs, cell phone towers and billboards. It is suggested that US residents may be more accustomed to these structures and therefore notice them less.

d) Sims and Dent (2004) – Cumbernauld, Scotland

The study focused on a mixed-residential development of 664 properties on a site of approximately 104 acres. Houses within the development ranged in distance from HVOTL pylons and transmission lines. The study found:

- The data indicated a positive correlation between value and distance from the transmission lines and pylons, increasing at a rate of £37 per metre from pylons.
- Detached homes within 100 metres of a pylon had a mean value between 6% and 13.3% lower than similar detached homes located more than 250 metres away from a pylon.
- Semi-detached homes within 100 metres of a pylon had a mean value between 10% and 17.7% lower than similar semi-detached homes located over 250 metres from a pylon.
- Properties with a front view of a pylon were found to have average reduced values of 14.4% and properties with a rear view of a pylon were found to have average reduced values of 7.1%.
- The presence of a pylon had a more significant impact on value than an overhead transmission line and could reduce value by up to 20.7% when compared to similar property over 250 metres from the pylon.
- Results of the study were noted to not be linear as and no clear pattern of value loss was apparent.
- All negative impacts appeared to decrease with distance, becoming negligible at approximately 250 metres.

Studies Addressing Noise Issues

From the studies we have reviewed (summarized in the Bibliography in Appendix A) and from our own experience, it is apparent that proximity to noise sources (such as traffic) does have an impact on value. During the operational phase, we have made the assumption that, based on the Stantec Report, sound levels associated with the transformer and ventilation systems would not be sufficient to be of concern. However, the information only allows us to conclude that while there will be additional noise at these locations, it is not sufficient to permit comparison to noise levels at all locations that might be affected.

No studies relating to the type of noise anticipated during the construction phases have been identified. A recent decision by the Supreme Court of BC (Gautam v. Canada Line) found there was evidence of value loss to some adjacent commercial properties during the construction of the Canada Line on Cambie Street. Construction noise alone, however, was not addressed as an issue. Publications relating to noise in proximity to wind turbines were also reviewed, but any effects described were the result either of visual intrusion or of longer term exposure to noise and are not considered applicable to the short-term and periodic (rather than sustained) effects described in this instance.

Conclusions

The conclusions that can be drawn from the reviews described above can be summarized as follows:

1. No studies were identified that specifically address the type of potential value impacts considered applicable in the case of the proposed underground substations, namely: Health related issues as a result of exposure to EMF in this context, and noise during the construction phase.

2. As noted previously, the principal factors affecting property values in the vicinity of electrical or communication infrastructure - these being the type of projects that have some degree of similarity (albeit limited) to the proposed substations – are: visual intrusion, perception of health risks (resulting from exposure to EMF) and concern over resale value.

3. Our assumptions are that the proposed substations would have very little visual impact. They are described as being over 99% below ground. As a result it can be assumed that any visual impact would be low and quite different from the types of infrastructure which formed the subject of the studies. The types of value impacts identified in those studies (the most comprehensive of which was the Glick and Troy in 2016) are not therefore considered to be of direct assistance in assessing potential value impacts attributable to the proposed underground substations.

4. Because the impact of visually intrusive electrical and telecommunication infrastructure is attributable to the three factors described above, the question arises as to whether the value impact effects observed in the studies referred to can be segmented in any way. There is, however no data from which such conclusions could be drawn. In an earlier study undertaken by Altus Group, it was observed that although the literature on the threat of EMF to health is inconclusive, the apprehension of health effects can have an impact on the behaviour of market participants. If this apprehension exists, it can result in diminished value. It was also concluded that independent study of the effect of this uncertainty is likely not possible as it is only one of a set of factors which can impact property values in the vicinity of high voltage electric transmission lines.

5. Further to the above, it is noted that the Aura Report concluded that in the case of the proposed substations "…from an exposure perspective, neither substation not their associated underground cables are expected to produce exposure of concern to the general public." This being the case there is no technical reason to conclude there would be any value impact. However, as the studies have pointed out, and as Aura conclude "…due to proximity of human populations, the perceived risk may be of concern." Whether the concern is sufficient to affect property values would require further analysis similar to that described in the literature reviewed, but with a focus on the specific circumstances of underground substations described in this report.

6. As described in the Stantec Report, noise levels during construction "could result in annoyance". No studies or decisions were found relating to the impact on value of surrounding properties due to construction noise alone.

Certification

Subject of Consulting Report: Proposed Underground Substations – Vancouver, BC

I certify that, to the best of my knowledge and belief:

- The statements of fact contained in this report are true and correct
- The reported analyses, opinions, and conclusions are limited only by the reported Extraordinary Assumptions and Limiting Conditions and Contingent and Limiting Conditions, and is my personal, unbiased professional analyses, opinions and conclusions
- I have no present or prospective interest in the properties that are the subject of this report, and I have no personal interest or bias with respect to the parties involved
- I am not in a conflict of interest to undertake this assignment
- I have no bias with respect to the property that is the subject of this report or to the parties involved with this assignment
- My engagement in and compensation for this assignment was not contingent upon developing or reporting predetermined results, the amount of the value estimate, or a conclusion favouring the client
- To the best of my knowledge and belief, the reported analyses, opinions and conclusions were developed, and this report has been prepared, in conformity with the Canadian Uniform Standards of Professional Appraisal Practice ("The Standards")
- Robbie Bishop, AIC Candidate Member, provided professional assistance to the undersigned with respect to research and report preparation. Altus Group Cost Consulting provided a construction cost estimate which has been assumed to be correct.
- The undersigned has the knowledge and experience to complete the assignment competently
- As of the date of this report the undersigned had fulfilled the requirements of the Appraisal Institute of Canada Continuing Professional Development Program for members and is a member in good standing of the Appraisal Institute of Canada.

Altus Group Limited

Carl Nilsen, B.Sc., AACI, P.App, FRICS
Senior Director
Report date: February 14, 2017

Appendix A

Source Material

Source Material

1. National Institute for Science, Law and Public Policy. 2014. EMF Real Estate Survey Results: “Neighbourhood Cell Towers & Antennas – Do They Impact a Property’s Desirability?”

2. Bond, S. & K.K. Wang. 2005. The Impacts of Cell Phone Towers on House Prices in Residential Neighbourhoods. Published in *The Appraisal Journal, Summer 2005.*

3. Bond, S. 2004. The Effect of Distance to Cell Phone Towers on House Prices in Florida. Published in *The Appraisal Journal, Fall 2007.*

4. Sims, S. & P. Dent. 2004. High-voltage Overhead Power Lines and Property Values: A Residential Study in the UK. Published in *Urban Studies, Vol. 42, No. 4, 665-694, April 2005.*

5. Tatos, T. et al. 2016. Property Value Impacts from Transmission Lines, Subtransmission Lines, and Substations. Published in *The Appraisal Journal, Summer 2016.*

6. Sims, S. 2002. The Effect of Public Perception on Residential Property Values in Close Proximity to Electricity Distribution Equipment: A case study in the UK currently in progress. Presented at the *Pacific Rim Real Estate Society Conference, January 2002.*

7. SSM’s Scientific Council of Electromagnetic Fields (2016) Recent Research on EMF and Health Risk.

8. Government of Canada. Health information. https://www.canada.ca/en/health-canada/services/home-garden-safety/electric-magnetic-fields-power-lines-electrical-appliances.html

9. Land Compensation Reports. Volume 81 & 83. 2004.

10. Gautam v. Canada Line Rapid Transit Inc., 2015 BCSC 2038

11. El-Gohary. M. 2004. Property Valuation Model: Effect of Traffic Noise on Property Value.

12. Suksmith, P.L. & V. Nitivattananon. 2014. Aviation Impacts on Property values and Management: The Case of Suvarnabhumi International Airport. Published in *IATSS Research 39 (2015) 58-71.*

13. Wilhelmsson, M. 2000. The Impact of Traffic Noise on the Values of Single-Family Houses. Published in *the Journal of Environmental Planning and Management, 43(6), 799-815, 2000.*

14. Nova Scotia Department of Energy. Undated. Wind Turbine Effects. Published on the Nova Scotia Department of Energy website: https://energy.novascotia.ca/sites/default/files/Wind%20Turbine%20Effects.pdf

15. Health Canada. Modified October 2014. Wind Turbine Noise and Health Study: Summary of Results. Published on the Health Canada website: http://www.hc-sc.gc.ca/ewh-semt/noise-bruit/turbine-eoliennes/summary-resume-eng.php

16. Guerin, B. et al. 2012. Impact of Industrial Wind Turbines on Residential Property Assessment in Ontario. Published by the Municipal Property Assessment Corporation (MPAC).

APPENDIX G BC HYDRO: ESTIMATION OF MAGNETIC FIELD LEVELS FOR THE PROPOSED UNDERGROUND SUBSTATIONS IN DOWNTOWN VANCOUVER

ESTIMATION OF MAGNETIC FIELD LEVELS FOR THE PROPOSED UNDERGROUND SUBSTATIONS IN DOWNTOWN VANCOUVER

BC Hydro
Power smart

ENGINEERING

Report No. TD2017-00.605

File: T2017-6002

January 2017

ESTIMATION OF MAGNETIC FIELD LEVELS FOR THE PROPOSED UNDERGROUND SUBSTATIONS IN DOWNTOWN VANCOUVER

T2017-6002

Prepared by: Hamed Ahmadi, Ph.D., P.Eng. Date: Jan 31, 2017

Checked by: Mazana Armstrong, Ph.D., P.Eng. Date: Jan 31, 2017

Reviewed by: Mazana Armstrong, Ph.D., P.Eng. Date: Jan 31, 2017

Accepted by: Ola Onifade, Ph.D., P.Eng. Date: Jan 31, 2017

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
Dr. M. ARMSTRONG
33367

Jan 2017

Estimation of Magnetic Field Levels for the Proposed Underground Substations in Downtown Vancouver

CONTENTS

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1.0 INTRODUCTION

BC Hydro is planning to build new underground substations in downtown Vancouver. Based on BC Hydro Stations Planning ScopeNote ID2332, a new 230/12-25 kV West End Substation (WTE) will be built near West End area in Vancouver downtown. Two other substations are also proposed to meet the demand in downtown Vancouver, namely New Dal Grauer Substation (NDG) in Yaletown area and New Murrin Substation (NMU) in Mount Pleasant area. In this report, WTE is analyzed as an example. The design concepts are expected to be similar for NDG.

The initial firm capacity of WTE will be 286 MVA (restricted by feeder section capacity) and the ultimate will be 400 MVA. This substation will operate at both distribution voltages 12 kV and 25 kV. Initially, this station will be fed through two 230 kV underground cables, designated as 2L033 and 2L025. Eventually, an additional 230 kV cable will be connected to this station, designated as 2L021. The proposed location to build this substation is Nelson Park, surrounded by Nelson St, Thurlow St, Comox St, and Bute St.

The Transmission Line Electrical Design (TLED) team has been approached to provide an estimate on the expected magnetic field (MF) levels produced by the proposed substation. Since this project is at its very early stages, no detail engineering designs have been done and only conceptual ideas have been proposed at this point. Therefore, in order to provide an estimate for the MF levels, an existing substation was selected to be used as a reference, namely Cathedral Square (CSQ) substation. The idea is that the proposed substation will have similar layouts and the MF levels produced by CSQ are expected to be similar to WTE. MF measurements were carried out on January 13, 2017 inside and outside CSQ substation and the results are presented and discussed in this report. Advanced simulation techniques were used to reproduce the field measurement results.

There are several factors that influence the MF at any given location produced by a three-phase electric source:

- Phase current (magnitude and angle) which, in turn, depends on many other factors such as time of the day due to the daily load variation, system configuration, phase current unbalance, etc.
- Distance to the source
- Background noise from other sources (distribution or transmission overhead/underground, building wirings, etc.)
- Phase-to-phase separation
- Presence of any conductive object between the source and the measurement point, e.g., cable sheath, cable steel pipe, rebar concrete, metallic enclosures, etc.

To generalize the measurement results, the variations with loading and distance are used to calculate the expected MF profiles.

2.0 SAFETY BY DESIGN

Safety by Design (SbD) is an application of engineering principles and standards for designing features into new and existing facilities that contribute to increased safety.
This report applies Safety by Design by calculating the expected magnetic field levels generated by the proposed substation. Several methods are proposed to minimize the magnetic field levels produced by underground cables.

3.0 MEASUREMENTS AT CATHEDRAL SQUARE (CSQ)

On January 13, 2017, TLED visited CSQ substation and collected MF data from various locations, both inside and outside the substation. The measurement device used is shown in Appendix A. The purpose of these measurements was to identify significant sources of MF at the ground level, where the public may be present. Only the measurements that are relevant to the analysis in this report are presented.

3.1 Inside CSQ-Level 1-2L33

The measurements were collected near 2L033 cables, as shown in Figure 1. The loading of this circuit was 475A (ph-A), 458A (ph-B), 490 A (ph-C), at 10:45 AM. The measurement results are shown in Figure 2. Neglecting the influence of the cable sheaths, the cables were modelled in TLED's in-house tool to calculate the MF. This tool uses the formulation derived in [1]. The results are presented in Figure 2. There is a good agreement between the results. The possible sources of differences in the results are:

- The cables are modeled as straight conductors, whereas in the actual case they are placed in a curve (see Figure 1).
- The sheath current is small in the cross-bonded system hence was not modelled.
- The noise from other sources was not modelled.
- The error in distance measurement and phase-phase separation between cables

The MF levels are almost negligible in a distance of 8m from the outermost cable. The dependency to distance and current magnitude for this particular case can be approximated as follows:

$$|B| = 0.78\frac{I^{+}}{x^{1.44}}$$

Where B is the magnetic flux density (mG); I^{+} is the positive sequence current (A); and x (m) is the distance from the outermost cable. This indicates how fast the magnetic flux density norm decays as a function of distance.

Figure 1: Measurement location near 2L033 (230kV Cables) inside CSQ Substation, Level 1.

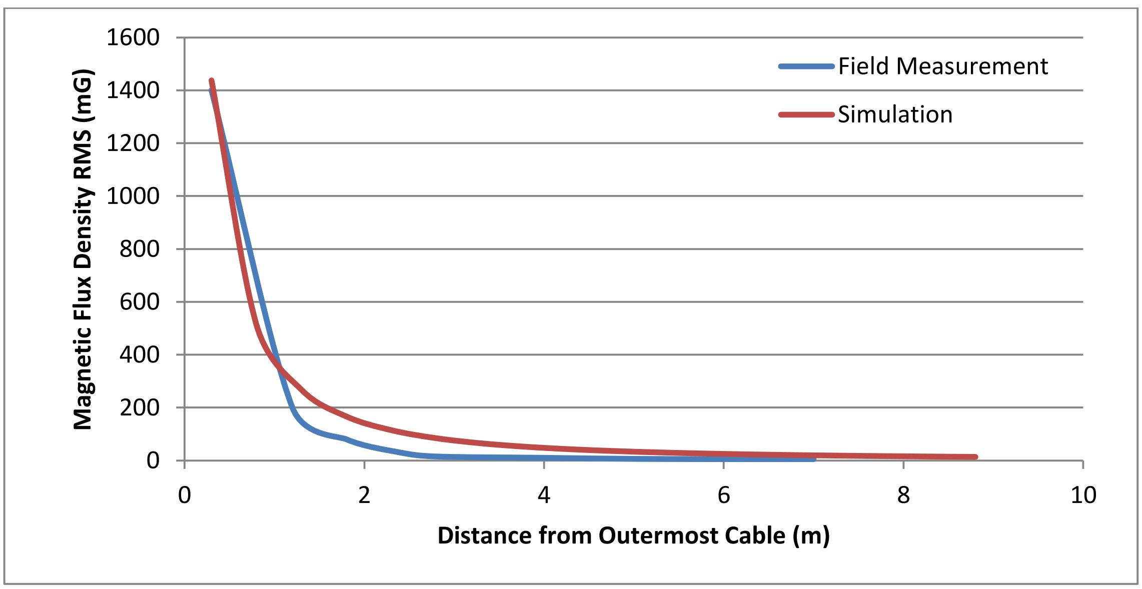

Figure 2: Magnetic flux density norm as a function of distance for 2L033 inside CSQ.

3.2 Inside CSQ-Level 1-2L020

Measurements were taken near 2L020 cables, as shown in Figure 3. The loading of this circuit was 434A (ph-A), 438A (ph-B), 433 A (ph-C), at 10:50 AM. The measurement results are shown in Figure 4. Neglecting the influence of the cable sheaths, the cables were modelled in TLED's in-house tool to calculate the MF. The results are presented in Figure 4. There is a good agreement between the field data and the simulation results. Same factors mentioned in the previous section could have contributed to the differences between the two results.

Figure 3: Measurement location near 2L020 (230kV Cables) inside CSQ Substation, Level 1.

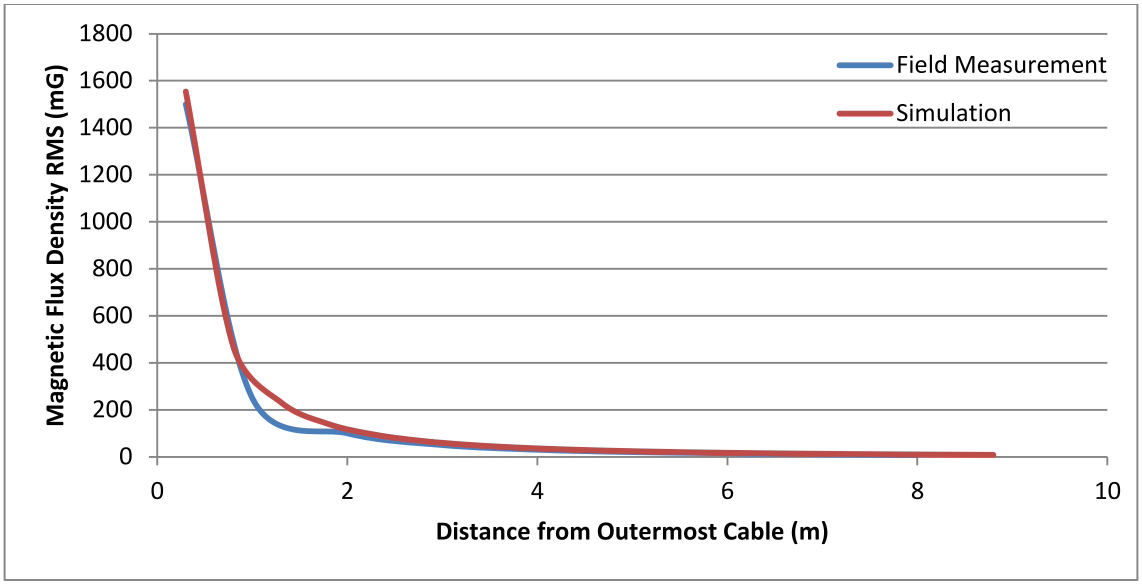

Figure 4: Magnetic flux density norm as a function of distance for 2L020 inside CSQ.

3.3 Outside CSQ Substation

Measurements were taken outside the substation, around Cathedral Square. Five traverses were taken, as shown in Figure 5. Traverse 1 yielded the highest MF levels and the results for this traverse are shown in Figure 6. In this figure, the magnetic flux density, which is a vector quantity, is presented by its magnitude (norm). The peak happened right on top of the 230kV cables. There are several sources contributing to this profile: 2L031, 2L032, 2L033, distribution underground, distribution overhead, etc. Drawing BCH 2L031-V07-B64 R1 shows that the cables for 2L031 and 2L032 are located inside a steel pipe, which is filled with oil. These steel pipes substantially reduce the magnetic field produced by 2L031 and 2L032. Therefore, the main source of the high measurements for this location would be 2L033 and the distribution cables. 2L033 has a different configuration than 2L031 and 2L032 and the cables are placed further apart from each other and there is no steel pipe. Typical cross sections for 2L033 were obtained from drawing 2L033-V08-B15.

Traverse 2 passes over a distribution duct and approaches another one towards the end. The distribution duct in the middle seems to be contributing minimally to the MF. The duct towards the end has a higher contribution.

Traverse 3 passes over a few distribution ducts and there is a good correlation between the location of these ducts and the peaks in the measured MF.

Traverse 4 passes over 2L020, where a peak value of 22mG was recorded. Since this circuit was carrying similar load as 2L033, it is suspected that this duct bank is buried deeper and/or is enclosed within the concrete rebar of the substation building (the blue line in Figure 5). Towards the end of this traverse, a slight rise in the MF level was observed, which is explained by the proximity to the distribution ducts.

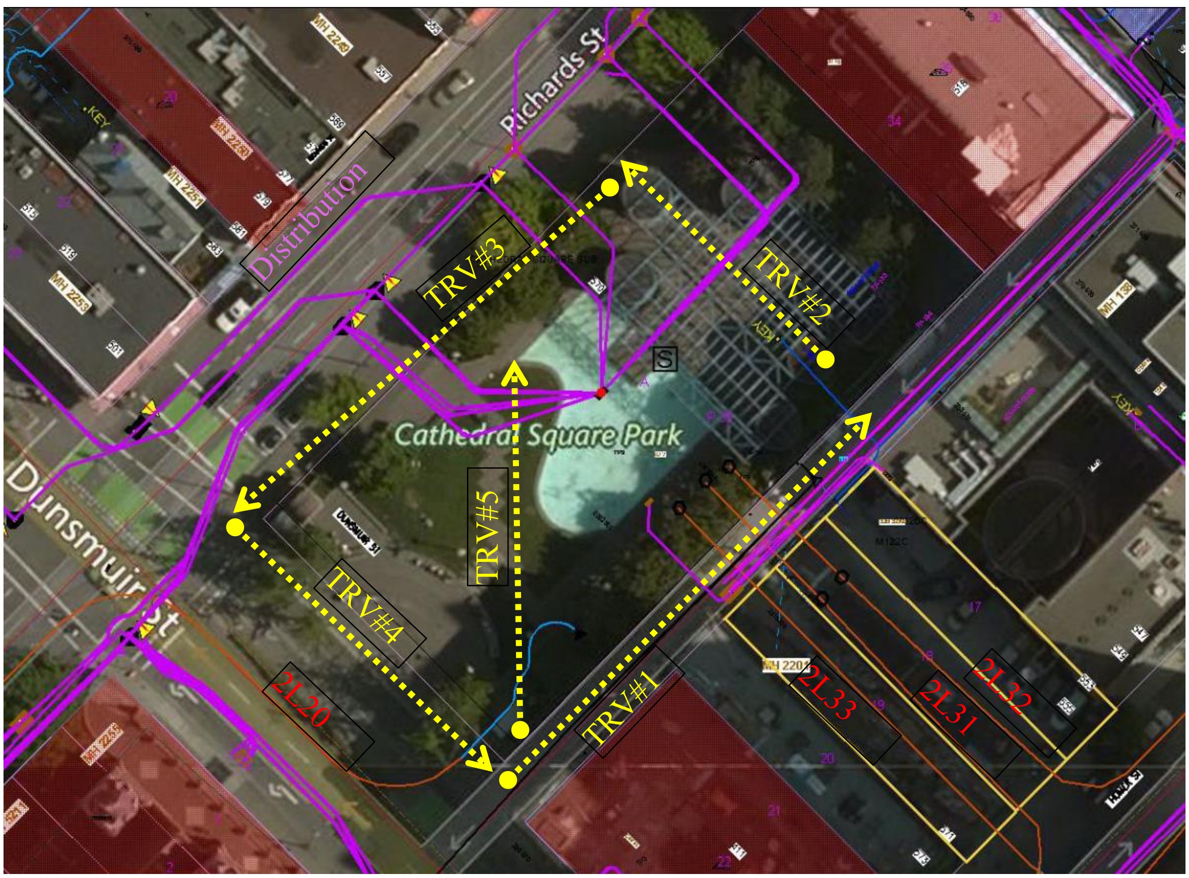

Figure 5: Traverses at Cathedral Square Park.

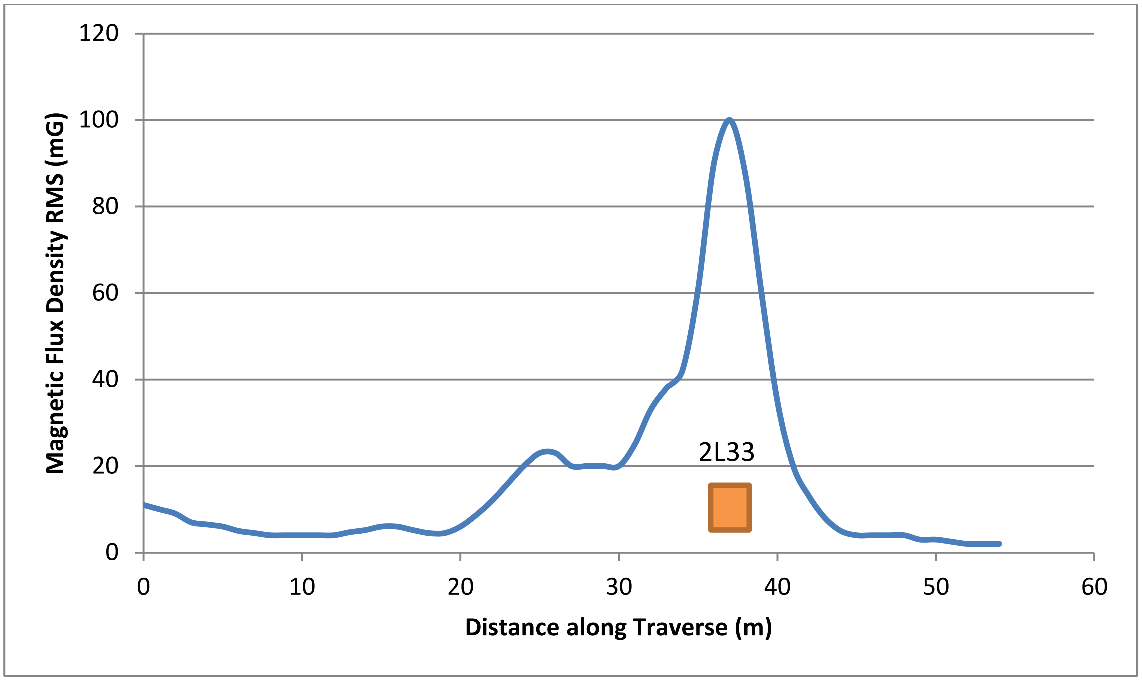

Figure 6: Measured magnetic flux density norm as a function of distance along TRV#1.

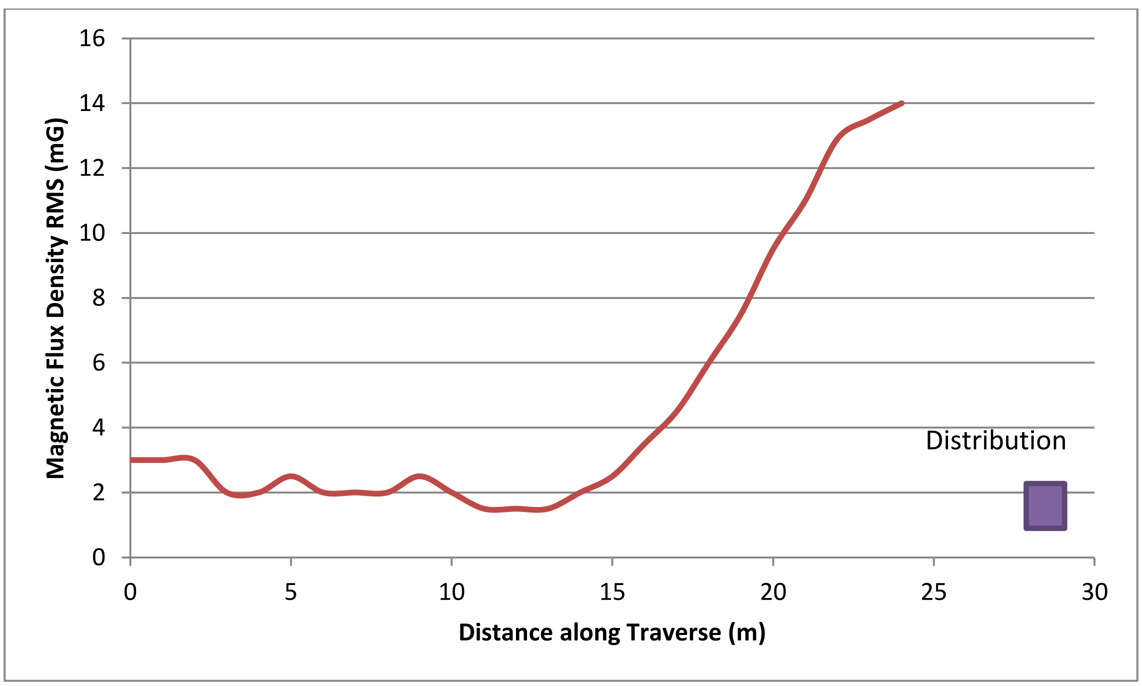

Figure 7: Measured magnetic flux density norm as a function of distance along TRV#2.

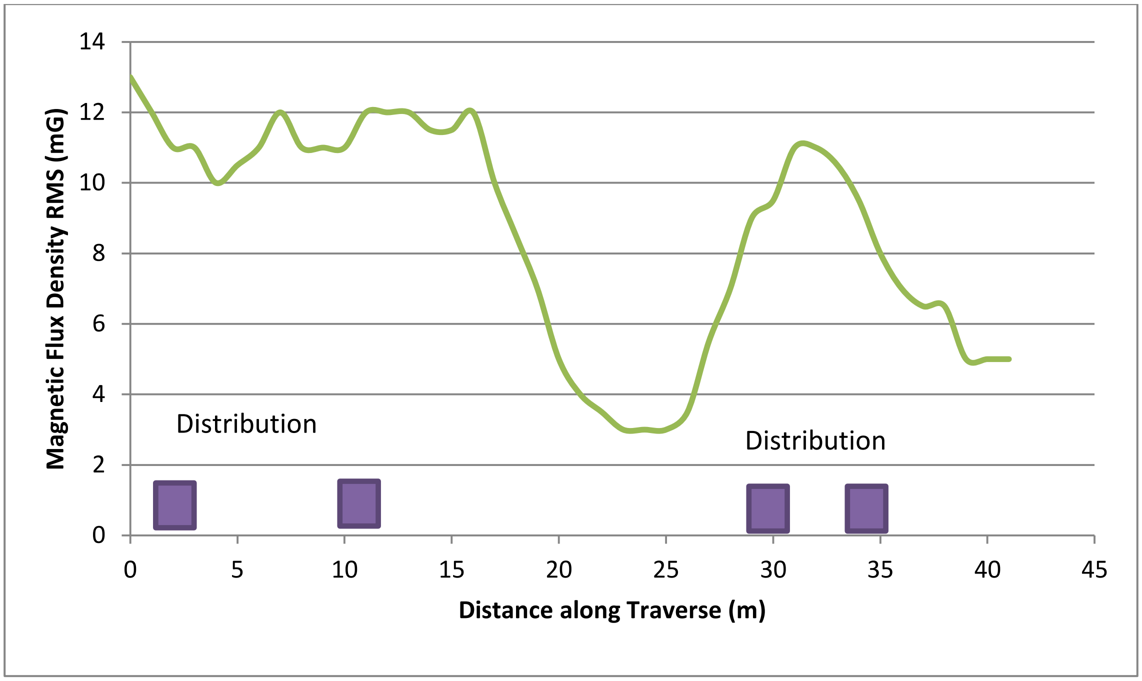

Figure 8: Measured magnetic flux density norm as a function of distance along TRV#3.

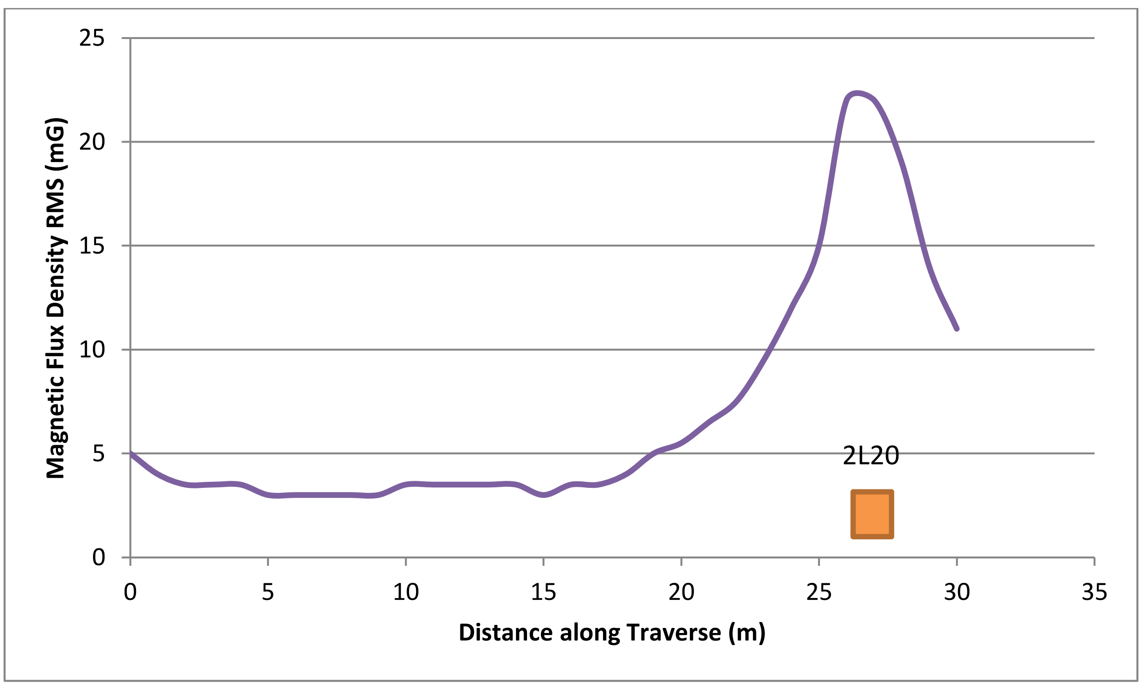

Figure 9: Measured magnetic flux density norm as a function of distance along TRV#4.

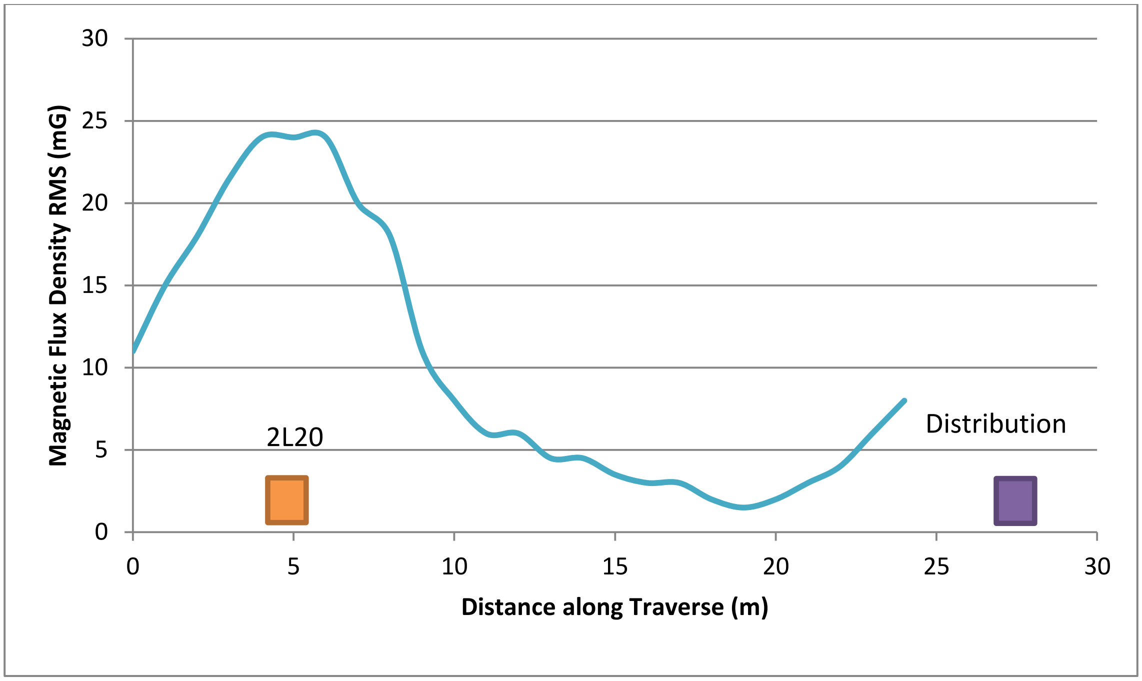

Figure 10: Measured magnetic flux density norm as a function of distance along TRV#5.

3.4 Variation of Magnetic Field Levels over Time

The loading in the circuits changes daily, weekly, and on a seasonal basis. The historical data for 2L031, 2L032, and 2L033 from the past year is plotted in Figure 11. It is important to note that when one circuit is out, the loading on the other circuits goes up. The histograms of line loading data are presented in Figure 12 to Figure 14. Based on the graph for 2L033, and assuming that the measurements in Figure 6 were mostly contributed to by 2L033, it can be concluded that about 85% of the time, the magnetic field levels will be lower than the profile shown in Figure 6. The maximum expected peak MF is about 200mG (twice as much as the measured value) during a contingency (when one circuit is out of service). This event has a probability of a fraction of one percent.

The loading in 2L020 is shown in Figure 15. The line loading at the time of measurement was about 450A. This means that for about 95% of time, the MF levels are expected to be below 25mG. Based on the maximum loading of this circuit, the maximum MF level generated by this circuit at this particular location is expected to be less than 35mG.

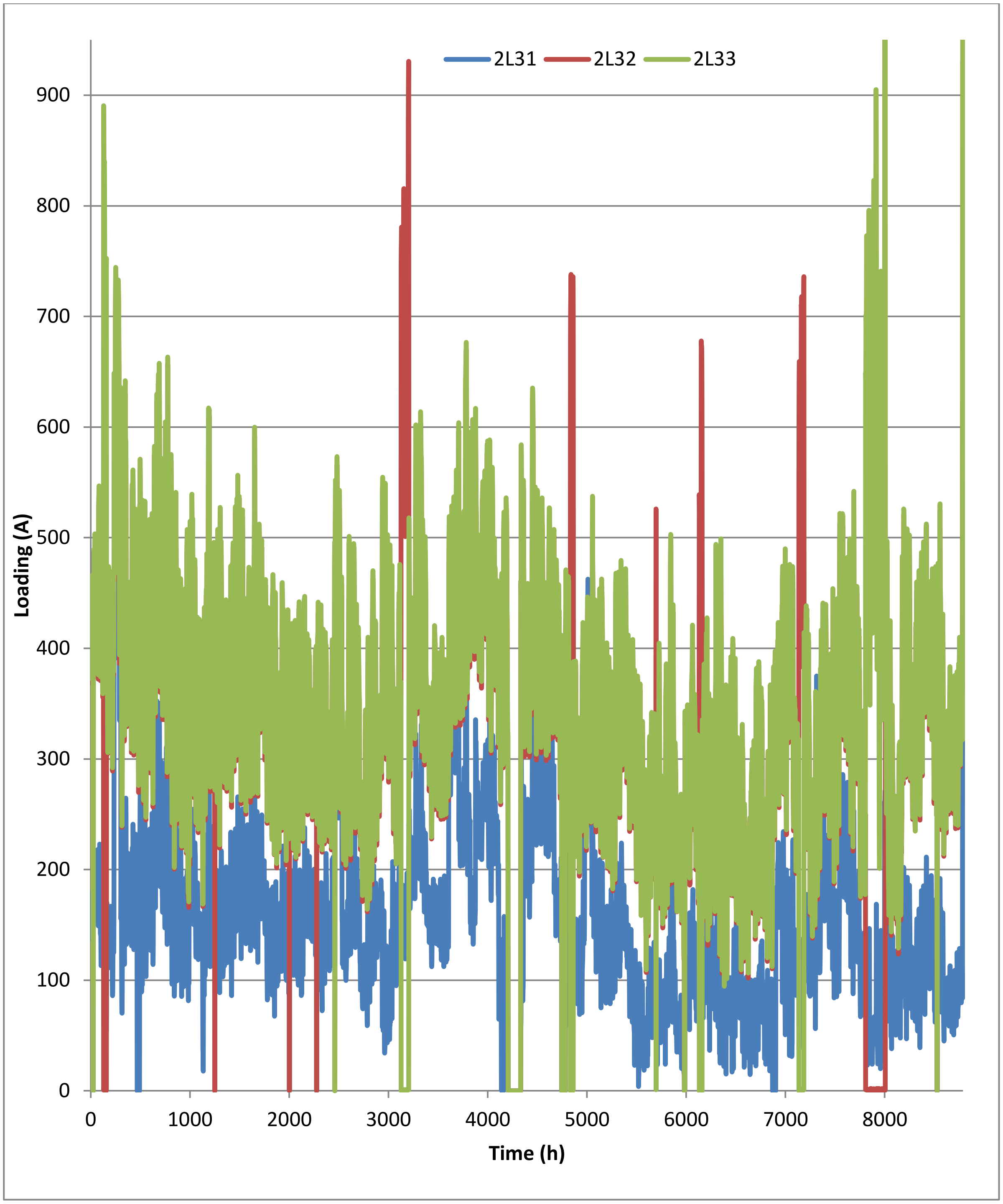

Figure 11: Loading on 2L031, 2L032, and 2L033 measured at CSQ from Jan. 2016 to Jan. 2017 (Sampling rate = 2hours).

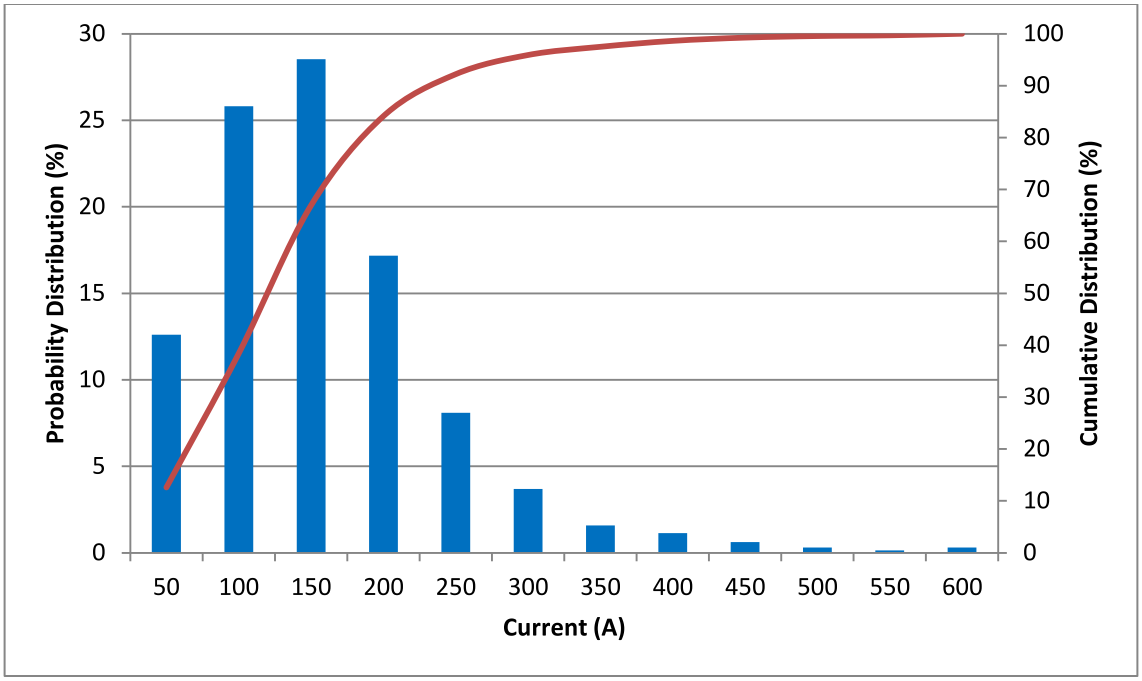

Figure 12: Loading profile for 2L031 based on historical data from Jan. 2016 to Jan. 2017.

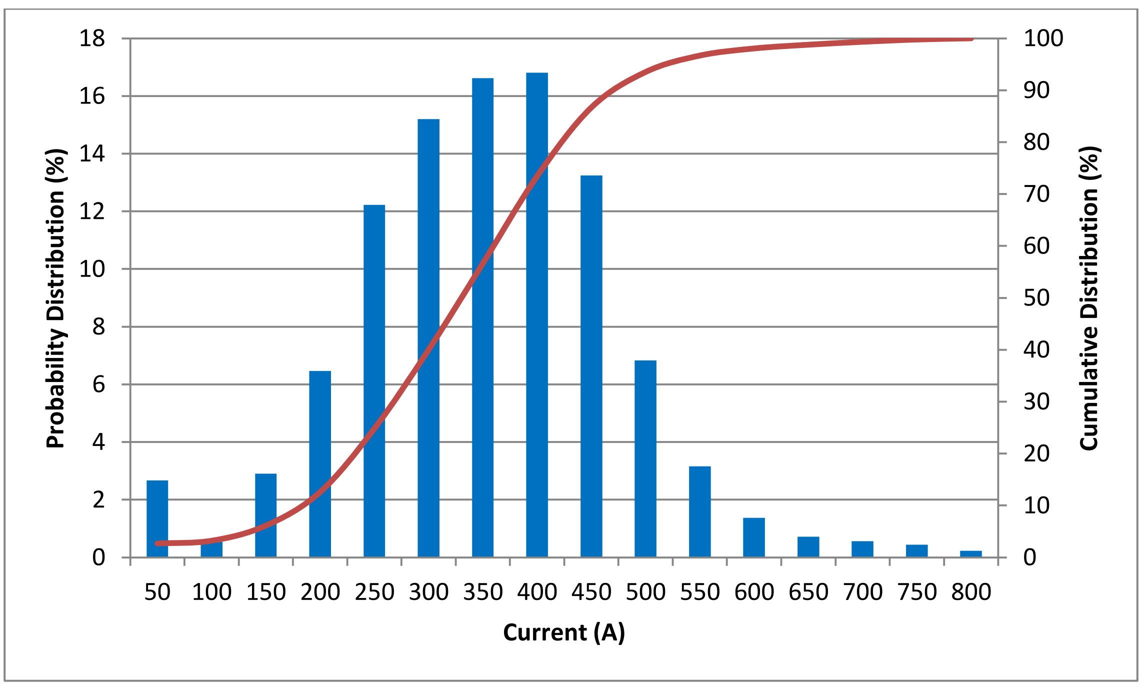

Figure 13: Loading profile for 2L032 based on historical data from Jan. 2016 to Jan. 2017.

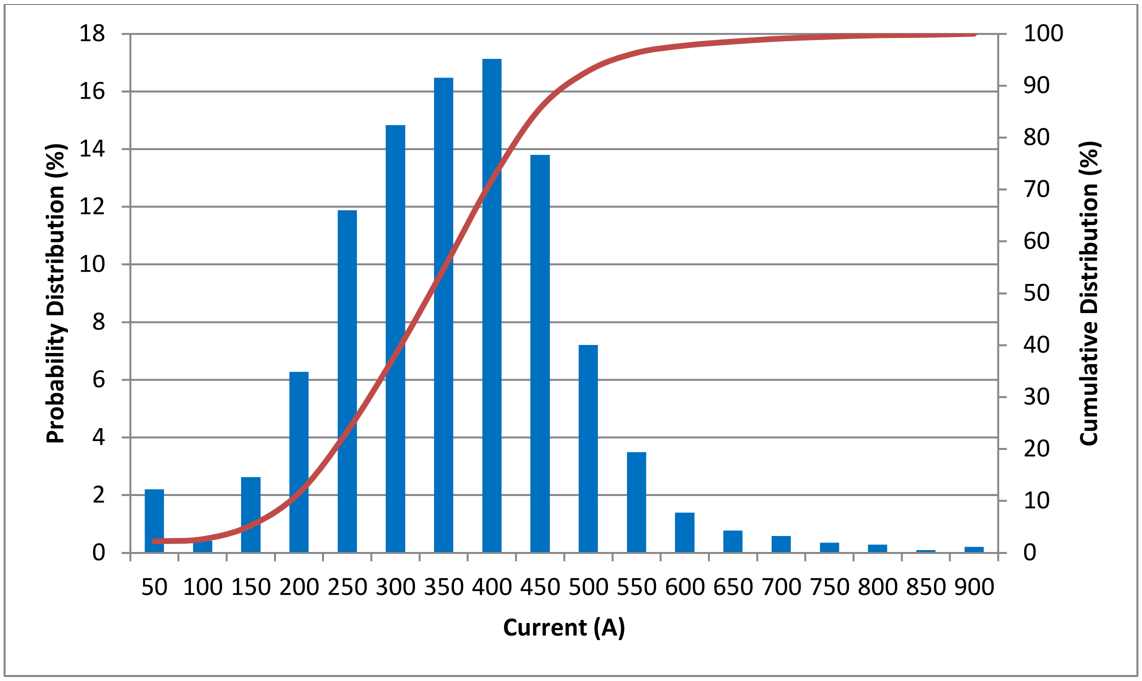

Figure 14: Loading profile for 2L033 based on historical data from Jan. 2016 to Jan. 2017.

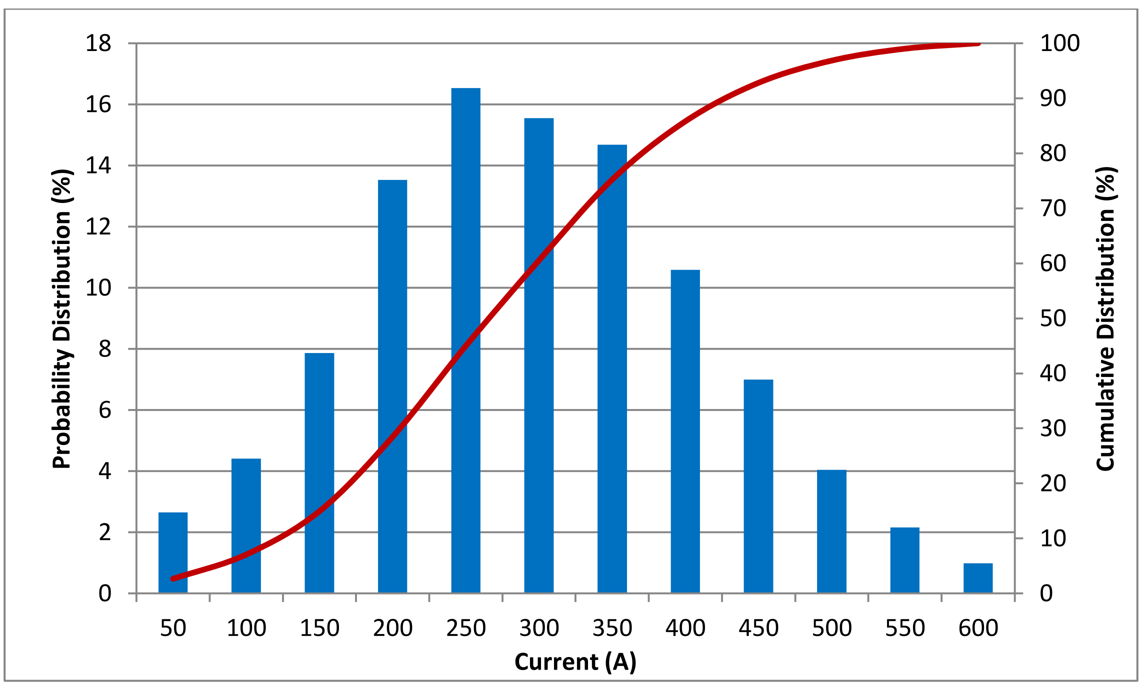

Figure 15: Loading profile for 2L020 based on historical data from Jan. 2016 to Jan. 2017.

4.0 METHODS FOR REDUCING MAGNETIC FIELD LEVELS

There are several methods to reduce the MF produced by underground cables. The most obvious method is to increase the burial depth. Figure 16 shows a typical cross section of 230kV underground cable circuits. The MF profile 1m above ground was calculated using COMSOL Multiphysics® for different depth of duct bank and the results are presented in Figure 17. In this figure, increasing the burial depth from 1.5m to 5.0m reduces the peak magnetic flux density from 47mG to 11mG. Increasing burial depth is, however, costly and causes heat dissipation challenges.

The expected peak loading for the proposed 2L033 from HPN to WTE was given as 460 A by BC Hydro Growth Capital Planning (2L025 and future 2L021 have lower expected loading than 2L033). This value was used in the simulations. In the case of an emergency/contingency, this circuit may experience higher loading levels (up to 890A). The contingency scenarios have very low probability and short duration and are not considered here.

The second method for reducing the magnetic field levels is to add metallic plates around the duct bank to shield the magnetic field. Three cases were simulated in COMSOL Multiphysics® and the results are presented in Figure 18. The most effective configuration is to put two plates on the sides and one plate on the top of the duct. By doing so, the peak magnetic flux density will be reduced from 47mG to 5mG. Note that the burial depth was kept at 1.5m.

Instead of plates, steel pipes can be used. 2L031 and 2L032 are examples of pipe-enclosed design.

Adding these plates can cause induced currents to appear in the plates, leading to losses and heating the duct bank. A more thorough analysis is required to evaluate the impacts on the heat flow of the duct bank.

Another method for magnetic field reduction is the phase arrangement. In particular, the flat arrangement usually produces higher MF levels compared to the trefoil arrangement [2]. When multiple circuits are buried in close proximity, relative phasing plays an important role [2]. Since the design is not available at this point, further analysis will be done to determine the optimal phasing once an initial design becomes available.

There have been other methods proposed for magnetic field control for underground cables. High magnetic coupling passive loops have been proposed and tested in [3], [4]. It requires further analysis to understand the pros and cons of this method.

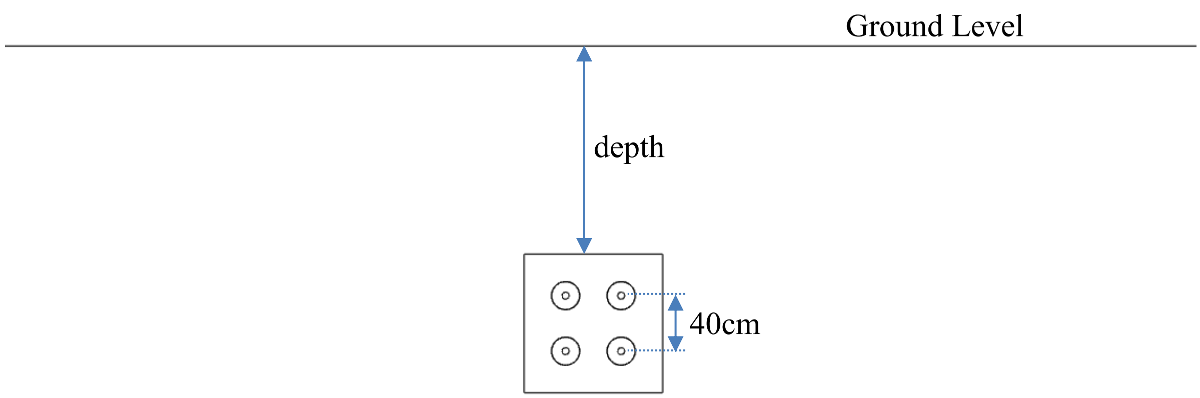

Figure 16: Typical cross section of a 230 kV underground cable circuit.

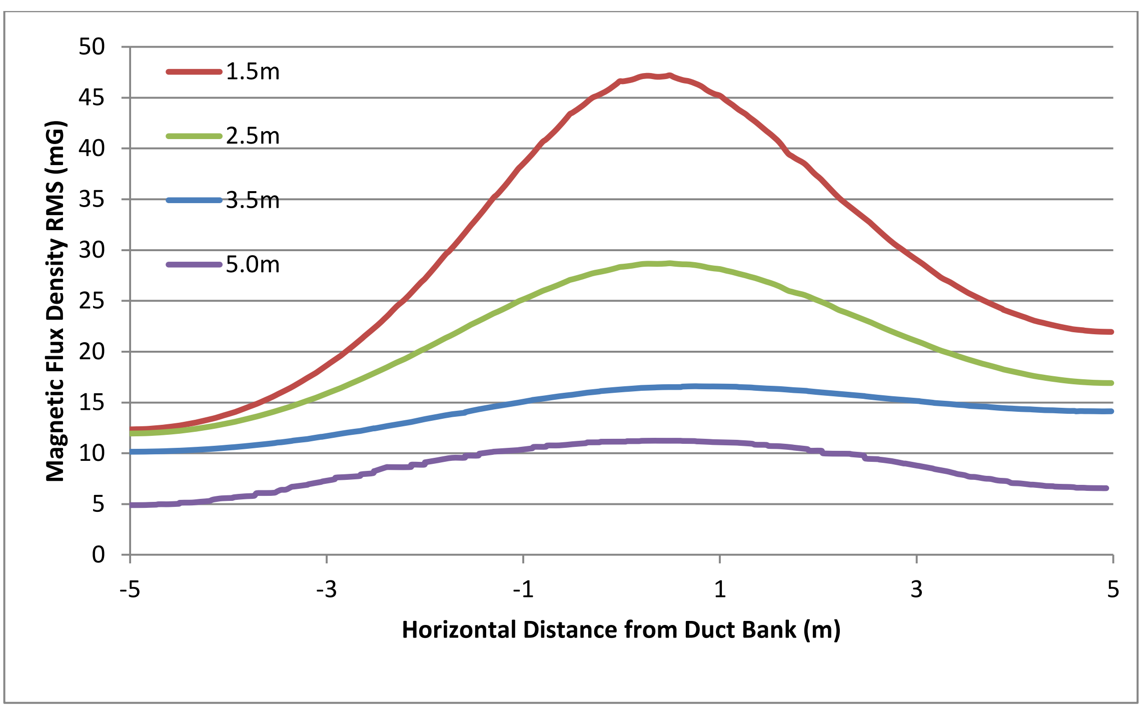

Figure 17: Magnetic field profile (1m above the ground level) as a function of the duct burial depth for a typical 230 kV cable (460A).

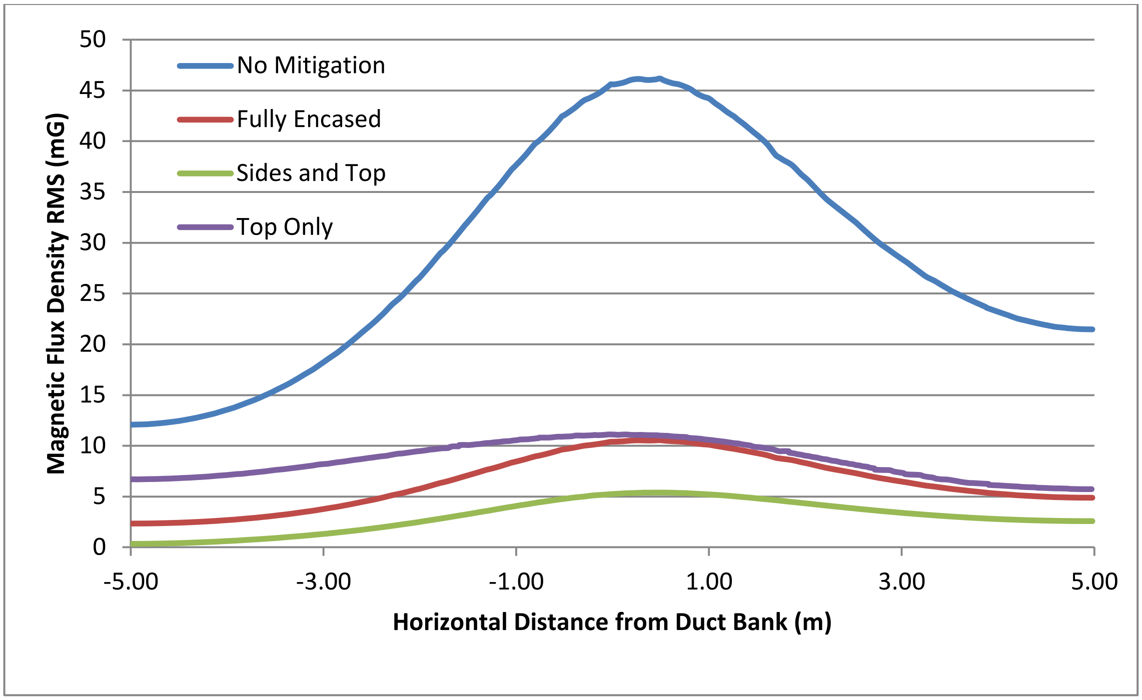

Figure 18: Magnetic field profile (1m above the ground level) for different shielding configurations for a typical 230 kV cable (460A).

5.0 GUIDELINES ON MAGNETIC FIELD EXPOSURE LIMITS

There are three internationally recognized institutions that have published guidelines on the limits of exposure for MF, namely the Institute of Electrical and Electronics Engineers (IEEE) [5], the International Commission on Non-Ionizing Radiation Protection (ICNIRP) [6], and American Conference of Governmental Industrial Hygienists (ACGIH) [7]. The recommended reference levels by these guidelines are summarized in Table 1. These guidelines have been adopted by utilities and health organizations worldwide, such as The Energy Networks Association Australia [2], Hydro Quebec [8], Canadian Electricity Association [9], The National Institute of Environmental Health Sciences [10], The Federal-Provincial-Territorial Radiation Protection Committee-Canada [11], AltaLink [12], etc. BC Hydro Transmission Engineering follows these guidelines in designing transmission lines [13].

Two comprehensive reports have been published by World Health Organization (WHO) on the possible health effects of power frequency magnetic fields in 2002 [14] and 2007 [15]. Details of the effects on human body and related literature review are beyond the scope of this report and interested readers are invited to consult these two references.

6.0 CONCLUSION

Magnetic field (MF) measurements were collected at Cathedral Square (CSQ) Substation on Jan. 13, 2017. The field measurements were compared against simulation results and good agreements were observed. Underground cables were identified as the major sources of MF in the area above the substation building (Cathedral Square Park). Loading variation for the underground circuits were derived based on historical data and an approximate probability distribution for the MF level was established. Based on these statistics, it is expected that the MF levels on top of 2L033 will be less than the measured profile (with a maximum peak of 100mG) for 85% of the time. The maximum expected peak MF is about 200mG during a contingency (when one circuit is out of service) for the same location. This contingency event has a very low probability. Based on the findings of this report and comparing the measured and simulated values with the reference levels in Table 1, the MF levels produced by the proposed West End Substation and the new Dal Grauer Substation (NDG) are expected to be well below these guidelines. Engineering techniques were proposed to minimize the MF levels produced by underground cables. Further analysis is required to evaluate the applicability of the proposed techniques.

Table 1: Recommended Limits for Magnetic Field Exposure (1mG = 0.1µT).

	IEEE [5]	ICNIRP [6]	ACGIH [7]
General Public	9,000 mG (head and torso)	2,000 mG	-
Occupational	27,000 mG (head and torso)	10,000 mG	10,000 mG

7.0 BIBLIOGRAPHY

[1] Electric Power Research Institute, EPRI AC Transmission Line Reference Book-200 kV and Above, 3rd ed., Palo Alto: EPRI, 2005.

[2] The Energy Networks Association, "EMF Management Handbook," ENA, Australia, January 2016.

[3] P. Cruz, C. Izquierdo and M. Burgos, "Optimum passive shields for mitigation of power lines magnetic field," *IEEE Transactions on Power Delivery,* vol. 18, no. 4, pp. 1357-1362, 2003.

[4] A. Canova and L. Giaccone, "Magnetic field mitigation of powre cables by high magnetic coupling passive loops," in *CIRED 20th International Conference on Electricity Distribution*, Prague, June 2009.

[5] IEEE C95.6, "IEEE Standard for Safety Levels With Respect to Human Exposure to Electromagnetic Fields, 0-3 kHz," IEEE, 2002.

[6] ICNIRP, "Guidelines for Limiting Exposure to Time-varying Electric and Magnetic Fields (1 Hz-100 kHz)," *Health Physics,* vol. 99, no. 6, pp. 818-836, 2010.

[7] American Conference of Governmental Industrial Hygienists, "Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices," ACGIH, 2012.

[8] Hydro Quebec, "The Power System and Health: Electric and Magnetic Fields," Hydro Quebec, 2016.

[9] Canadian Electricity Association, "Electric and Magnetic Fields," CEA, March 2010.

[10] National Institution of Environmental Health Sciences, "Electric and Magnetic Fields Associated with the Use of Electric Power," June 2002.

[11] The Federal-Provincial-Territorial Radiation Protection Committee-Canada , "HEALTH EFFECTS AND EXPOSURE GUIDELINES RELATED TO

EXTREMELY LOW FREQUENCY ELECTRIC AND MAGNETIC FIELDS - AN OVERVIEW," January 2005.

[12] AltaLink, "EMF & ELECTRICAL EFFECTS," AltaLink, [Online]. Available: http://www.altalink.ca/responsibility/health/emf-electrical-effects.cfm. [Accessed 20 January 2017].

[13] BC Hydro Engineering Standard ES 41K Section 3.3 R2, "Electric and Magnetic Fields," BC Hydro, Burnaby, Dec. 2013.

[14] World Health Organization & International Agency for Research on Cancer, "IARC Monographs on the Evaluation of Carcinogeneic Risks to Humans. Volume 80 Non-Ionizing Radiation, Part 1: Statis and Extremely Low Frequency (ELF) Electric and Magnetic Fields," IARC Press, Lyon, France, 2002.

[15] World Health Organization, "Environmental Health Criteria 238: Extremely Low Frequency Fields," WHO, Spain, 2007.

8.0 APPENDIX A: MAGNETIC FIELD MEASUREMENT DEVICE