McKenzie/Highway 1 Interchange Ecosystem Mitigation Plan
Part 1: Ecosystem Valuation

prepared for the Ministry of Transportation and Infrastructure

Prepared by Aruncus Consulting July 2017

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Cover Photograph: Garry Oak woodland by Spectrum School. Photo © Matt Fairbarns.

Table of Contents

1 Introduction 4
1.1 McKenzie Interchange Project 4
1.2 Site Description (pre-construction) 4
1.2.1 The Garry Oak Woodland 6
1.3 Trembling Aspen ecosystem 9
1.3.1 Other Areas 11
2 Mitigation Approach 11
2.1 The provincial mitigation policy 11
2.2 Mitigation hierarchy 11
2.3 Avoidance, minimization and on-site restoration of impacts 12
2.4 Offsetting Residual Impacts 12
3 Valuation of the Garry Oak Woodland and Trembling Aspen Forest 13
3.1 Approaches to Valuing Trees - Background 13
3.2 Models for Evaluating Shrubs – Raw Cost Method 14
3.3 Setting Values for Herbaceous Plants 15
4 Results 16
4.1 Garry Oak Woodland 16
4.1.1 Forest Canopy 16
4.1.2 Shrub Layer 16
4.1.3 Herbaceous and Moss/Lichen Layers 18
4.2 Trembling Aspen forest south of the highway 19
4.2.1 Forest Canopy 19
4.2.2 Shrub Layer 19
4.2.3 Herbaceous and Moss/Lichen Layers 20
5 Summary 20
6 Next Steps 21
7 References 21
8 Appendix 1: The Trunk Formula Method for Valuing a Tree 23

List of Tables

Table 1 Tree Canopy Composition 7
Table 2 Native Shrub Composition - Garry Oak Woodland..... 7
Table 3 Native Shrub Composition – Trembling Aspen Forest 10
Table 5 Shrub Replacement Costs - Garry Oak woodland 17
Table 7 Shrub Replacement Costs – Trembling Aspen Forest 20

List of Figures

Figure 1. Project Layout 5
Figure 2. Key impacted ecosystems..... 6

1 Introduction

1.1 McKenzie Interchange Project

The Province of British Columbia and the Government of Canada are implementing a project to build a new interchange where McKenzie Avenue/Admirals Road intersects with the Trans-Canada Highway in Saanich. This intersection is currently the single most severe bottleneck on Vancouver Island. Once complete, the new interchange is expected to greatly reduce traffic congestion during peak hours, reduce collisions between motor vehicles (particularly rear-end collisions during peak hours) and improve pedestrian and bicyclist safety.

The project design includes an overpass across the Trans-Canada Highway (Highway 1), a partial cloverleaf interchange on the south side of the highway, and a re-alignment and widening of the Galloping Goose Trail on the north side of the highway including a pedestrian/bicyclist overpass across McKenzie Avenue.

This is the first of multiple reports which will address mitigation of the project impacts to natural vegetation. This report provides provisional valuations for the Garry Oak woodland north of the highway and the Trembling Aspen forest south of the highway, in Cuthbert Holmes Municipal Park. Subsequent reports will identify options for off-site mitigation of the impacts, provide cost-estimates for the most efficient and economical options, and provide detailed project plans for the preferred options, once selected.

1.2 Site Description (pre-construction)

The project area centres on the Trans-Canada Highway where it intersects the McKenzie Avenue-Admirals Road corridor (Figure 1). South of the Trans-Canada Highway, most of the project area is bounded by Cuthbert Holmes Municipal Park (District of Saanich). A portion of the proposed partial cloverleaf extends into an area previously included within Cuthbert Holmes Municipal Park.

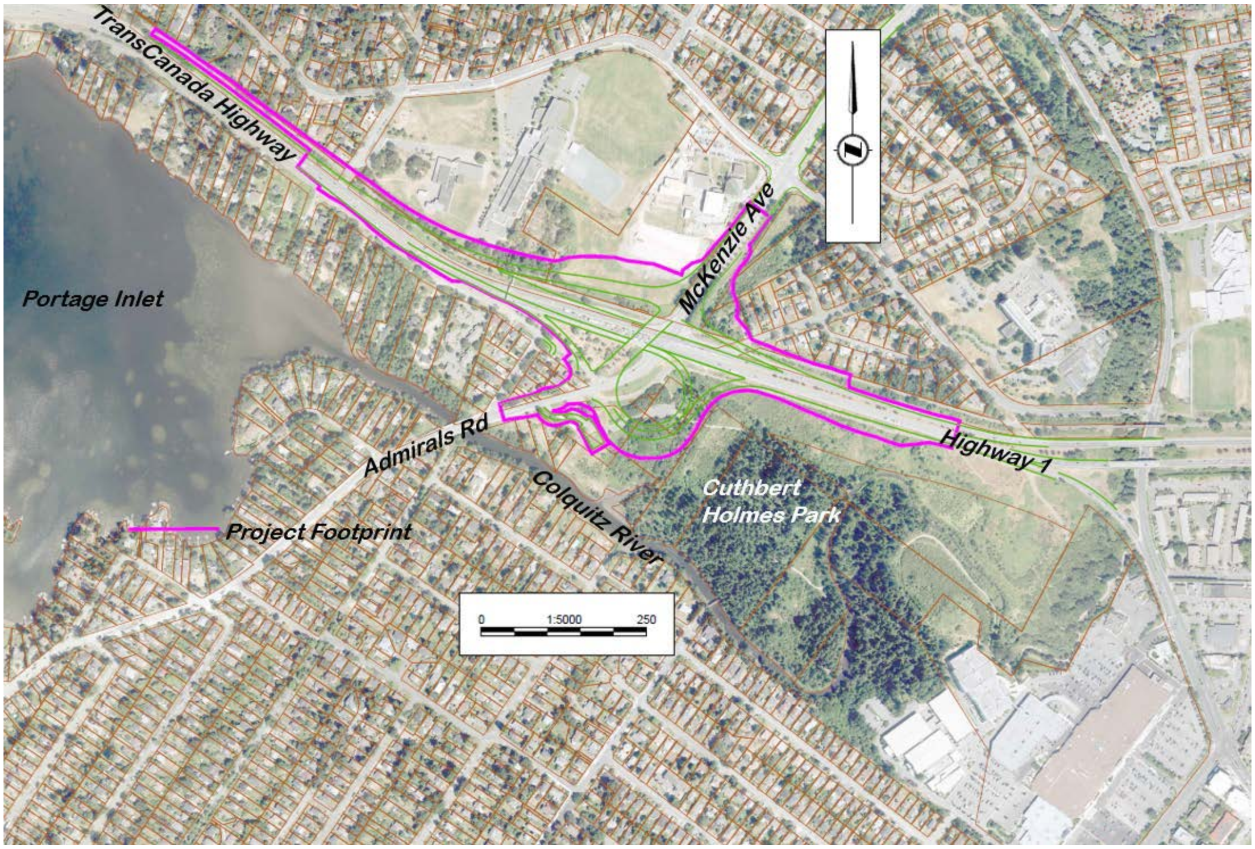

Figure 1. Project Layout

North of the Trans-Canada Highway and west of McKenzie Avenue the project area is bounded by St. Joseph's Catholic School, Spectrum Community School and Marigold Elementary School. The Galloping Goose Regional Trail runs parallel to and approximately 10-15 m north of the Trans-Canada Highway.

Prior to construction, a strip of Garry Oak (*Quercus garryana*) woodland lay between the Galloping Goose Regional Trail and Spectrum Community School/Marigold Elementary School. An area of Trembling Aspen (*Populus tremuloides*) forest lay south of the Trans-Canada Highway and east of Admirals Road. These two impacted ecosystems (Figure 2) were the primary focus of this ecosystem mitigation plan.

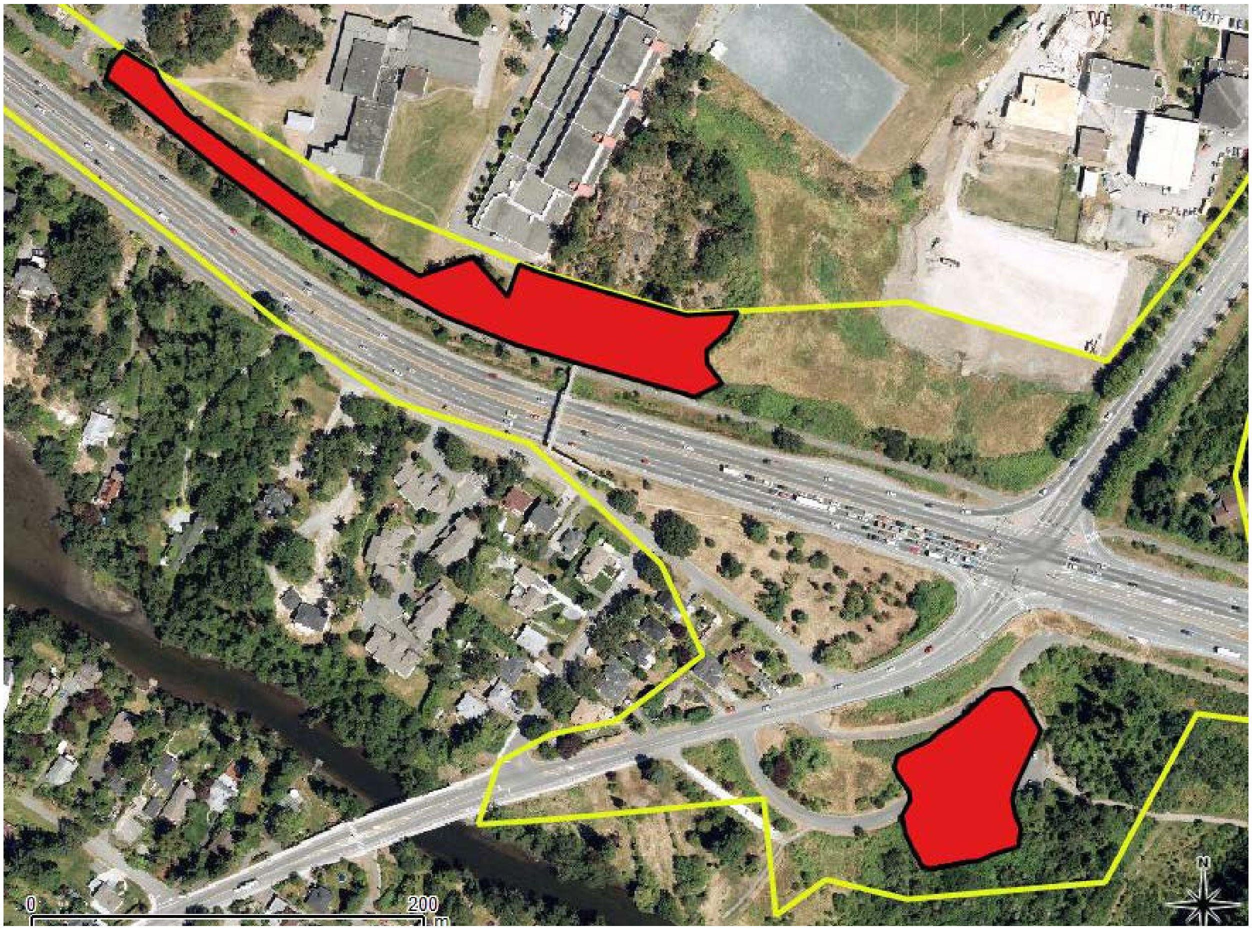

Figure 2. Key impacted ecosystems
Upper red polygon shows location of Garry Oak forest. Lower red polygon shows location of Trembling Aspen forest. Yellow line shows project footprint.

1.2.1 The Garry Oak Woodland

Tree Canopy

The Garry Oak woodland occurred on complex topography consisting of deep to moderately deep surficial deposits with interspersed areas of shallow soil and rock outcrops. The complexity was fine-grained, with canopies of the large trees that rooted in deeper soils extending over areas of shallower soil and rock outcrops. In contrast, the canopies of small trees, which mostly rooted in shallow soils or in crevices and fissures within outcropping rock, rarely extended much into areas with deeper soils. The result was that most of the Garry Oak woodland was moderately to densely shaded, although there were small patches with sparse tree canopies in the centre of large areas of outcropping rock. The canopy of the Garry Oak ecosystem (Table 1) was composed primarily of Garry Oak itself, although Arbutus (*Arbutus menziesii*). Douglas-fir (*Pseudotsuga menziesii*), Bigleaf Maple (*Acer macrophyllum*), Black Cottonwood (*Populus trichocarpa*), and Western Redcedar (*Thuja plicata*) were also present.

Table 1 Tree Canopy Composition[1]

Species	Number of Individuals	Average Diameter (cm)	Average Height (m)	Average Condition (%)
Garry Oak	182	25.5	10.3	93.7
Arbutus	14	23.4	15.2	95.0
Douglas-fir	12	57.4	18.6	95.5
Bigleaf Maple	2	16.7	6.8	94.0
Black Cottonwood	1	34.0	14.0	100.0
Western Redcedar	1	33.0	9.0	94.0
All species	212	27.2	11.0	93.9

Shrub Layers

The shrub layers were sampled by conducting a full count of native shrubs[2] within each of nine subplots (2.5 m radius) and extrapolating the results to estimate the shrub composition of the entire stand (Table 2). The tree data provided by Golder Associates did not include individuals with a basal diameter (measured 15 cm from the base of the stem) so tree saplings were counted during the shrub survey.

Table 2 Native Shrub Composition - Garry Oak Woodland

	Number of Individuals Per Stem Size Class			Total Number of Stems
	0-100 cm	105-200 cm	>200 cm	
Saskatoon	46	138	780	963
Ocean-spray	92	183	2,110	2,385
Dull Oregon-grape	3,394	780	321	4,494
Indian Plum	275	642	871	1,789
Bitter Cherry	0	46	46	92
Garry Oak (saplings)	46	46	0	46
Nootka Rose	275	688	1,192	2,155
Common Snowberry	6,375	11,052	2,201	19,628
All species	10,502	13,575	7,521	31,552

On deeper soils, the tall shrub layer of the Garry Oak woodland was well-developed and dominated by Oceanspray (*Holodiscus discolor*), Nootka Rose (*Rosa nutkana*), Indian-plum (*Oemleria cerasiformis*), Saskatoon (*Amelanchier alnifolia*) and Bitter Cherry (*Prunus emarginata*). Two invasive tall shrubs - Oneseed Hawthorn (*Crataegus monogyna*) and Himalayan Blackberry (*Rubus armeniacus*) – were also present in significant amounts. Conversely, the low shrub layer was best developed in areas of thin soils where more light

[1] Data provided by S. Black, Golder Associates Ltd.
[2] Non-native shrubs were not counted as they do not contribute to the ecological value of the stand

reaches the lower foliage. The most abundant low shrub was Common Snowberry (*Symphoricarpos albus*) but Dull Oregon-grape (*Mahonia nervosa*) was also common. The low shrub layer also contained significant amounts of Spurge-laurel (*Daphne laureola*), an introduced invasive species.

<u>Herbaceous and Moss/Lichen Layers</u>

By the time the field work started on July 8, 2016 most of the plants in the herbaceous layer had died back. Fortunately, the author had briefly visited the site on May 4, 2016 while inspecting a nearby population of an endangered species. Brief field notes made at that time, supplemented by what observations could be made in late summer, allow for a general characterization of the herbaceous layer of the Garry oak woodland as follows:

The most common native species in the herbaceous layer were forbs, dwarf shrubs and native grasses and grass-like plants.

The leading native forbs in open meadow areas, on medium to deep soils, were Pacific Sanicle (*Sanicula crassicaulis*), Common Camas (*Camassia quamash*), Great Camas (*Camassia leichtlinii*), White Fawn Lily (*Erythronium oreganum*), Yarrow (*Achillea millefolium*), Rein-orchid (*Piperia* sp.), Western Buttercup (*Ranunculus occidentalis*), Chocolate Lily (*Fritillaria affinis*), and Broad-leaved Shooting-star (*Primula hendersonii*). Native grasses and grass-like plants present on medium to deep soils included California Brome (*Bromus carinatus*), Blue Wildrye (*Elymus glaucus*), Short-stalked Wood-rush (*Luzula subsessilis*) and Long-stoloned Sedge (*Carex inops*). In most areas, native forbs were much more abundant than grasses and grass-like plants although there was a significant component of non-native herbaceous plants including several grasses such as Orchard-grass (*Dactylis glomerata*), Barren Brome (*Bromus sterilis*), Soft Brome (*Bromus hordeaceus*), Barren Fescue (*Vulpia bromoides*), Early Hairgrass (*Aira praecox*), Silvery Hairgrass (*Aira caryophyllea*), and forbs such as Hairy Cat's-ear (*Hypochaeris radicata*), Sheep Sorrel (*Rumex acetosella*), Common Vetch (*Vicia sativa*), Hairy Vetch (*Vicia hirsuta*), Common Chickweed (*Stellaria media*), and Common Stork's-bill (*Erodium cicutarium*).

In much of the Garry Oak woodland the herbaceous layer was poorly developed (estimated average cover of 7%) either because there was a dense shrub layer which reduced light available for subordinate herbaceous species, or because there was abundant English Ivy (*Hedera helix*), which smothered native herbaceous plants. In these areas, native herbaceous plants had an average cover estimated at 7%.

On rock outcrops, the native herbaceous cover was sparse (averaging approximately 20%); rooting in rocks fissures and crevices and spreading onto adjacent areas of bare rock. Mosses and lichens covered little of the ground except on rock outcrops, where there were discontinuous patches dominated by Rock-moss (*Racomitrium* spp.) and Broom Moss (*Dicranum scoparium*).

Conservation Significance

In the past, First Nations likely burned the site and extensive adjacent Garry Oak stands regularly to maintain crops of Camas and make it easier to spot and hunt game. Such burning would have formerly maintained an herb-rich, shrub-poor Garry Oak ecosystem on the site.

The deep-soil element belongs to the Garry Oak / California Brome ecological community which is provincially, nationally and internationally ranked as critically imperilled (S1, N1 and G1). The shallow-soil variant belongs to the Garry Oak / Oceanspray ecological community which is also ranked as critically imperilled at the provincial, national and international levels. These two rare ecological community types often form mosaics as is the case at the McKenzie interchange site (B.C. Conservation Data Centre 2017).

1.3 Trembling Aspen ecosystem

The Trembling Aspen ecosystem occurred in a low-lying area on either side of the Admirals Road parking lot. The construction of the parking lot disrupted natural drainage patterns; the portion of the Trembling Aspen community north of the parking lot likely experienced longer periods of standing water before the parking lot was built. The portion south of the parking lot was further disrupted by the construction of a ditch which drained standing water southwards towards the estuary. The soils are derived primarily from fine-textured materials and regular annual floods deposit fresh silts and clays each year.

Tree Canopy

The Trembling Aspen stand south of the highway contained 309 trees, two were Oregon Ash (*Fraxinus latifolia*) and the rest were Trembling Aspen. The Trembling Aspen had an average diameter of 15.1 cm (5.9”) and an average height of 9.16 m (30.0’). The larger of the two Oregon Ash had a diameter of 12.4 cm (4.9”) and a height of 7.8 m (25.6’). Values for the smaller Oregon Ash were 11.1 cm (4.4”) and 7.6 m (24.9’) respectively.

Oregon Ash is critically imperilled in British Columbia and Canada. It has not yet been assessed for inclusion under the Species at Risk Act (SARA) due to a lack of funding necessary to prepare a status report but other plant species with similar distributions, levels of abundance and degree of threat have generally been assessed as either Threatened or Endangered and protected under SARA. There is no legal obligation to protect Oregon Ash until it has been assessed but it rare species such as Oregon Ash are generally protected where possible during development projects.

Shrub Layers

The Trembling Aspen forest was characterized by a very well-developed shrub understory (Table 3).

Table 3 Native Shrub Composition – Trembling Aspen Forest

	Number of Individuals Per Size Class (cm)						Total # Stems
	0-100	105-200	205-300	305-500	505-1000	>1000	
Red Osier Dogwood	23	135	180	225	968	0	1,530
Black Hawthorn	0	23	23	23	23	0	90
Twinberry	0	113	270	360	405	0	1,148
Pacific Crab Apple	0	23	0	90	68	0	180
Trembling Aspen	113	315	45	0	0	0	473
Cascara	0	0	0	0	45	0	45
Nootka Rose	45	135	0	113	45	23	360
Pacific Willow	45	23	23	0	23	0	113
Common Snowberry	180	2,610	2,295	158	0	0	5,243
all species	405	3,375	2,835	968	1,575	23	9,180

The tall shrub layer was well-developed in most places and dominated by native species such as Red Osier Dogwood (*Cornus stolonifera*), Twinberry (*Lonicera involucrata*), Nootka Rose, Pacific Crab Apple (*Malus fusca*), Pacific Willow (*Salix lasiandra var. lasiandra*), and Black Hawthorn (*Crataegus douglasii*). Non-native tall shrubs including Himalayan Blackberry, One-seed Hawthorn, and English Holly (*Ilex aquifolium*) were present in lesser amounts.

The low shrub layer was less well-developed, largely due to shading by the tree canopy and tall shrubs. The most abundant low shrub, Common Snowberry, is a native species. The low shrub layer also had small amounts of non-native species including Spurge-laurel and Common Privet (*Ligustrum vulgare*).

The shrub layer also contained many suppressed stems of Trembling Aspen which were not counted in the tree survey because their basal stem diameter was less than 15 cm.

<u>Herbaceous and Moss/Lichen Layers</u>

Most of the plants in the herbaceous layer had died back by the time the field work started. Remnant dead and dying foliage indicated that the herb layer was poorly developed, with an estimated cover of approximately 10%. The species composition of the herb layer consisted of a mix of native and non-native species with the former strongly dominating. It was not possible to determine the leading species in the herb layer due to the late sampling date. Mosses and lichens did not cover much of the forest floor.

Conservation Significance

Despite the scarcity of Slough Sedge, the Trembling Aspen stand is either part of or closely related to the Trembling Aspen/Pacific Crab Apple/Slough Sedge ecological community (C. Cadrin pers. comm. 2017) which is ranked provincially, nationally and internationally as imperilled (S1S2, N1N2 and G2). This rare ecological community type typically occurs in small patches within matrix vegetation, as is the case at the McKenzie interchange site (B.C. Conservation Data Centre 2017).

1.3.1 Other Areas

There were several other native trees elsewhere in the project footprint but as they were not part of an ecosystem with high conservation values, the mitigation plan does not consider their loss. The mitigation plan also does not address the heavily disturbed understory layer or the non-woody vegetation associated with trees outside of the Garry Oak and Trembling Aspen forests described above.

2 Mitigation Approach

2.1 The provincial mitigation policy

The mitigation plan for the McKenzie Interchange Project's impacts on rare species/ecosystems and native trees is informed by mitigation policy and procedures developed by the B.C. Ministry of Environment (BC Ministry of Environment 2014a, 2014b).

2.2 Mitigation hierarchy

B.C. Ministry of Environment mitigation policy recommends that mitigation efforts be addressed by a four-stage hierarchy:

1. Avoid: where possible, avoid impacts to priority environmental values and their associated components. Measures to avoid should be considered before measures to minimize, restore on site, and/or offset. This may be accomplished by:
    a. altering or adjusting the location of a project/activity within the project area;
    b. applying alternative methodologies;
    c. adjusting the timing of activities; or
    d. not proceeding with the activity.

2. Minimize: once measures to avoid impacts have been taken, or when avoidance is not practical, measures should be taken to minimize (partially avoid) impacts to priority environmental values and their associated components. These measures may include altering the location, methodology or timing of an activity as outlined above.

3. Restore on-site: After an activity, the impacts to priority environmental values and their associated components may be reversed by conducting on-site restoration to return the priority environmental values and their associated components to pre-project or historical conditions. Due to the temporal loss of biodiversity, both during the construction phase and during what may be a long recovery period before pre-existing conditions are

restored, on-site restoration is less desirable than mitigation by avoiding or minimizing impacts.

4. Offset: Avoidance, minimization and on-site restoration may not be possible, or may not entirely mitigate project impacts. The residual impacts may be mitigated by offset measures, which may occur within or outside of the project footprint.

2.3 Avoidance, minimization and on-site restoration of impacts

It was not possible to avoid impacts to the Garry Oak and Trembling Aspen communities because of the location of the existing road network and the permanent nature of the new interchange. The site layout, chosen to minimize the project footprint while maintaining a safe interchange design, also serves to minimize impacts to the Garry Oak and Trembling Aspen communities. On-site restoration is not a practical option because most of the project footprint consists of either of hardscaped design elements or areas of green space too small to allow for natural ecosystem function.

2.4 Offsetting Residual Impacts

After minimizing the project footprint, the residual impacts to key environmental consist of a loss of approximately 8,100 m^2 of a Garry Oak ecosystem and approximately 4,500 m^2 of a Trembling Aspen ecosystem. Offsets may be appropriate when all measures to fully avoid, minimize and restore on-site have been duly considered and where residual impacts remain.

The BC Ministry of Environment Mitigation Policy establishes some fundamentals when considering offsets:

Units of Measurement

The same unit of measurement should be used for both the impact and the proposed offset (or a rationale for not doing so). For example, if 5 ha of a valuable ecosystem are lost then a 5-ha area should be proposed as an offset. If this is not possible, then there must be a rationale for the decision not to provide a 5-ha offset. Units of measure may include spatial extent, number of individuals, or demographic rates.

Ecological Equivalency and Like-for-Like

The offsets should be ecologically equivalent to the impacted environmental values and associated components (e.g., if a Garry Oak woodland is lost it should be offset with a Garry Oak woodland, not a different ecological community).

On-site or In-proximity Offsetting

Where possible, the offsets should be located on-site or in a nearby area with similar ecological capability, and the conservation outcomes should include a functioning ecosystem that provides similar ecological goods and services as did the impacted site.

Incrementality

An offset should deliver a conservation outcome that is additional to outcomes that would otherwise be achieved. For example, removal of weeds from a Garry Oak woodland in an Ecological Reserve would not fully offset the loss of a Garry Oak woodland.

Adjusting for Uncertainty

The amount of offsetting needed to mitigate impacts will depend upon the degree of uncertainty regarding:

- the effectiveness of the proposed offset measures
- the risk to the environmental components
- the timeline to which the offset measures will be implemented
- any combination of these factors

Practically speaking, if a proposed offset measure is only believed to have a 50% chance of achieving the target number of units then the amount offsetting needed to mitigate impacts will increase proportionally using ratios or multipliers).

In-Lieu Payments

When a proponent lacks the capacity to implement environmental offset measures they may provide funds to a third party who will then implement conservation measures to offset impacts. The in-lieu payments should cover all costs of implementing the offset, including monitoring and adaptive management which would increase according to the uncertainty regarding the predicted outcomes.

3 Valuation of the Garry Oak Woodland and Trembling Aspen Forest

Establishing the value of a resource to be offset, such as Garry Oak woodland or a Trembling Aspen forest, provides a first approximation of the cost of an offset program. If there is an opportunity to offset the loss of the Garry Oak woodland and/or the Trembling Aspen forest by establishing comparable ecosystems elsewhere then a detailed project plan to establish the compensatory ecosystems will provide the basis for the final cost of the offset. If no opportunity can be found to establish a compensatory ecosystem then the first approximation of cost serves as the basis for an in-lieu payment, which can be used to improve the condition of comparable existing Garry Oak woodlands and/or the Trembling Aspen forests.

3.1 Approaches to Valuing Trees - Background

There are multiple models for establishing the value of an individual tree. The three most common approaches, described by the Council of Tree and Landscape Appraisers (2000) are:

- The Replacement Cost method: This method is appropriate when the tree which is damaged or killed can be replaced by a tree of comparable size and vigour. The

Replacement Cost method is not suitable to valuing trees lost in the McKenzie Interchange project because the trees that were lost during construction are much larger than the largest replacement stock commercially available.

- The Compounding Cost method: This method is based on the premise that a replacement tree increases in value at a fixed annual rate until it reaches parity with the size and vigour of the tree it is replacing. The compounded cost of the tree that was lost is based on several factors including:
  - The cost of preparing the planting site,
  - The cost of purchasing and planting the replacement tree,
  - The number of years it will take the replacement tree to reach parity with the tree it is replacing,
  - The compounding interest rate.

  The Compounded Cost Method has been heavily criticized when applied to valuing trees; cost estimates are quite sensitive to estimates of how long it will take replacement trees to reach parity with the tree being replaced and to year-by-year estimates of maintenance costs between when the replacement tree is planted and when it reaches parity. As well, the choice of an appropriate interest rate is problematic – if inflation increases occurs then the sum set aside to maintain the tree until parity may be insufficient to the task. Conversely, in an environment of falling interest rates the sum set aside to maintain the tree may exceed the actual costs. The Council of Tree and Landscape Appraisers (2000) does not provide an example for applying the Compounding Cost method for replacing trees in its workbook section.

- The Trunk Formula method: This method (see Appendix 1 for an example) is commonly used for valuing trees that are too large to be replaced with nursery stock of similar size and vigour. Its core premise is that the value of a tree is approximated by the cost of installing a replacement tree, multiplied by the size ratio of the original tree to its replacement sapling. The calculation of Basic Tree Value is straightforward but it is adjusted with discounts for (1) species value; (2) tree condition; and (3) location value to come up with the final Appraised Tree Value. Selecting the appropriate discounts for each of these factors may be subjective; if heavy discount factors are applied then the Appraised Tree Value may not even cover the cost of purchasing and installing a replacement tree. In general, native species naturally occurring in a natural environment are not discounted for species value. For the purposes of this valuation, there is no discount applied for the native tree species, a tree condition discount is applied (it is minor as field data documented that most trees were in good condition), and the location discount reflects the fact that the site is adjacent to a transportation coordinator (e.g. Highway 1).

3.2 Models for Evaluating Shrubs – Raw Cost Method

The Raw Cost method calculates the value of a shrub as the sum of the costs required to prepare the site, purchase and install the shrub and maintain it until it reaches parity (a size comparable to the shrub being replaced).

The Raw Cost Method tends to provide lower valuations than the Compounded Cost method (see 3.1) because it does not consider an interest rate (compounding factor). To provide sufficient resources to allow for establishment of a replacement shrub layer, the valuation amount would have to be invested in a manner which equals the inflation rate over the length of the time it takes for the replacement shrubs to reach parity with those they are replacing.

The Compounding Cost method – though rarely used for trees (see 3.1) – may be a suitable method for valuing shrubs because they reach parity over a much shorter period (Council of Tree and Landscape Appraisers 2000); this reduces the risks associated with long-term estimates of maintenance needs and interest rates.

The Compounded Cost method considers:

- the cost of a purchasing the replacement plant,
- the cost of remediating a site to prepare it for planting the replacement shrub,
- the cost of installing the replacement shrub,
- discounts for the condition and location of the shrub to be replaced,
- the number of years it will take the replacement shrub to reach parity with the shrub it is replacing,
- annual maintenance costs for the period between planting and when the replacement shrub reaches parity, and
- a compounding factor such as the inflation rate, to reflect the difference in value between the replacement shrub and the shrub it is replacing.

For this valuation, the Raw Cost method was chosen because current interest rates are low and the parity will be reached quickly.

3.3 Setting Values for Herbaceous Plants

Values are easily set for herbaceous plants because they can be established quickly and if planting densities are sufficient they can quickly fill in available space. In a meadow or open woodland, a mix of grass and forb plugs and small bulbs planted at a density of 28 plants/m^2 would cost approximately \$50/m^2 including:

- the cost of purchasing plants,
- the cost of planting out, and
- the cost of weeding and tending in year 2 and 3.

For lower planting densities, cost can be adjusted on a *pro rata* basis.

Costs for site preparation are not included in this estimate as they were factored in the cost estimate for shrub valuation.

3.4 Summary

In summary, the tree canopy layer was valued using the tree trunk formula method; the shrub layer was valued using the raw cost method; and the herbaceous layer (where present and well-developed) was valued at $50/m^2.

4 Results

4.1 Garry Oak Woodland

4.1.1 Forest Canopy

The Appraised Tree Value for the Garry Oak woodland was calculated as $557,014. This value is based on formulas established by the Council of Tree and Landscape Appraisers (2000) and the estimated cost of replacement saplings in 2007 as provided by International Society of Arboriculture. Pacific Northwest Chapter (2007), adjusted for inflation (using the Canadian Consumer Price Index). The Appraised Tree Value discounts the Basic Tree value by 52% to account for location[3], and tree condition as estimated from condition values recorded during surveys conducted by Golder Associates (Scott Black pers. comm. 2016).

The Appraised Tree Value presented here is the lowest plausible valuation for the tree canopy. If no discounts were applied to the natural tree canopy, considering it is an essential element of the rare Garry Oak / California Brome and Garry Oak / Oceanspray ecological communities, the Appraised Tree Value would be much higher.

See section 3.1 (Trunk Formula method) for a more detailed discussion of discount factors.

4.1.2 Shrub Layer

The composition of the shrub layer was determined by measuring the size of each shrub within nine sample plots spread across the original Garry Oak woodland. Each plot measured 2.5 m in radius. The total number of shrubs was multiplied by the ratio of the stand to the sum of the areas of the plots to come up with an estimate of shrub composition (Table 2) for the entire stand.

There is no standardized method for valuing shrubs, however “raw cost method” calculations will be applied. Cost-of-replacement calculations should consider site preparation costs, the costs of purchasing and planting replacement stock, and the cost of maintaining the replacement stock until it reaches parity with conditions in the original stand.

The age-to-parity varies depending on the size and species of the shrub; the largest shrubs found in the Garry Oak woodland included some Saskatoon plants which had stems of over 8 m long

[3] The Council of Tree and Landscape Appraisers (1998) suggests using a 50% discount for trees in transportation corridors. The rest of the discount applied to the Garry Oak woodland canopy considers that the many of the trees were not in excellent condition, having some canopy dieback.

with a spread of up to 5 m. Miskelly and Miskelly (pers. comm. 2016) estimated that Saskatoon, which is a slow-growing species, will take about 15-20 years to reach such a size. Much of the shrub layer consists of smaller individuals, however, and the shrub layer of a replacement stand is likely to reach near-parity with the shrub layer of the removed stand in as few as 10 years. Furthermore, planting densities do not need to be as dense as the density of existing shrubs because planted stock of the rhizomatous species will spread laterally as well as growing vertically; a planting density of 25 shrubs/100 square metres should be sufficient to achieve near-parity with the shrub layer of the original Garry oak woodland within 10 years. Table 5 provides an estimate of cost establishing a comparable shrub layer in a replacement stand over a 10-year period.

Most replacement costs for the shrub layer are incurred in preparing the site and purchasing/planting stock. Site preparation costs vary considerably among restoration sites, from a much as $25/m^2$ in areas with dense, intertwined English Ivy to as little as $3/m^2$ in areas with little or no cover of invasive woody species (mulching will usually still be necessary to control non-native herbaceous weeds). The site preparation costs assume that the pre-planting site has a moderately well-developed layer of invasive woody plants which could be removed at a cost of $5.00/m^2$. This value is adjusted to $4.20/m^2$ to consider that invasive species were moderately abundant in approximately 16% of the Garry Oak site at the McKenzie Interchange prior to construction

In year 1, stand tending costs ($3.00/m^2$) will cover weeding, watering, and (if necessary) fertilization. In year 2, some replanting will be necessary to replace mortality, but supplemental watering and fertilization will only be needed for replacement stock and total costs decline to $2.00/m^2$. In subsequent years, there will be no need to provide supplemental watering or fertilization and weeding costs will decline as the shrub canopies expand.

Table 4 Shrub Replacement Costs - Garry Oak woodland

task	unit	unit cost	# units	extended cost
site preparation	square metres	$4.2	8,100	$34,020
purchase of stock	1 gallon stock	$10.0	2,025	$20,250
planting costs	shrub	$10.0	2,025	$20,250
tending costs - year 1	square metres	$3.0	8,100	$24,300
tending costs - year 2	square metres	$2.0	8,100	$16,200
tending costs - year 3	square metres	$1.0	8,100	$8,100
tending costs - year 4	square metres	$1.0	8,100	$8,100
tending costs - year 5	square metres	$1.0	8,100	$8,100
tending costs - year 6	square metres	$1.0	8,100	$8,100
tending costs - year 7	square metres	$0.5	8,100	$4,050
tending costs - year 8	square metres	$0.5	8,100	$4,050
tending costs - year 9	square metres	$0.5	8,100	$4,050
total cost				$159,570

The total cost for replacing the shrub layer is estimated at $159,570 ($19.70/m^2).

4.1.3 Herbaceous and Moss/Lichen Layers

The Garry Oak woodland contained 380 m^2 of open meadow habitat where native herbaceous plants formed a continuous ground cover and 545 m^2 of rock outcrop habitat where herbaceous plants had a cover of about 20%. The remainder of the Garry Oak woodland (7,175 m^2) had an herbaceous layer with an average cover of only 7%. The estimated cost to re-establish the native herbaceous component of the vegetation is as follows:

- $19,000 in the meadow habitats (380 m^2 @ $50/m^2)
- $5,450 in the rock outcrop habitats (545 m^2 * 20% @ $50/m^2)
- $25,112.50 in the rest of the Garry Oak woodland (7,175 m^2 * 7% * $50/m^2).

Summed up, the cost of re-establishing the native herbaceous flora is $49,562 at an average cost of $6.12/m^2.

4.1.4 Roll-up of Valuations

In summary, the valuation for the tree canopy is $557,014; the valuation for the shrub layer is $159,570 and the valuation for the herbaceous layer is $49,562. The total Garry Oak ecosystem valuation is $766,146.

4.2 Trembling Aspen forest south of the highway

4.2.1 Forest Canopy

The Appraised Tree Value for the Trembling Aspen forest was calculated as $279,127, using the same considerations presented in section 4.1.1. This value discounts the Basic Tree value by 45% to account for location[4], and tree condition as estimated from foliage dieback values recorded during surveys conducted by Golder Associates (Scott Black pers. comm. 2016).

The Appraised Tree Value presented here is the lowest plausible valuation for the tree canopy. If no discounts were applied to the natural tree canopy, considering it is an essential element of the rare Trembling Aspen/Pacific Crab Apple/Slough Sedge ecological community, the Appraised Tree Value would be much higher.

See section 3.1 (Trunk Formula method) for a more detailed discussion of discount factors.

4.2.2 Shrub Layer

The composition of the shrub layer was determined by measuring the size of each shrub within two large sample plots spread across the original Garry Oak woodland. Each plot covered 100 m^2. The total number of shrubs was multiplied by the ratio of the stand to the total area of the plots to come up with an estimate of shrub composition (Table 7) for the entire stand.

The understorey in the Trembling Aspen stand was dominated by tall shrubs, with an average stem length of approximately 300 cm. The leading tall shrubs were Red Osier Dogwood, Twinberry and Nootka Rose. The shrub layer of a replacement stand is likely to reach near-parity with the shrub layer of the removed stand in 15-20 years. Most of the larger species - including Red Osier Dogwood, Black Hawthorn, Twinberry, Pacific Crab Apple, Cascara and Scouler's Willow – do not tend to spread but because of their large size planting densities do not need to be as dense as the density of existing shrubs. A planting density of 25 shrubs/100 square metres should be sufficient to achieve near-parity with the shrub layer of the original Trembling Aspen forest within 15 years. Table 5 provides an estimate of cost establishing a comparable shrub layer in a replacement stand over a 15-year period.

Most replacement costs for the shrub layer are incurred in preparing the site and purchasing/planting stock. Site preparation costs tend to be relatively high in the moist environments favoured by the shrubs present in the existing Trembling Aspen stand. The calculations in Table 8 estimate site preparation costs at $15/$m^2$. No adjustment was made to account for invasive shrubs present in the stand being replaced, as they were not abundant. In year 1, stand tending costs ($3.00/$m^2$) will cover weeding, watering, and (if necessary) fertilization. In year 2, some replanting will be necessary to replace mortality, but supplemental watering and fertilization will only be needed for replacement stock and total costs decline to

[4] The Council of Tree and Landscape Appraisers (1998) suggests using a 40% discount for trees in parks and residential areas. The rest of the discount applied to the Trembling Aspen canopy considers that the many of the trees were not in excellent condition, having some canopy dieback.

$2.00/m^2. In subsequent years, there will be no need to provide supplemental watering or fertilization and weeding costs will decline as the shrub canopies expand. The total cost for replacing the shrub layer is estimated at $175,500 ($38.89/m^2).

Table 5 Shrub Replacement Costs – Trembling Aspen Forest

Task	Unit	Unit Cost	Number of Units	Extended Cost
site preparation	square metres	$15.00	4,500	$67,500
purchase of stock	1 gallon stock	$10.00	1,125	$11,250
planting costs	shrub	$10.00	1,125	$11,250
tending costs - year 1	square metres	$3.00	13,500	$40,500
tending costs - year 2	square metres	$2.00	4,500	$9,000
tending costs - year 3	square metres	$1.00	4,500	$4,500
tending costs - year 4	square metres	$1.00	4,500	$4,500
tending costs - year 5	square metres	$1.00	4,500	$4,500
tending costs - year 6	square metres	$1.00	4,500	$4,500
tending costs - year 7	square metres	$0.50	4,500	$2,250
tending costs - year 8	square metres	$0.50	4,500	$2,250
tending costs - year 9	square metres	$0.50	4,500	$2,250
tending costs - year 10	square metres	$0.50	4,500	$2,250
tending costs - year 11	square metres	$0.50	4,500	$2,250
tending costs - year 12	square metres	$0.50	4,500	$2,250
tending costs - year 13	square metres	$0.50	4,500	$2,250
tending costs - year 14	square metres	$0.50	4,500	$2,250
total cost				$175,500

4.2.3 Herbaceous and Moss/Lichen Layers

The Trembling Aspen forest (4,500 m^2) had an herbaceous layer with an average cover of approximately 10%. The estimated cost to re-establish the native herbaceous component of the vegetation is $22,500 (4,500 m^2 * 10% * $50/m^2). This equates to an average cost of $5.00/m^2.

4.2.4 Roll-up of Valuations

In summary, the valuation for the tree canopy is $279,127; the valuation for the shrub layer is $175,500 and the valuation for the herbaceous layer is $22,500. The total Trembling Aspen ecosystem valuation is $477,127.

5 Summary

The valuation of the Garry Oak woodland and Trembling Aspen forest areas are $766,146 and $477,127 respectively ($1,243,273 in total).

The provisional valuations provided above, however, are the first step to developing an offset mitigation plan. If sites can be identified for establishing offsetting impacts, actual site-specific offsetting costs may be higher or lower than the valuations presented above. If no suitable offset areas can be identified for the Garry Oak woodland and/or the Trembling Aspen forest, the payments in-lieu will rely upon valuations provided above.

6 Next Steps

The next step will be an analysis of off-site mitigation options. Mitigation for the loss of the Trembling Aspen forest will focus on the establishment of a stand of comparable composition and extent in a nearby, degraded area of Cuthbert Holmes Municipal Park.

Mitigation for the loss of the Garry Oak woodland will consider opportunities to offset impacts by establishing a new woodland of comparable composition and extent in a degraded area within 20 km of the project area. If no suitable site can be identified, then the focus will switch to using the in-lieu funding to restore multiple existing woodlands within a 20-km radius, considering multiple factors including:

- whether the proposed restoration sites occur within protected areas such as municipal, regional, provincial or national parks or ecological reserves,
- whether the proposed restoration sites can be restored to a comparable mix of Garry Oak / California Brome and Garry Oak / Oceanspray ecological communities,
- potential threats to each proposed restoration site, and
- estimated restoration costs per hectare.

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8 Appendix 1: The Trunk Formula Method for Valuing a Tree

1. Calculate the Unit Tree Cost of the Replacement

The unit tree cost of the replacement is the cost of purchasing and installing a replacement sapling, expressed as $/trunk area. It is calculated as follows:

- Determine the cost of purchasing the replacement tree – This varies depending on the tree species and market conditions, as well as the size of the replacement stock. The Pacific Northwest Chapter of the International Society of Arboriculture (2007) estimated that in the Lower Mainland a 3" diameter deciduous tree would cost an average of $249, while a 3" diameter evergreen tree would cost $199. A 20% adjustment for inflation over the subsequent decade (based on the consumer price index) would adjust these figures upwards to approximately $300 for a deciduous tree and $240 for an evergreen tree.
- Determine the cost of installing the replacement tree – this varies depending on the effort it takes to move the replacement tree to the planting spot, the condition of the planting spot, and labour costs. The Pacific Northwest Chapter of the International Society of Arboriculture (2007) estimated that in the Lower Mainland it would cost $350 to plant a 3" diameter replacement tree. With a 20% inflation adjustment, the 2017 cost would be $420. In a natural environment, where rocks and compacted, stony soils might complicate installation, the actual costs may be considerably higher.
- Calculate the installed cost – this is the combined cost of purchasing and installing the replacement tree. Using the preceding values, the installed cost would be approximately $720 for a deciduous tree and $$660 for an evergreen tree.
- Calculate the installed cost per unit trunk area – a replacement tree with a 3" diameter trunk would have a trunk area of approximately 7 inches^2 (45 cm^2). The unit tree cost would thus be about \$100/inch^2 (~\$16/cm^2) for a deciduous tree and \$90/inch^2 (~\$15/cm^2) for a coniferous tree.

2. Calculate the Basic Tree Cost

The basic tree cost is the value assigned to the tree being replaced. It is a function of the difference between the trunk area of the replacement tree and the tree it is replacing, and the Unit Tree Cost.

- Determine the trunk area of the tree being replaced. For example, a deciduous tree with a 20-cm diameter would have a trunk area of 314 cm^2.
- Determine the difference between the area of the replacement tree and that of the tree it is replacing. For example, using the above figures the increase in trunk area would be (314-45) = 269 cm^2.
- Multiply the increase in trunk area (269 cm^2) by the unit tree cost (\$16/cm^2) to come up with the estimated value of the increase in trunk area: \$4,304.
- Add the installed cost of the replacement tree ($720) to the value of the increase in trunk area (4,304) to come up with the basic tree cost: $5,024.

3. Calculate the Appraised Tree Value

The appraised tree value is calculated by adjusting the basic tree cost according to three factors – the condition of the tree, its location, and its desirability as a species.

The condition of an individual tree influences its value. This may be determined directly by a detailed assessment of its roots, trunk, scaffold branches, small branches, twigs and foliage (Council of Tree and Landscape Appraisers 2000) or more rapidly, though indirectly, by visually estimating percent crown dieback (Nowack et al. 2008). Golder Associates collected data on percent crown dieback (S. Black pers. comm. 2016) so dieback was used for the McKenzie Interchange project.

The location of a tree plays a significant role in determining its value. The location rating is determined by averaging ratings for the value of the site where it occurs, the contribution the tree makes within the setting, and the placement of the tree within the site (Council of Tree and Landscape Appraisers 2000). Establishing the location rating for a tree is a highly subjective process, largely because there is little guidance for assigning numeric values to factors related to location (Watson 2002). Early editions of the CTLA manual (e.g., Council of Tree and Landscape Appraisers 1998) provided generalized location discounts which are still used by iTree (an application arborists commonly use to approximate location discounts). These are as follows:

- golf course 80%;
- commercial/industrial, cemetery, and institutional 75%;
- parks and residential 60%;
- transportation and forest 50%;
- agriculture 40%;
- vacant 20%;
- wetland 10%.

The absence of a location class for which there is no discount implies that there is no class of location where a tree reaches its full value (basic tree cost). It could be argued, however, that in an imperilled plant community each native tree characteristic of that community realizes its full potential value.

The desirability (rating) of a tree species is a function of its relationship to its environment, and the rating for a given species varies depending on the environment being considered. The rating reflects how well it is adapted to the prevailing climate and soils, is resistance or tolerance of insects, diseases and air pollution, and the growth characteristics of the species such as its vigour, structural strength, life expectancy and pruning requirements (Council of Tree and Landscape Appraisers 2000). Generalized (default) tree species ratings have been proposed for different regions. In the Pacific Northwest Region – which the International Society for Arboriculture defines as Alaska, the Yukon Territory, British Columbia, Washington, Idaho and Oregon – generalized ratings are provided for many native and ornamental tree species both within coastal and interior settings (Pacific Northwest Chapter of the International Society of Arboriculture 2007). Western Redcedar, for example, is assigned default ratings of 80% in interior settings and

90% in coastal settings. The generalized species ratings are, however, insufficient to represent the value of the species in different ecological settings even within a single region (Council of Tree and Landscape Appraisers 2000). For example, Garry Oak has a default rating of 85% for coastal portions of the Pacific Northwest Region but this is not appropriate for coastal areas of Alaska and most coastal areas of British Columbia because it is unable to grow in these regions. Trees that are native to an area are often well adapted to a site. In such environments, they may be given a 100% species rating (Council of Tree and Landscape Appraisers 2000).

The application of condition, location and desirability discounts are applied to the basic tree cost to come up with an adjusted tree cost. For example, consider a tree with:

- a basic tree cost of $5,024,
- with an 80% condition rating (20% crown dieback),
- growing in a location with a 75% location rating (e.g., an institutional setting), and
- a species rating of 85%.

Its Appraised Tree Value would be $5,024 * 80% * 75% * 85% = 2,562.24.