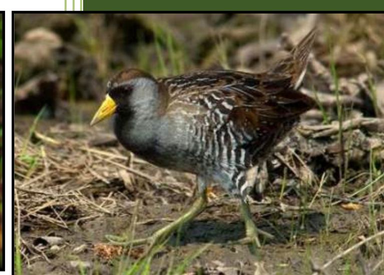
Appendix 1. Assessment of Wetland Function for the Site C Clean Energy Project

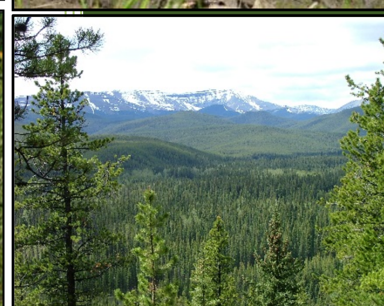
Assessment of Wetland Function for the Site C Clean Energy Project

– Prepared for BC Hydro –

October 2017





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Assessment of Wetland Function for the

Site C Clean Energy Project: Table of Contents

1.0 Introduction

Condition 11 of the Federal Decision Statement requires BC Hydro to develop a plan that addresses, amongst other things, the potential effects of the Project on wetlands.

Condition 11.4 states that the plan shall include:

11.4.1 *baseline data on the biogeochemical, hydrological and ecological functioning of the wetlands and associated riparian habitat in the area affected by the Designated Project, including: ground and surface water quality and quantity; vegetation cover; biotic structure and diversity; migratory bird abundance, density, diversity and use; species at risk abundance, density, diversity and use; and current use of the wetlands for traditional purposes by Aboriginal people, including the plant and wildlife species that support that use;*

11.4.4 compensation measures to address the unavoidable loss of wetland areas and functions supporting migratory birds, species at risk, and the current use of lands and resources by Aboriginal people in support of the objective of full replacement of wetlands in terms of area and function;

Condition 12 of Schedule B Table of Conditions issued by the province requires:

The EAC Holder must develop a Wetland Mitigation and Compensation Plan. The Wetland Mitigation and Compensation Plan must include an assessment of wetland function lost as a result of the Project that is important to migratory birds and species at risk (wildlife and plants). The Wetland Mitigation and Compensation Plan must be developed by a QEP with experience in wetland enhancement, maintenance and development.

This report outlines the wetland function assessment process (Figure 1) that was used to characterize the ecological functioning of wetlands for migratory birds, amphibians, bats, fauna species at risk, flora species at risk, and wetland plant and wildlife species used for traditional purposes by Aboriginal people (in accordance with Federal condition 11 and Provincial condition 12 above), then describes baseline ecological functioning of wetlands in the areas that may be affected by the Project.

This science-based system identifies function at the landscape level and uses peer-reviewed literature, in conjunction with existing GIS and baseline survey data from the Project, to identify the relative importance of wetlands for migratory birds, amphibians, bats, fauna species at risk, flora species at risk and species important to Aboriginal land use (see Table 10 and Section 8.0 - Record Keeping). It uses a model that was developed based on wetland function assessment processes reviewed in the literature such as a Habitat Equivalency Analysis (HEA; see Section 1.1 Assessment of Wetland Functions) to estimate the loss of wetland area and function supporting migratory birds, amphibians, bats, fauna species at risk, flora species at risk and species important to Aboriginal land use. Finally, it evaluates assumptions (see Section 5.1 - Model Assumptions) and uncertainty (see Section 5.4 – Sensitivity Analysis) of the wetland function assessment process by running a sensitivity analysis to evaluate the likelihood that compensation measures address wetland area and functional loss. To provide context for the model structure, wetland function assessment literature was reviewed followed by a discussion on the considerations made in developing a model to address the loss of wetland function supporting migratory birds, amphibians, bats, fauna species at risk, flora species at risk and current use of lands and resources by Aboriginal people for the Site C Clean Energy Project.

1.1 Assessment of Wetland Functions

Wetland function assessments measure an array of wetland functions and typically assign them a quantitative value (e.g., numerical) or qualitative ranking (e.g., high, medium, low; United States Department of Agriculture, USDA 2008; Novitzki et al. 1997). These values and rankings can be used to determine the importance of individual functions in terms of maintaining a particular wetland or the degree to which a wetland function benefits the overall ecosystem. Wetland function is defined in Smith et al. (1995) as the normal or characteristic activities that take place in wetland ecosystems as a result of their physical, chemical, and biological attributes (e.g., short-term storage of surface water, cycling of nutrients, maintenance/support of plant and animal communities, etc.). In many cases it is impossible or impractical to measure wetland functions directly, so “indicators” are used as a representation (e.g., the number of waterfowl/acre is used as an indicator to measure how well a wetland is performing its waterfowl habitat function; Novitzki et al. 1997). Each situation is unique as not all wetlands are able to perform every function (e.g., a wetland’s geographic location may have a strong influence on the species it supports) and many factors determine how well these functions are performed (e.g., climatic conditions, quantity and quality of water entering the wetland, and disturbances or alterations within the wetland or the surrounding ecosystem; Novitzki et al. 1997).

By assessing the functional value of several individual wetlands of the same type and making comparisons between them, wetlands can be ranked based on their ecological significance; areas that receive a high ranking would be prioritized for avoidance, if possible, during development. For projects where wetland loss is unavoidable, this information can be applied to the mitigation process and alternative wetlands can be enhanced, restored or constructed to offset the wetland functions lost. Wetland function assessments can also be used to determine the success (or failure) of programs and policies intended to protect or manage wetland resources (e.g., continuous assessment of the same wetlands in an agricultural area shows that the functional capacity of wetlands to provide habitat for aquatic animals improves as fertilizer restrictions are put in place) and to assist in identifying long-term trends in the condition of wetland resources (Novitzki et al. 1997).

The primary purpose of a wetland function assessment is to assist with wetland monitoring and assess project-level impacts to wetlands. Many wetland assessments are designed to estimate the loss or gain of wetland function as a result of a proposed project. Wetland processes can be assigned a score, which are then multiplied by the acreage of wetlands affected to develop mitigation ratios (Kusler 2006). One challenge of using wetland assessments to calculate mitigation ratios is that they can require detailed knowledge and data of the resource being managed, which is not always practical to obtain due to budget constraints, the amount of field data required, the accuracy of the information collected, or the intent of the original field data collection process. This is not a constraint if sufficient published information is available to develop regional benchmarks (Clark & Bradford 2014).

The wetland function assessment for the Site C project exclusively considers the functional score of wetlands to specific wildlife and plant groups during important periods of their lifecycles. Standardized wetland assessments, such as Rapid Wetland Assessment Methods and a Hydrogeomorphic Approach (HGM), typically address wetland functions related to the chemical, physical, and biological processes of wetlands (Kusler 2006) and rarely use a scope as focused as this project (i.e., wetland functions associated with migratory birds, species at risk and the current use of lands and resources by Aboriginal people). Because most wetland function assessments are completed at a much broader scale, so too is their high-level evaluation of wetland habitat functions (e.g., Does the existing wetland exhibit strong evidence of wildlife utilization, moderate evidence of wildlife utilization, minimal evidence of wildlife utilization, or no evidence of wildlife utilization?). Specific methodologies have been developed to evaluate animal species and biological communities in wetlands (e.g., Habitat Evaluation Procedures, U.S. Fish and Wildlife Service 1980; Indices of Biological Integrity, EPA 2002), but these are used primarily to monitor changes in habitat quality over time (Kusler 2006).

Most wetland function assessments only make comparisons between wetlands of the same types or classes. The BC Hydro Site C project wetland function assessment calculated the total loss of each wetland habitat function by quantifying the degree of loss for each respective wetland type (i.e., SE, TS, etc.). This is weighted based on the habitat type’s ability to perform a specific function and the wetland area scheduled to be lost as a result of construction. Functional loss for each individual wetland type can then be combined to achieve an understanding of total functional loss for each wetland function (i.e., functional loss of migratory bird breeding habitat in Sedge wetland, Tamarack Sedge wetland, Willow Sedge wetland, etc. all combined to calculate total functional loss of migratory bird breeding habitat). Some area-wide function assessments have been created, but these primarily focus on soils, topography and locations of wetlands and do not consider habitat functions or species of interest (Kusler 2006).

Wetland function assessments typically use a series of reference wetlands that are selected to represent “natural conditions”, then functional values of these wetlands are determined (e.g., HGM). The functional values for reference wetlands are then used as the benchmark for comparison amongst all other wetlands evaluated during the assessment process (Smith et al. 1995). During the wetland function assessment used for the BC Hydro Site C project, the existing state of wetland functions during the pre-construction period, which are scheduled to be impacted as a result of construction activities, are used as the baseline reference and then equated to total functional gain from mitigation efforts in an attempt to offset the two. This method is known as a habitat equivalency analysis (HEA), where “interim losses are quantified as lost habitat resources and services, and the scale of the restoration projects is that which provides equivalency between the lost and restored resources and services” (Penn & Tomasi 2002, Clarke & Bradford 2014). Service losses are represented as generic values (usually a percentage of the undamaged habitat) that attempt to integrate the overall loss of service. This avoids the need for detailed ecosystem studies (Clark & Bradford 2014). The science of equivalence is still in its early stages and although the HEA concept was introduced in 1990, many of the primary papers discussing its utility were written in the mid 2000’s and the process is still subject to refinement (Clark & Bradford 2014).

1.2 Assessment of Wetland Functions for the Site C Clean Energy Project

Based on the literature reviewed above, in order to quantify project-related wetland functional loss as per Federal Condition 11.4 and Condition 12 issued by the Province of British Columbia, the wetland function assessment process for the Site C Clean Energy Project considers three components:

Component 1. **Classification of Wetland Types and Area**;
Component 2. **Selection of Wetland Indicator Species,** including migratory birds, amphibians, bats, fauna species at risk, flora species at risk, and species important to Aboriginal land use; and
Component 3. **Identification of Important Wetland Habitat Functions.**

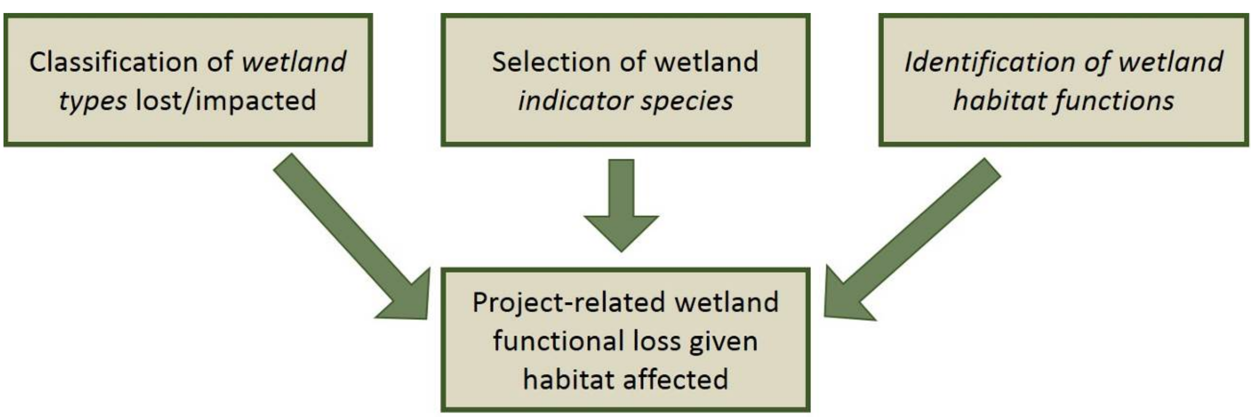


Figure 1. Wetland function assessment process for the Project.

For the purposes of this wetland function assessment, this process defines:

- *Wetland function* as the “…natural processes that are associated with wetlands, independent of considerations of the benefits of those processes to humans.” (Hanson et al. 2008), with a specific focus on the wetland functions important to migratory birds, amphibians, bats, fauna species at risk, flora species at risk and species important to Aboriginal land use.

- *Indicator species* as a species whose presence in a given area is used to indicate suitable conditions for a broader group of additional species.

Together, these three components are used to Determine *Total Functional Loss Given Habitat Affected*. First, a standardized habitat selection index (Manly et al. 2002) is established for each wetland habitat function. A simplified Habitat Equivalency Analysis, calculating area of habitat to restore based on estimates of the total loss of function provided by the wetland habitats, is then used to determine *Total Functional Loss Given Habitat Affected*. This is calculated using the selectivity index created for indicator species/assemblages and the area of wetland habitat that will be affected as a result of construction activities associated with the Site C project. An understanding of *Total Functional Loss Given Habitat Affected* helps assess wetland habitat function that will be lost across all species groups identified (e.g., migratory birds, amphibians, bats, fauna species at risk, flora species at risk and species important to Aboriginal land use) due to the Project and will inform planning and estimation of the mitigation measures required to offset functional loss. This equivalency analysis is classified as an "out of kind" offset as the impacts and offsets are of a different form than a like-for-like comparison and wetland function is used as the common metric (i.e., wetland habitat types are not replaced on a like-for-like basis but rather on a function for function basis; Clark & Bradford 2014).

The literature review and data assessment are summarized, as part of the identification of important wetland habitat functions, to provide the structure for the evaluation process (see Sections 3.0 and 4.0). The evaluation process is then outlined step by step for fauna and flora species, as well as practical examples and assumptions made as part of the process (see Section 5.0). All calculations in the ranking process are provided in Excel spreadsheets, as well as described below. Two excel spreadsheets for flora and fauna (NPS_bchydro_siteC_faunaspp_wetlandfunction_Oct2017.xlsx and NPS_bchydro_ siteC_floraspp_ wetlandfunction_Oct2017.xlsx), as well as one for species important to Aboriginal land use (NPS_bchydro_siteC_Aboriginalspp_wetlandfunction_Oct2017.xlsx) also provide the data used in the ranking and allocates that information to wetlands within the LAA. Should the reader not have access to the Excel spreadsheets, the ranking data tables can be found in Appendix I. The LAA was defined in the EIS (Hilton et al. 2013a) as:

> "The area within which the potential adverse effects of the Project are assessed. The LAA encompasses the Project activity zone, buffered by an additional 1,000 m. For the proposed reservoir, the erosion impact line has a 1,000 m buffer. The LAA also extends downstream from the dam to the Alberta border, and includes a 1,000 m buffer on both the south and north banks of the Peace River."

This document provides a summary of the process described above, and outlines the ranking process, commencing with Component 1, the classification of wetland types to be affected by the Project.

2.0 Component 1. Classification of Wetland Types and Area.

Classification of wetland types in the LAA followed the structure of mapping and terrestrial ecosystem classification presented in the EIS (Hilton et al. 2013a). TEM developed for the Site C project was used to confirm the area and distribution of wetland types across the LAA (Figure 2). While the total wetland area within the transmission line right-of-way is included in the function assessment not all will be affected by the Project. The area of wetland to be affected by the Project, including habitat alteration and fragmentation (i.e., see Section 13.1.2.3 in Hilton et al. 2013a for further description of potential project interactions with vegetation and ecological communities, including wetlands) will be calculated based on the final transmission line design and the construction footprint. Areas presented in Table 1 will be adjusted based on monitoring during construction to provide an accurate value for wetlands lost and impacted. Some additional ecosystem types mapped have been classified as wetlands for this function assessment. Examples are:

- The Labrador Tea – Sphagnum ecosystem type (BT) has been added as a wetland type due to its description as a bog.
- Tufa seep and marl fen habitats were included due to their uniqueness as habitats for flora species at risk. Tufa seep and marl fen habitat were recorded in the baseline as point occurrences; therefore, the ranking of their wetland function has not been included at this time. Their habitat will be included at a later date once their areas have been verified in the field.

The Provincial classification system was used to identify wetlands. Therefore, wetlands could not be assigned to one of the five major classes of the Canadian Wetland Classification System (National Wetlands Working Group 1997; i.e., swamp, bog, marsh, fen and shallow open water). Several of the wetland ecosystem types described in Hilton et al. (2013a) share characteristics of more than one of the five major classes (e.g., BT has characteristics of both a bog and a swamp). Descriptions of these wetland ecosystem types, including the dominant and associated plant species for each structural stage as well as location characteristics for the project site, can be found in Hilton et al. (2013d).

Where possible, habitat associations and categories of use for the indicator species were described by mapped wetland types (Table 1). Baseline information on the biogeochemical, hydrological and ecological functioning of the wetland habitat types, where it informed indicator species use, was inferred based on general descriptions of the habitat types in the EIS (Hilton et al. 2013a), MacKenzie and Moran (2004), and Delong et al. (2011). Further information on the wetland habitat features, as per Federal Condition 11.4.1, will be verified in the field as part of the wetland monitoring program (see Section 6.0 - Collecting Baseline Data on the Biogeochemical, Hydrological and Ecological Functioning of the Project Area Wetlands). For flora species at risk, in the review of secondary habitat associations, species were assessed following classification used in MacKenzie and Moran (2004), and then compiled to the level of classification used in the EIS.

During operations the monitoring of wetlands along and adjacent to the transmission line will be used to gather data on potential changes to area and function. Data collected will also be used to inform the wetland mitigation plan through the assessment of existing wetland features, attributes, landscape positioning and connectivity to other habitat systems.

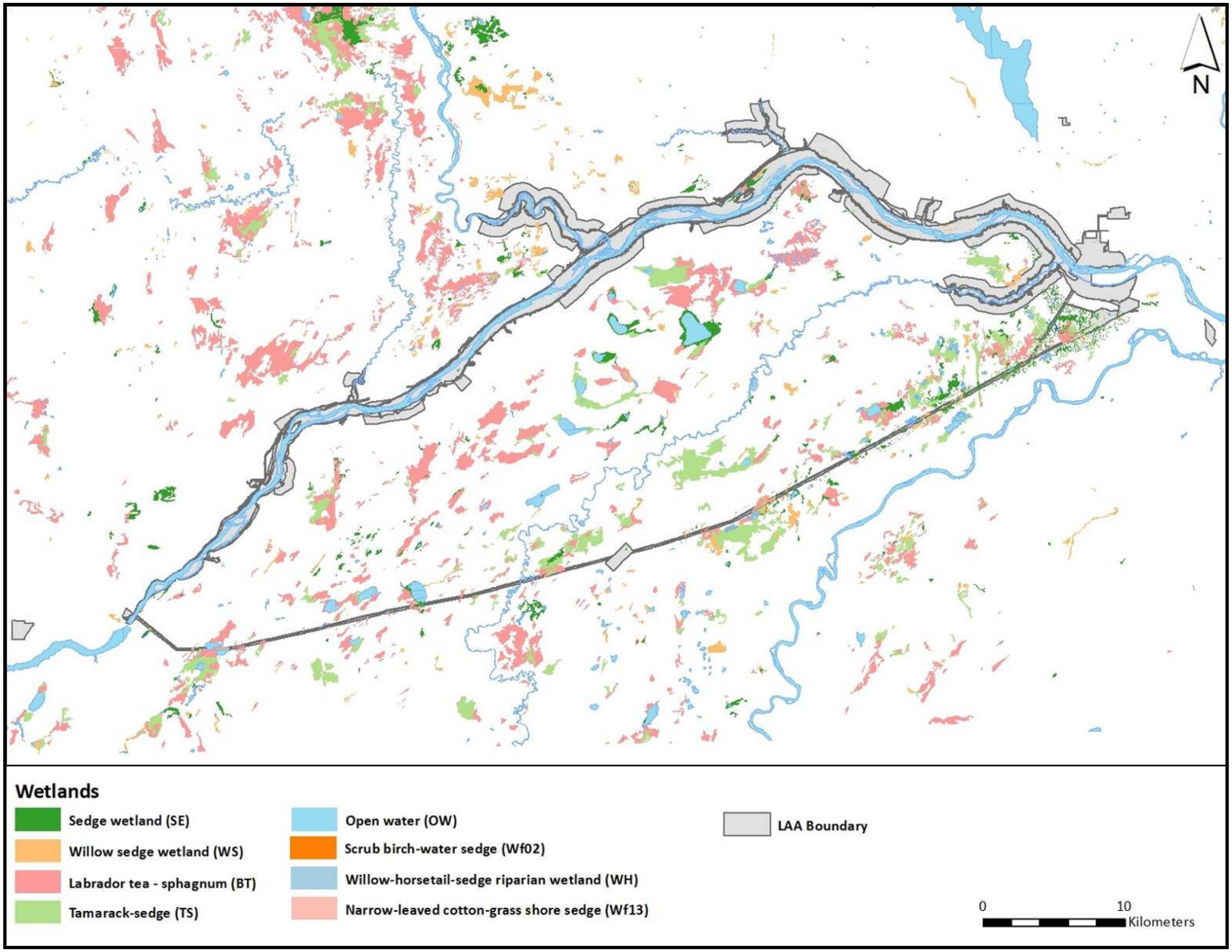


Figure 2. Detailed and TEM wetland mapping for the Site C project.

Table 1. Wetland ecosystem types in the Site C LAA[1]. Minimum area and maximum area are the smallest and largest polygon sizes of the wetland ecosystem types within the TEM data, showing the range in wetland sizes in the LAA. Total area to be affected by construction and operations is as described in Hilton et al (2013a).

Wetland Ecosystem	Total area in LAA (ha)	Count[2,3]	Minimum area (ha)[2]	Maximum area (ha)[2]	Average area (ha)[2]	Total area to be affected by construction (ha)	Total area to be affected by operations (ha)
Labrador Tea – Sphagnum (BT)	2051	418	0.0005	166.612	4.908	93	58
Shallow Open Water (OW)	75	40	0.083	11.239	1.924	17	1
Sedge wetland (SE)	1169	507	0.0000073	67.634	2.306	142	55
Tamarack Sedge (TS)	1406	289	0.00000053	102.054	4.860	68	47
Willow-Horsetail-Sedge riparian wetland (WH)	1009	247	0.00481	52.457	4.087	392	1
Willow Sedge wetland (WS)	363	99	0.00282	38.144	3.587	50	16
Scrub Birch-Water Sedge (Wf02)	10	3	0.873	4.941	3.331	0	0
Narrow-leaved Cotton-Grass Shore Sedge (Wf13)	9	4	0.946	4.179	2.113	<1	<1
Marl Fen	N/A	1	N/A	N/A	N/A	N/A	N/A
Tufa Seep	N/A	12	N/A	N/A	N/A	N/A	N/A

[1] Ecosystem coding is shown in brackets, where present, total area in the LAA, and area to be affected by construction and operations (modified from Hilton et al. 2013a). Labrador Tea – Sphagnum (BT) habitat was included as part of this wetland function assessment. This was not considered wetland in the EIS. At this time, the exact area for marl fen and tufa seep are not available.
[2] Count, minimum area (ha), maximum area (ha) and average area (ha) were calculated from the TEM mapping data from the LAA. Note that only count data is available for marl fen and tufa seep, as these are point data occurrences.
[3] Count is the number of polygons for a wetland type (S1, S2 or S3) in the TEM mapping from the LAA.
N/A : Not Applicable. Marl fen and tufa seep locations are identified only as point data, and therefore area data are not currently available for these wetland types.

3.0 Component 2. Selection of Wetland Indicator Species.

In order to determine project-related wetland functional loss, indicator species (see definition on how this term was utilized in Section 1.2 Assessment of Wetland Functions for the Site C Clean Energy Project) were selected from the list of species documented in the Project baseline studies. The selection of wetland indicator species for migratory birds, amphibians, bats, fauna species at risk, flora species at risk and species important to Aboriginal land use are described below. Information from peer-reviewed literature, provincial databases, and experts has been used to form an understanding of wetland habitat use by indicator species for the wetland function ranking. Baseline wildlife and vegetation survey data from the LAA was used to verify and confirm the literature review. See Section 4.0 - Component 3: Identification of Important Wetland Functions as to how this information was used. Appendices A and B in this document lists the literature reviewed for each of the indicator species considered as part of this process.

3.1 Selection of Migratory Bird Indicator Species

A detailed review of the baseline conditions and the available literature was used to identify the important functions wetland habitats provide migratory bird species and how the Project will impact these functions. Due to the high number of migratory bird species observed in the LAA, bird species were combined into assemblages that share similar morphology and habitat use patterns. One to three indicator species were then selected to represent each assemblage. Thirteen assemblages of migratory bird species were identified and are described below. Information on species assemblages was taken from the National Geographic Field Guide to the Birds of North America (Dunn & Alderfer 2006) and the Cornell Lab of Ornithology: All About Birds website (Cornell University 2011).

Dabbling Ducks – Ducks of the genus *Anas* that feed on the water surface or by tipping, tail up, to reach aquatic plants. In most cases this assemblage nests in dry locations above the waterline at suitable wetland and upland sites.

Diving Ducks – Duck species that feed by diving below the water's surface and typically nest over water or close to the water's edge. This assemblage includes pochards (*Aythya*) and stiff-tailed ducks (*Oxyura*), as well as most sea ducks (*Melanitta, Clangula*, and *Histrionicus*) and mergansers (*Mergus*), with the exception of those that nest in tree cavities.

Cavity-nesting Ducks – Duck species that utilize tree cavities for nesting. The generas *Bucephala, Mergus*, and *Lophodytes* are diving ducks, while Wood Ducks (*Aix sponsa*) are surface feeders.

Swans and Geese – Large, long-necked and primarily aquatic birds from the family Anatidae. This assemblage of waterfowl contains the genera *Cygnus, Anser, Chen,* and *Branta*.

Waterbirds – Aquatic diving birds from the families Gaviidae (loons) and Podicepedidae (grebes).

Gulls and Terns **–** Species from the family Laridae, which frequent coastal waters or inland lakes and wetlands and can be highly pelagic.

Forest-nesting Shorebirds – Species from the family Scolopacidae that spend most of their time along the water's edge and tend to nest in forested or shrubby areas.

Marsh-nesting Shorebirds – Species from the families Charadriidae and Scolopacidae that spend most of their time along the water's edge and tend to nest in open or marshy areas.

Rails – Marsh birds with short tails and short, rounded wings from the family Rallidae

Open Habitat Songbirds – Songbirds include the orders Passeriformes, Apodiformes, Columbiformes, and Coraciiformes. This assemblage consists of songbirds that occupy primarily open habitat types.

Deciduous Songbirds – Songbirds include the orders Passeriformes, Apodiformes, Columbiformes, and Coraciiformes. This assemblage consists of songbirds that occupy primarily deciduous tree- or shrub-dominated habitat types

Coniferous Songbirds – Songbirds include the orders Passeriformes, Apodiformes, Columbiformes, and Coraciiformes. This assemblage consists of songbirds that occupy primarily coniferous-dominated habitat types

Aerial Insectivores – Swallows and nighthawks from the families Hirundinidae and Caprimulgidae that feed on swarming insects during flight.

Indicator species representing the 13 assemblages were chosen from the species recorded during baseline inventories conducted within the LAA (Table 2). The chosen species had a strong association with wetland habitats, used the Peace River region as a core part of their range, were important from a conservation standpoint, and do not have broad or generalized habitat preferences. Species with generalized habitat preferences were not selected because they would diminish the importance of wetland habitats in terms of assessing their functional value as many generalist species use a wide array of habitat types. To narrow this list of representative species further, species identified by Environment Canada as conservation priorities for the Boreal Taiga Plains Region (BCR-6), which includes the Peace River area, were also selected (Environment Canada 2013a). Species listed as "priority species" in wetland habitats were preferred as indicator species.

The final selection of species excluded those that were found in low numbers during baseline studies in the LAA (i.e., less than 100 observations for waterfowl during transect surveys, and less than 10 detections for other bird species during breeding bird surveys), occurred in the region at the periphery of their range, had habitat preferences that mirrored other species on the list, were not considered migratory, or had more general habitat preferences in relation to other species that fell into the same category. Experts from within Ducks Unlimited Canada were also consulted during the selection process and included Stuart Slattery PhD (Research Scientist – boreal waterfowl ecology), Darryl Kroeker (Head of Conservation Programs, BC Peace), and Julienne Morissette PhD (Conservation Scientist – National Boreal Program). In total, 23 species were selected to represent the 13 different assemblages. See Table 2 for the complete rationale behind the inclusion or exclusion of BCR-6 priority species for wetland habitats from the list and Figure 3 for a flow chart that outlines the selection process for migratory bird indicator species. This initial list was further refined following discussion with colleagues from Environment Canada's Canadian Wildlife Service and British Columbia's Ministry of Environment (MOE).

Few songbird species met the above criteria and often those that did were extremely rare on the landscape, therefore it was suggested that additional species be added to the Deciduous Songbirds and Coniferous Songbirds species assemblages to improve their representation (Julienne Morrisette, pers. comm., Ducks Unlimited Canada). Based on their distinct preferences for specific wetland habitat types and occurrence within the LAA, the two species added were Lincoln's Sparrow and Northern Waterthrush. Lincoln's Sparrows are representative of shrubby and coniferous wetland and riparian habitat types in the boreal region and Northern Waterthrush are representative of deciduous wetland and riparian habitat types. It was also recommended after initial review that a swallow species be added to represent the aerial insectivore assemblage. There were no swallow species classified by Environment Canada as priority species in wetland habitats, but one swallow species observed in the Site C LAA, the Bank Swallow, is considered a priority species in "Waterbodies" habitat (i.e., lakes and ponds >2 m deep, rivers, streams and reservoirs). Therefore, Bank Swallows were selected to represent the aerial insectivore assemblage. With the addition of these three species the total number of indicator species representing migratory birds in the wetland function assessment is 26. A list of the migratory bird indicator species, and their wetland habitat associations for each function (see Section 4.0) can be found in the Excel file 'NPS_bchydro_siteC_faunaspp_wetlandfunction_Oct2017.xlsx', or Appendix I.

Table 2. Rationale for migratory bird species inclusion[1]. Yellow highlight indicates species selected as an indicator.

Species	Included	Rationale[2]
Songbirds		
Alder Flycatcher *Empidonax alnorum*	Y	Wetland species found in bog habitats; represents deciduous and early successional habitat types
Common Yellowthroat *Geothlypis trichas*	Y	Found in deciduous-dominated wetland and riparian areas; important habitat features include a dense shrub understory
Connecticut Warbler *Oporornis agilis*	N	Red-listed wetland species. In this part of its range, habitat preferences shift from bog habitats towards upland deciduous types
Le Conte's Sparrow *Ammodramus leconteii*	Y	Found in marsh and bog habitats; represents open habitat types
Nelson's Sparrow *Ammodramus nelsoni*	Y	Red-listed wetland species found in marsh and fen habitats; represents open habitat types
Olive-sided Flycatcher *Contopus cooperi*	Y	Blue-listed wetland species associated with coniferous habitats with tall trees/snags and forest openings; represents coniferous habitat types
Rusty Blackbird *Euphagus carolinus*	Y	Blue-listed wetland species; represents coniferous and early successional habitat types
Lincoln's Sparrow *Melospiza lincolnii*	Y	Not a priority species in wetland habitats within BCR-6, but indicative of shrubby and coniferous (Julienne Morissette, pers. comm., Ducks Unlimited Canada) wetlands and frequent throughout the landscape
Northern Waterthrush *Parkesia noveboracensis*	Y	Not a priority species in wetland habitats within BCR-6, but indicative of deciduous wetland and riparian habitats (Julienne Morissette, pers. comm., Ducks Unlimited Canada) and frequent throughout the landscape
Aerial Insectivores		
Bank Swallow *Riparia riparia*	Y	Priority species in waterbody habitats in BCR-6; strong association with rivers and perennial streams due to their nesting requirements
Common Nighthawk *Chordeiles minor*	Y	Federally listed as Threatened under the *Species at Risk Act*; nests in bogs and other open wetlands containing bare ground and forages over waterbodies and open habitats
Shorebirds		
Greater Yellowlegs *Tringa melanoleuca*	N	Similar habitat preferences as Lesser Yellowlegs and Solitary Sandpiper and found in low numbers within the study area
Killdeer *Charadrius vociferus*	N	Considered a habitat generalist found in open or disturbed habitat types

Table 2. (continued)

Species	Included	Rationale[2]
Shorebirds *continued*		
Least Sandpiper *Calidris minutilla*	N	Found in low numbers within the study area and considered a transient species found only during migration
Lesser Yellowlegs *Tringa flavipes*	Y	Shorebird species found in marshes and all types of forested habitat near water; nesting occurs in forested habitat types
Solitary Sandpiper *Tringa solitaria*	Y	Shorebird species occupying bogs and found in coniferous and early successional habitat types near water; nesting occurs in forested habitat types
Upland Sandpiper *Bartramia longicauda*	N	Red listed; found in low numbers within the study area and has similar habitat preferences to Wilson's Snipe
Wilson's Snipe *Gallinago delicata*	Y	Shorebird species found in marshes and early successional habitats near water; nesting occurs in open habitat types
Sora *Porzana carolina*	Y	Found in marsh habitat associated with non-perennial ponds/small lakes
Yellow Rail *Coturnicops noveboracensis*	Y	Red-listed; found in bog, fen, and marsh habitat
Gulls and Terns		
Arctic Tern *Sterna paradisaea*	N	Found in low numbers in the study area and considered a transient species
Black Tern *Chlidonias niger*	Y	Found in marshes and shallow water; emergent vegetation is an important habitat feature
Bonaparte's Gull *Chroicocephalus philadelphia*	Y	Found in marshes and bogs; islands are an important habitat feature; preferred nesting sites are in coniferous trees near water
California Gull *Larus californicus*	N	Blue-listed; found in low numbers in the study area and considered a transient species
Caspian Tern *Hydroprogne caspia*	N	Blue-listed; found in low numbers in the study area and considered a transient species
Common Tern *Sterna hirundo*	N	Found in low numbers in the study area and considered a transient species
Waterbirds		
Common Loon *Gavia immer*	Y	Found in marsh habitat and lakes and wetlands with shallow water (<0.5 m); prefers large perennial lakes
Horned Grebe *Podiceps auritus*	Y	Designated as Special Concern by COSEWIC; found in shallow water and associated with emergent vegetation; prefers smaller waterbodies or secluded areas of lakes

Table 2. (continued)

Species	Included	Rationale[2]
Waterbirds *continued*		
Pacific Loon *Gavia pacifica*	N	Found in low numbers in the study area and considered a transient
Pied-billed Grebe *Podilymbus podiceps*	N	Very similar to Horned Grebe in terms of habitat use; found in marsh habitat; prefers smaller waterbodies or secluded areas of lakes
Red-necked Grebe	N	Similar to Horned Grebe and Common Loon in terms of habitat use; prefers large perennial lakes
Dabbling Ducks		
American Wigeon *Mareca americana*	Y	Common within the area, but is a species of conservation interest due to population declines in the boreal region (Stuart Slattery, pers. comm., Ducks Unlimited Canada)
Blue-winged Teal *Spatula discors*	N	Numbers lower than other dabbling duck species with similar habitat preferences within the area
Gadwall *Mareca strepera*	N	Very low numbers found within the study area; similar habitat preferences to other dabbling ducks
Green-winged Teal *Anas crecca*	Y	Common species within the region and represents the typical habitat use of dabbling ducks, using a mixture of wetlands and adjacent uplands for breeding
Mallard *Anas platyrhynchos*	N	Very common species within the study area but has the most generalized nesting preferences of all dabbling ducks
Northern Pintail *Anas acuta*	N	A relatively common dabbling duck species in the area with breeding observations and migration requirements similar to other dabbling duck species
Northern Shoveler *Spatula clypeata*	N	Numbers within the study area were low in relation to other dabbling duck species and habitat preferences similar to American Wigeon and Green-winged Teal
Diving Ducks		
Canvasback *Aythya valisineria*	N	Very low numbers within the study area, has similar habitat preferences to other diving duck species, and does not sufficiently represent the waterfowl community in the Peace River region (Darryl Kroeker, pers. comm., Ducks Unlimited Canada)
Lesser Scaup *Aythya affinis*	Y	Common diving duck species within the area and nests on land and over water
Long-tailed Duck *Clangula hyemalis*	N	Blue-listed; very low numbers within the study area and considered a transient species
Ring-necked Duck *Aythya collaris*	Y	Most common diving duck species within the area and nests over water, which is typical of diving duck species

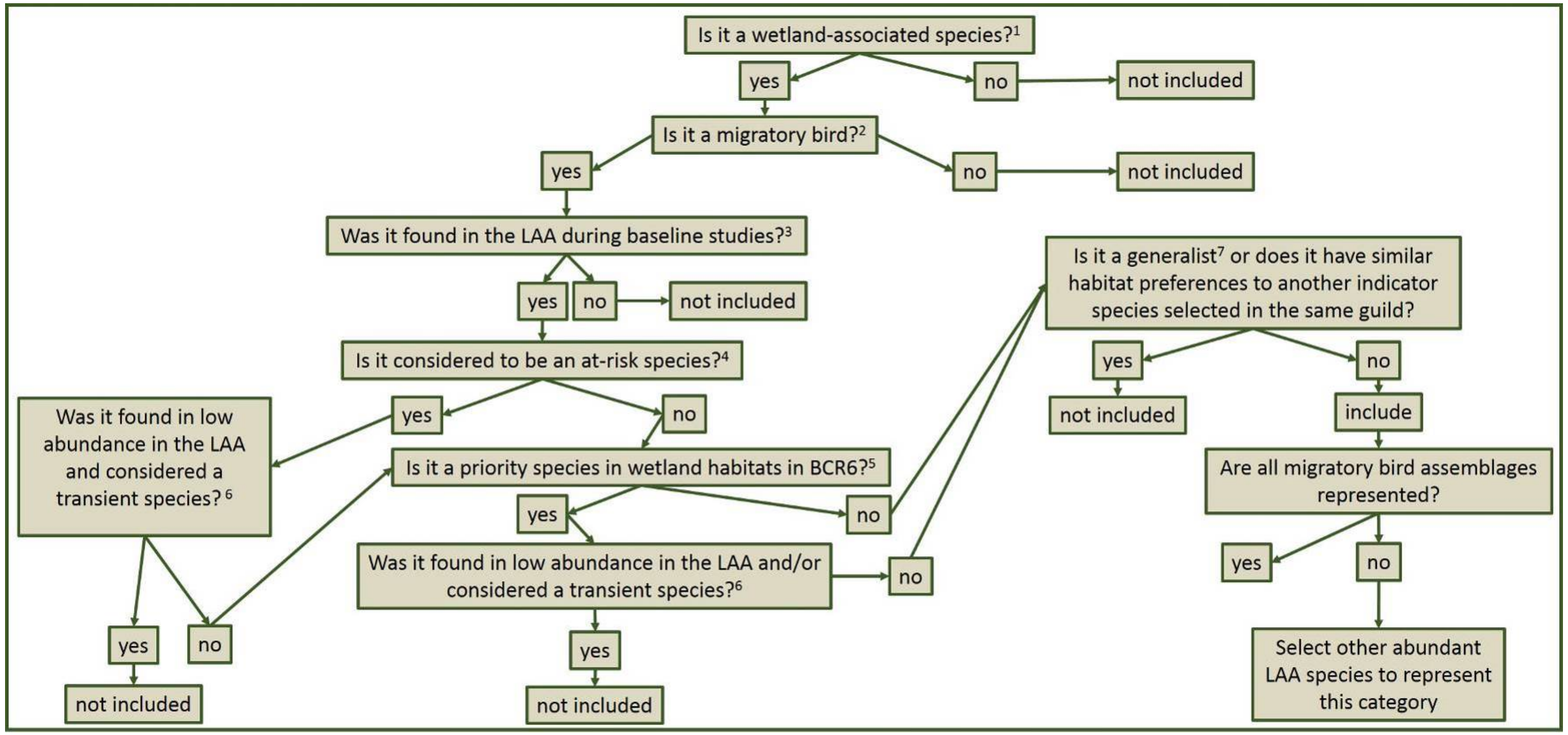
Table 2. (continued)

Species	Included	Rationale[2]
Diving Ducks *continued*		
Surf Scoter *Melanitta perspicillata*	N	Blue-listed; very low numbers within the study area and does not sufficiently represent the waterfowl community in the Peace River region (Darryl Kroeker, pers. comm., Ducks Unlimited Canada)
White-winged Scoter *Melanitta fusca*	N	Very low numbers within the study area and does not sufficiently represent the waterfowl community in the Peace River region (Darryl Kroeker, pers. comm., Ducks Unlimited Canada)
Cavity-nesting Ducks		
Barrow's Goldeneye *Bucephala islandica*	N	Found in the study area in much lower numbers than other cavity nesting waterfowl, has similar habitat preferences, and does not sufficiently represent the waterfowl community in the Peace River region (Darryl Kroeker, Ducks Unlimited Canada pers. comm.)
Bufflehead *Bucephala albeola*	Y	Common cavity nesting species that uses wooded areas adjacent to wetlands for nesting
Common Goldeneye *Bucephala clangula*	Y	Common cavity nesting species that uses wooded areas adjacent to wetlands for nesting
Geese and Swans		
Cackling Goose *Branta hutchinsii*	N	Low numbers within the study area and considered a transient species
Trumpeter Swan *Cygnus buccinator*	Y	Breeds within the study area and has narrower nesting habitat preferences than Canada Goose

All species listed in the table are listed as 'Priority species' for wetland habitat in the BCR-6 by Environment Canada (except for Lincoln's Sparrow and Northern Waterthrush) and were found in the BC Hydro Site C LAA.

[2] 'low numbers' within the LAA was defined as less than 100 observations for waterfowl during transect surveys, and less than 10 detections for other bird species, during breeding bird surveys. Note that any reference to the provincial (i.e., red- or blue-listed) or federal Species at Risk Act status is current as of December 2016.

Figure 3. Flow chart outlining indicator species selection process for migratory birds.



[1] A wetland-associated species was defined as a species that shows a strong association with wetland habitats in the region for an important life function (e.g., nesting).
[2] A migratory bird species was defined as one that is listed under the Migratory Birds Convention Act, 1994 (Environment Canada 2016a).
[3] Baseline studies include breeding bird point counts (2006, 2008, 2011, 2012), migratory encounter surveys (2012), waterfowl surveys (2006, 2008, 2013, 2014), Common Nighthawk call playback surveys (2010-2012), marsh bird call playback surveys (2008, 2011, 2012), swallow nest counts (2010) and swallow point counts (2011-2012).
[4] An at risk species is one that is federally-listed (Environment Canada, 2016b) or has been defined as at risk (i.e., red- or blue-listed) by the British Columbia Conservation Data Centre (B.C. Conservation Data Centre, 2016.).
[5] See Environment Canada (2013a).
[6] Low abundance was defined as species that were found during baseline studies in low numbers within the LAA (i.e., less than 100 observations for waterfowl during transect surveys, and less than 10 detections for other bird species, during breeding bird surveys). Transient was defined as species that occurred in the region at the periphery of their range.
[7] A generalist was defined as a species that uses a wide array of wetland habitat types for a particular function.

3.2 Selection of Amphibian Indicator Species

The amphibians in the study area are particularly vulnerable to wetland disturbance as they rely on available water to complete their breeding cycle. Five amphibian species were detected within the LAA during baseline surveys: Boreal Chorus Frogs (*Pseudacris maculate*), Columbia Spotted Frogs (*Rana luteiventris*), Long-toed Salamanders (*Ambystoma macrodactylum*), Western Toads (*Anaxyrus boreas*), and Wood Frogs (*Lithobates sylvaticus*). Due to the low detection rate of Columbia Spotted Frogs and Long-toed Salamanders they were considered to be rare in the LAA (as defined by Hilton et al. 2013c). Three amphibian species were selected to represent the amphibian assemblage. Each differs based on the type of wetlands they use for breeding and their use of upland habitats. Columbia Spotted Frogs are highly dependent on permanent water sources. Western Toads require pools of water to breed, but otherwise inhabit drier upland sites. The habitat requirements of Boreal Chorus Frogs exist between these two extremes using both wetland and upland habitat during the non-breeding period. Western Toad is the only amphibian recorded in the LAA that is a provincially or federally listed species. It is provincially blue-listed (B.C. Ministry of Environment 2014) and on Schedule 1 of *SARA,* where it has a designation of species of concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2014). A list of the amphibian indicator species, and their wetland habitat associations for each function (see Section 4.0) can be found in the Excel file 'NPS_bchydro_siteC_faunaspp_wetlandfunction_Oct2017.xlsx', or Appendix I.

3.3 Selection of Bat Indicator Species

Eight bat species were captured or detected acoustically during baseline surveys in the LAA: the Little Brown Myotis (*Myotis lucifugus*), Northern Myotis (*Myotis septentrionalis*), Long-eared Myotis (*Myotis evotis*), Long-legged Myotis (*Myotis volans*), Big Brown Bat (*Eptesicus fuscus*), Silver-haired Bat (*Lasionycteris noctivagans*), Hoary Bat (*Lasiurus cinereus*), and Eastern Red Bat (*Lasiurus borealis*). The Northern Myotis is a Blue-listed species (B.C. Ministry of Environment 2014). The Little Brown Myotis and Northern Myotis have received emergency listings as Endangered by COSEWIC as a result of an outbreak of a fungal disease in eastern Canada known as white-nose syndrome (COSEWIC 2014). Both species have been added to Schedule 1 of *SARA*.

Because all eight bat species differ in terms of their foraging and roosting habitat preferences, all were selected to represent bats and the potential loss of important functions this group would experience as a result of wetland loss. A list of the bat indicator species, and their wetland habitat associations for each function (see Section 4.0) can be found in the Excel file 'NPS_bchydro_siteC_faunaspp_wetlandfunction_Oct2017.xlsx', or in Appendix I.

3.4 Selection of Fauna Species at Risk Indicator Species

In accordance with Federal Condition 11.4.4, fauna species at risk, considered separately from flora species at risk, are included in the wetland function assessment. A fauna species at risk is one that is federally-listed under the Species at Risk Act (SARA; Environment Canada 2016b) or has been defined as at risk (i.e., red- or blue-listed) by the British Columbia Conservation Data Centre (B.C. Conservation Data Centre 2016) as of December 2016. Of the list of federally- and provincially-listed fauna species at risk found in the LAA, only those that were wetland-associated were considered (i.e., a species that shows a strong association with wetland habitats for an important life function [e.g., nesting] in the region). In addition, if a species was found in low abundance during baseline surveys (i.e., less than 100 observations for waterfowl during transect surveys, and less than 10 detections for other bird species, during breeding bird surveys) or was transient to the region (i.e., species that occurred in the region at the periphery of their range), it was not included. In total, 19 fauna species at risk were incorporated into the model, including seven butterflies, one dragonfly, one amphibian, two bats and eight birds (Table 3). Of the eight birds, five are also included as indicator species for migratory bird wetland functions. The one amphibian and two bats are also included as an indicator species for wetland function. A list of the species at risk indicator species, and their wetland habitat associations for each function (see Section 4.0), can be found in the Excel file ‘NPS_bchydro_siteC_faunaspp_wetland function_Oct2017.xlsx’ or Appendix I.

Table 3. List of fauna species at risk, including their federal and provincial status (last status update: December 2016).

Common name	Scientific name	Provincial status	Federal Species at Risk Act status[1]	COSEWIC status[1]
Aphrodite Fritillary, *manitoba* subspecies	*Speyeria aphrodite manitoba*	Blue	No status	No status
Assiniboine Skipper	*Hesperia assiniboia*	Red	No status	No status
Bronze Copper	*Lycaena hyllus*	Blue	No status	No status
Common Ringlet, *benjamini* subspecies	*Coenonympha tullia benjamini*	Blue	No status	No status
Common Woodnymph	*Cercyonis pegala*	Blue	No status	No status
Great Spangled Fritillary, *pseudocarpenteri* subspecies	*Speyeria cybele pseudocarpenteri*	Red	No status	No status
Tawny Crescent	*Phyciodes batesii*	Blue	No status	No status
Prairie Bluet	*Coenagrion angulatum*	Blue	No status	No status
Western Toad	*Anaxyrus boreas*	Blue	Schedule 1-SC	SC
Northern Myotis	*Myotis septentrionalis*	Blue	Schedule 1-E	E
Little Brown Myotis	*Myotis lucifugus*	Yellow	Schedule 1-E	E
Surf Scoter	*Melanitta perspicillata*	Blue	No status	
Common Nighthawk	*Chordeiles minor*	Yellow	Schedule 1-T	T
Barn Swallow	*Hirundo rustica*	Blue	No status	T
Rusty Blackbird	*Euphagus carolinus*	Blue	Schedule 1-SC	SC
Olive-sided Flycatcher	*Contopus cooperi*	Blue	Schedule 1-T	T
Nelson's Sparrow	*Ammodramus nelsoni*	Red	No status	NAR
Yellow Rail	*Coturnicops noveboracensis*	Red	Schedule 1-SC	SC
Short-eared Owl	*Asio flammeus*	Blue	Schedule 1-SC	SC

[1] Although COSEWIC status is given, note that it is the SARA status (in addition to the Provincial status) that is used to identify the fauna species at risk indicator species. E = endangered, T = threatened, SC = special concern, NAR = not at risk (i.e., after evaluation).

3.5 Selection of Flora Species at Risk Indicator Species

This wetland function assessment focused only on flora species at risk (also referred to as 'rare plant species' in this document, particularly when referring to rare plant surveys conducted as part of the EIS) documented in the LAA that have strong associations to wetland habitat types. An initial list of wetland-associated flora species at risk was compiled from baseline data (Hilton et al. 2013a), confirmed with the BC Hydro rare plant botanist, reassessed based on their conservation status rank (Table 4) and used to conduct the preliminary ranking. Flora species at risk were confirmed as wetland plants by their wetland indicator status for the Western Mountains, Valleys, and Coast (USDA 2014; Lichvar 2013; Table 4). Wetland zonation for plants includes Obligate Wetland (OBL) species and Facultative Wetland (FACW) species (Table 4). OBL species are plants that always occur in wetlands. FACW plants typically occur in wetlands but can also be found in non-wetland habitats (USDA 2014). Flora species at risk were selected, based on their conservation status rank and their assignment to the Conservation Data Centre's (CDC) red or blue list (i.e., Red: S1 and/or S2 and Blue: S2 and/or S3; BC CDC 2016a-k; see Table 4), which includes any indigenous species or subspecies considered to be threatened or vulnerable in BC. A list of the flora species at risk, and their wetland habitat associations for each function (see Section 4.0), can be found in the Excel file 'NPS_bchydro_siteC_floraspp_wetlandfunction_Oct2017.xlsx' or in Appendix I.

3.6 Selection of Species Important to Aboriginal Land Use Indicator Species

To assist in assessing potential impacts to Aboriginal Groups, Traditional Land Use Studies (TLUS) were prepared for the Project during completion of the Environmental Impact Statement (BC Hydro 2013a). Eight plant and one wildlife wetland-associated species were identified in the EIS as being species of traditional use in the LAA. These species could be impacted by Project construction activities and were included in the wetland function assessment.

Only plant species that had a strong association with wetland habitats were included (i.e., plant species that with either OBL or FACW wetland status in the Western Mountains, Valleys, and Coast Zone [USDA 2014, Anderson 2006]) and these are provided in Table 5. Two plant species with a strong association to wetlands were included in this category (i.e., Labrador Tea and Highbush Cranberry). Moose were also included because of their use of wetland habitat for important functions, such as feeding and birthing sites. A list of the species important to Aboriginal land use, and their wetland habitat associations for each function (see Section 4.0), can be found in the Excel file 'NPS_bchydro_siteC_Aboriginalspp_wetlandfunction_Oct2017.xlsx', or in Appendix I. Additional species may be added following further consultation with Aboriginal groups.

Table 4. Flora species at risk considered threatened or vulnerable by the BC CDC (2016a-k). Wetland indicator status for the Western Mountains, Valleys, and Coast zone, unless otherwise noted (USDA 2014; Anderson 2006).

Common Name	Scientific Name	Provincial List (Red or Blue; 2016)[1]	Wetland Status[2]
Hudson Bay Sedge	*Carax heleonastes*	Blue	OBL (Alaska)
Iowa Golden-saxifrage	*Chrysosplenium iowense*	Red	OBL (Midwest)
Hall's Willowherb	*Epilobium halleanum*	Blue	FACW
Slender Mannagrass	*Glyceria pulchella*	Blue	OBL (Alaska)
White Adder's-mouth Orchid	*Malaxis brachypoda*	Blue	FACW (Alaska)
Small-flowered Lousewort	*Pedicularis parviflora* ssp. *parviflora*	Red	FACW (Alaska)
Meadow Willow	*Salix petiolaris*	Blue	OBL
Slender Wedgegrass	*Sphenopholis intermedia*	Blue	FAC
Ochroleucous Bladderwort	*Utricularia ochroleuca*	Blue	OBL
No common name given	*Herzogiella turfacea*	Red	N/A
Rocky Mountain Willowherb	*Epilobium saximontanum*	Red	FACW

[1] Provincial status (i.e., red- or blue-listed) is current, as of December 2016.
[2] Wetland indicator status taken from Anderson, 2006. OBL - Obligate Wetland, FACW - Facultative Wetland, FAC – Facultative wetland and non-wetland habitats.

Table 5. List of plant species important to Aboriginal land use and their wetland indicator status for the Western Mountains, Valleys, and Coast zone (USDA 2014, Anderson 2006). Yellow shading indicate a species with a strong association to wetlands, which were included in the Site C wetland habitat function assessment.

Common Name	**Scientific Name**	**Wetland Status**[1]
Labrador Tea	*Ledum groenlandicum*	OBL
Lingonberry	*Vaccinium vitis-idaea*	N/A
Dwarf Red Raspberry	*Rubus arcticus*	FAC
Cloudberry	*Rubus chamaemorus*	N/A
Highbush Cranberry	*Viburnum opulus* var. *americanum*	FACW
Prickly Rose	*Rosa acicularis*	FACU
Stinging Nettle	*Urtica dioica*	FAC
Red Raspberry	*Rubus idaeus*	FACU

[1] Wetland indicator status taken from Anderson, 2006. OBL - Obligate Wetland, FACW - Facultative Wetland, FAC – Facultative wetland and non-wetland habitats, FACU – Facultative Upland.

4.0 Component 3. Identification of Important Wetland Habitat Functions.

Wetland functions were selected based on the critical habitat requirements for each species assemblage and the indicator species chosen to represent them. A total of 12 wetland habitat functions were selected that are applicable to migratory birds, amphibians, bats, fauna species at risk, flora species at risk and species important to Aboriginal land use:

- Function 1 – Migratory Bird Nesting Habitat
- Function 2 – Migratory Bird Feeding Habitat
- Function 3 – Migratory Bird Brood-Rearing Habitat
- Function 4 – Migratory Bird Migration Habitat
- Function 5 – Amphibian Breeding Habitat
- Function 6 – Amphibian Feeding Habitat
- Function 7 – Amphibian Wintering Habitat
- Function 8 – Bat Feeding Habitat
- Function 9 – Bat Roosting Habitat
- Function 10 – Fauna Species at Risk Habitat
- Function 11 – Flora Species at Risk Habitat
- Function 12 – Species Important to Aboriginal Land Use

Functions provided by wetlands for migratory bird species were divided into four categories: Nesting, Feeding, Brood-rearing, and Migration. Wetland functions provided to amphibians included: Feeding, Breeding, and Wintering. The following functions for bat species are also provided by wetlands: Feeding and Roosting. The wetland function associated with fauna species at risk, flora species at risk and species important to Aboriginal land use consisted of a wetland type's ability to support these species.

A detailed review of available literature and the baseline conditions in the LAA was conducted to identify which existing wetland habitats within the project area facilitate each of these wetland functions. These sources are summarized in Appendices A and B. Species inventories were conducted during baseline surveys for the EIS; however, these inventories were never intended to evaluate wetland habitat use. Therefore, habitat type, including wetland habitat type, was rarely recorded with species observations. For many of the datasets, a thorough review as part of this report found that the sampling effort within wetland habitat types and the inability to confidently associate habitat type with observations makes them inadequate for this purpose (Appendix C). In addition, a statistical power analysis on the baseline datasets estimated the sampling effort per habitat type required to detect magnitude differences in species group-densities among wetland habitats (Appendix G). Results of the power analysis found that a tripling to quadrupling of sampling effort per survey would be needed to detect large differences among habitats (e.g., +/- 100% difference in baseline density). In addition, the number of wetlands required by wetland type needed to be sampled in order to inform the model was often not present in the Project footprint. Therefore, scientific literature was used as the primary source for assigning habitat use to indicator species and assemblages due to the shortage of raw data linked to specific wetland habitat types available from the region. Where possible, literature that was reflective of the species-habitat relationship in the region was selected. Existing baseline data were used, where possible, only to confirm indicator species habitat use. For example, in datasets (e.g., breeding bird point counts) where UTM coordinates were provided for a point count station, habitats were determined by overlaying UTM coordinates with mapped habitat data (Appendix C). In map polygons with more than one habitat, UTM coordinates given for a point count station may not represent the habitat a species was recorded in. Therefore, baseline data was used only when UTM coordinates could confidently associate a species observation with a particular habitat.

4.1 Function 1: Migratory Bird Nesting Habitat

Definition: The ability of wetlands to provide migratory bird nesting habitat is defined as their capacity to provide critical nesting features, such as proximity to the water's edge, moisture requirements at the nest site, and preferred vegetation species and vegetation structure. This wetland function considers nesting habitat selection at a species level, as well as generalized preference at an assemblage level for the diversity of bird assemblages that rely on wetland habitat types for nesting (e.g., waterfowl, songbirds and migratory bird species at risk).

Rationale: For migratory bird species, nesting habitat is considered to be one of the most important habitat functions in terms of long term persistence of a species. Without adequate nesting habitat to successfully raise offspring to adulthood, populations would quickly decline. Bellrose (1977) found that waterfowl densities and production generally increased as the number of wetlands increased. Marsh wetland types generally provide a higher habitat value for waterfowl species than other wetland types because of the nesting habitat they provide (Mackenzie & Moran 2004, Environment Canada 2013b). Wetlands also provide an important buffer or barrier to some land-based predators and reduce the risk of predation to nesting or young birds and many species have adapted to take advantage of this by nesting over water or on islands (Stewart 2014). Wetland obligate and wetland dependent species are particularly constrained to wetland habitat for nesting success. An estimated 38% of all waterfowl of Canada and the United States breed in the boreal forest of North America. In conjunction with adjacent and connected forest and riparian ecosystems, boreal wetlands provide nesting habitat for an estimated 26 million waterfowl comprising 35 species. Boreal wetlands also provide important shorebird habitat and up to 7 million shorebirds are estimated to breed within these wetlands (Cheskey et al. 2011). Because wetland birds are a diverse group of species, they also exhibit a high degree of variability in their nesting preferences, ranging from highly aquatic to terrestrial: (i) completely floating nests of buoyant vegetation (small grebes); (ii) in water but essentially resting on some substrate (some rails and ducks); (iii) above water and remote from shore (Least bitterns, herons); (iv) near shore but at wet-to-damp sites (some rails, American Bitterns, and ducks); (v) dry ground with varying degrees of short, herbaceous cover, at varying distances from, but associated with water (Common Yellowthroats, Sedge Wrens, some ducks); (vi) at bases of tall emergent vegetation, over land or water (sparrows, some New World blackbirds); (vii) mid-level in robust herbaceous vegetation or small trees that can support the weight of nest, eggs, and the incubating parent (New World blackbirds); (viii) at the top of sturdy vegetation such as trees or snags (ospreys, certain eagles, herons); (ix) tree holes created by woodpeckers (Bufflehead), larger tree cavities or crevices (Hooded Mergansers, Wood Ducks); and (x) cliff faces or solid soil banks (kingfishers; Weller 1999).

Relevant Site C EIS Datasets:

- 2006, 2008, 2011, & 2012 Breeding Bird Counts
- 2010 & 2012 Common Nighthawk Call Playback Surveys
- 2008, 2011, & 2012 Marsh Bird Call Playback Surveys
- 2010 Swallow Nest Counts
- 2011 & 2012 Swallow Point Counts

4.2 Function 2: Migratory Bird Feeding Habitat

Definition: The ability for wetlands to provide important feeding habitat for migratory birds is defined as the degree to which wetland habitat types provide suitable food sources and foraging habitat for wetland-dependent species. At a temporal scale, feeding habitat may overlap with other wetland functions associated with migratory birds (e.g., nesting habitat, migration habitat).

Rationale: Availability and timing of food resources utilized by wetland birds is critical so that energy can be directed towards functions, such as flight, migration, breeding, defense, etc. (Weller 1999). Wetlands are dynamic ecosystems and contain a unique assemblage of microhabitats and food resources that are products of the diversity of vegetation and animals they contain, which are themselves related to hydroperiods (i.e., duration of water in days, weeks, or months per year), timing of biological and environmental events (e.g., seasonal chronology), and water depths in different wetland types. Over time wetland birds have adapted to exploit every zone existing within wetland habitats (e.g., shoreline, above water, surface, water column, mudflat, basin substrate) and all of major foods they contain (e.g., seeds, plant material, invertebrates, fish, reptiles, amphibians, small mammals; Weller 1999, Stewart 2014). The standing water found in some wetland types (e.g., marshes) provides important breeding areas for invertebrates such as some caddisflies and midges, which are important food sources for many bird species (Environment Canada 2013b). Shorebird diets are composed largely of invertebrates, such as insect larvae, worms, crustaceans, and mollusks, existing within the mud and soils of wetlands (Cheskey et al. 2011). Food resources within wetlands can be diverse and vary temporally and spatially. Most birds are unique among vertebrates in their ability to use wetlands dispersed over hundreds or thousands of miles in their annual range (Weller 1999).

Relevant Site C EIS Datasets:

- None

4.3 Function 3: Migratory Bird Brood-Rearing Habitat

Definition: Migratory bird brood-rearing habitat is defined as wetlands that are able to support family groups during the brood-rearing period, which occurs once eggs have hatched and the family group has left the nest site. Brood-rearing is a wetland function that is only applicable to bird species with precocious young that develop the ability to travel with the female and abandon the nest site soon after the eggs hatch (e.g., waterfowl). The capacity of a wetland to provide brood-rearing habitat considers both the proportional use of a wetland type by a species in relation to other habitat types, as well as diversity of bird assemblages that rely on wetland habitat types (e.g., waterfowl, shorebirds).

Rationale: Brood-rearing habitats must contain a mixture of suitable food resources for the growth and development of young birds, and adequate vegetation cover, while young birds remain flightless and are vulnerable to predation. The food required by young and adult birds often differs; therefore, different habitats or microhabitats are required during this early stage, which separates it from *Function 2: Migratory Birds Feeding Habitat*. Young omnivores gradually shift from animal protein in early growth to more seeds and then foliage as they mature. Carnivores or piscivores show shifts more in size and species of prey (Weller 1999). Brood-rearing locations may be situated near nesting sites and occur in similar habitat, but females of some species may move hundreds of metres to kilometres to reach suitable nesting habitat. For example, mallards may move more than two kilometers to reach suitable habitat in entirely different wetland complexes (Baldassarre 2014).

Relevant Site C EIS Datasets:

- None

4.4 Function 4: Migratory Bird Migration Habitat

Definition: The functional capacity of wetlands to provide suitable migration habitat for bird species is defined as its ability to supply the appropriate food and cover resources during both the spring and fall migration periods. Assessment of this function takes into consideration both the functional importance of migration at a species level, as well as wetland habitat utilization for migration at an assemblage level (e.g., waterfowl, songbirds, etc.).

Rationale: Wetland habitats offer important stopover areas for waterfowl and other wetland birds for resting and to replenish energy reserves (Environment Canada 2013b, Stewart 2014). Birds linked to wetlands and riparian areas tend to migrate along large perennial streams and use marshes, wetlands, lakes, reservoirs, and other water bodies for stopover sites. Large lakes and wetlands in close proximity can support large groups of migrating waterfowl and shorebirds and provide safety from predators (Pocewicz et al. 2013). During the fall a total of 3.5 to 5 billion birds migrate south through the boreal region. Of the 7 million shorebirds estimated to breed in boreal forest wetlands, millions more also depend on them as stopover locations during migration (Cheskey et al. 2011). Wetland use by migratory birds also varies for spring and fall migrations. At northern latitudes, birds that are adapted to water environments are restricted to pools of run-off and ice-free wetlands and waterbodies during spring migration (Stewart 2014).

Relevant Site C EIS Datasets:

- 2012 Migratory Bird Encounter Surveys
- 2006, 2008, 2013, & 2014 Waterfowl Encounter Surveys

4.5 Function 5: Amphibian Breeding Habitat

Definition: The ability of wetlands to provide amphibian breeding habitat is defined as whether or not a wetland type contains the appropriate habitat features to support egg laying, tadpole development, and metamorphosis for amphibian species inhabiting the Peace River Region.

Rationale: Most amphibians require some sort of aquatic component to their habitat for breeding sites, egg laying, and habitat for larval development (Environment Canada 2013b, Meyer et al. 2003), although the specific hydrological requirements for each species varies (EPA 2002). Wetland classes are highly variable in terms of their hydrological conditions and therefore different amphibian species will inhabit different wetland classes. The aquatic larval stage of amphibians may last several days to many months (EPA 2003), and therefore the habitats required by breeding amphibians range from vernal wetlands or temporary pools to permanent ponds (EPA 2002). Wetland habitats used by amphibians for breeding may include marshes, swamps, bogs, and fens (EPA 2003).

Relevant Site C EIS Datasets:

- 2006 & 2008 Amphibian Auditory Surveys
- 2006, 2008, & 2012 Amphibian Pond Surveys

4.6 Function 6: Amphibian Feeding Habitat

Definition: The ability of wetland habitats to provide suitable foraging sites and prey species for amphibians throughout their active period. Feeding habitat exists in both the breeding and non-breeding periods but tends to be less specialized once breeding is complete.

Rationale: Wetlands provide a primary food source for many amphibian species, which includes prey such as insects, spiders, snails, worms, and small fish (EPA 2003). The importance of wetland habitats to amphibians for feeding varies considerably amongst species. Highly aquatic species, such as Columbia Spotted Frogs, feed primarily in or at the edge of the water in wetlands or waterbodies, but will occasionally forage in nearby meadows or damp woods during rainy periods. In comparison, Western Toads are less reliant on wetland habitats, using fields, forests, meadows, and shrubby thickets when foraging (B.C. Ministry of Forests 2014). However, because of moisture requirements even the most terrestrial amphibian species must seek out wetland habitats during prolonged dry periods (EPA 2003).

Relevant Site C EIS Datasets:

- None

4.7 Function 7: Amphibian Wintering Habitat

Definition: The ability for wetland habitats to contain appropriate over-wintering sites for amphibian species, including water depth, burrow requirements and structure.

Rationale: Typical wintering habitat includes waterbodies that do not freeze entirely to the bottom or burrows in the ground that maintain moisture and do not fall below a specific temperature range, although some frogs can tolerate freezing conditions. The importance of wetland habitat types is difficult to quantify as wintering habitat varies considerably amongst amphibian species. In the northern extent of their range, Columbia Spotted Frogs overwinter in the muddy bottoms of wetlands and waterbodies requiring highly-oxygenated water that does not freeze to the bottom (B.C. Ministry of Forests 2014). Other amphibian species (e.g., Western Toad, Wood Frog, Boreal Chorus Frog) hibernate on land in small mammal burrows, root masses, or beneath logs and leaf litter (B.C. Ministry of Forests 2014, Alaska Department of Fish and Game 2008). Conditions suitable for these other amphibian species may be present in wetland or terrestrial habitat types.

Relevant Site C EIS Datasets:

- None

4.8 Function 8: Bat Feeding Habitat

Definition: The capacity for wetland habitats to provide suitable foraging habitat for bat species. Suitable foraging habitat must contain concentrations of swarming insects and the appropriate vertical vegetation structure required by each individual species.

Rationale: Many bat species have frequently been observed feeding in wetlands and over water. Bat species at the northern extent of their range feed exclusively on insects and wetlands provide important breeding habitat for prey species, such as caddisflies and midges (Environment Canada 2013b, Maslonek 2009). Some bat species could also be considered wetland-dependent if the insect biomass produced by these wetlands in the late summer and early fall provides an essential portion of the pre-hibernation diet (Tiner 2005).

Relevant Site C EIS Datasets:

- 2005, 2006, 2008, 2009, & 2011 Bat Capture Surveys
- 2005, 2006, & 2008 Bat Detector Surveys

4.9 Function 9: Bat Roosting Habitat

Definition: The ability for wetlands to provide roosting habitat for bat species is defined as whether a habitat supports the necessary structural complexity required for bat roosting sites.

Rationale: Trees are important roost sites for many bat species (e.g., Big Brown Bat, Silver-haired Bat, Long-eared Myotis, Long-legged Myotis), which will occupy woodpecker holes, natural tree cavities and cracks, and areas beneath loose bark (Vohnof & Barclay 1996, OMNR 2000). Very little research has been conducted on the roosting potential of forested wetlands, but because they contain trees and are situated near important feeding areas, these wetland types are expected to provide suitable roosting habitat.

Relevant Site C EIS Datasets:

- 2006, 2008, & 2009 Bat Telemetry Studies

4.10 Function 10: Fauna Species at Risk Habitat

Definition: The likelihood that a wetland habitat demonstrates the appropriate conditions to support fauna species at risk.

Rationale: Of the fauna species at risk in the LAA whose populations have been identified as endangered, threatened or of special concern, habitat loss and modification is often listed as a threat to population decline. For example, the loss of wetlands has been noted to be a key threat to the Rusty Blackbird's breeding range (Environment Canada 2016c). Therefore, estimating a value for functional loss given the wetland habitat that is to be affected by construction in the LAA is important for determining whether the functional needs of fauna species at risk are met through mitigation.

Unlike functions for migratory birds, amphibians and bats, which were given multiple categories of use (e.g., breeding, feeding, etc.) within wetland habitats, fauna species at risk were considered as to their habitat use only (i.e., a single function). This is due to the fact that, for some fauna species at risk, limited information is available to make habitat associations at a functional level. For example, for the 'at risk' butterflies considered, insufficient information on feeding (i.e., larval) habitat and its associated plants was available to create a selectivity index for butterfly wetland function - feeding (Table 3; Hilton et al. 2013e). For fauna species at risk that were also considered as indicator species for other groups (e.g., Western Toad for amphibians; Common Nighthawk, Rusty Blackbird, Olive-sided Flycatcher, Nelson's Sparrow and Yellow Rail for migratory birds; Northern Myotis and Little Brown Myotis for bats), an average functional use was considered across all functions evaluated (e.g., for Western Toad, an average was taken across the indicator values for amphibian breeding, feeding and hibernation habitat). For those species that were considered as indicators only as part of the fauna species at risk group, species models completed in the EIS were used to make species-habitat associations where available (i.e., seven butterflies, one dragonfly and one owl). A literature review, the results of which were compared to baseline studies in the LAA, was conducted for remaining species (i.e., Surf Scoter, Barn Swallow).

Relevant Site C EIS Datasets:

- 2006, 2008, 2011, & 2012 Breeding Bird Counts
- 2010 & 2012 Common Nighthawk Call Playback Surveys
- 2008, 2011, & 2012 Marsh Bird Call Playback Surveys
- 2010 Swallow Nest Counts
- 2011 & 2012 Swallow Point Counts
- 2012 Migratory Bird Encounter Surveys
- 2006, 2008, 2013, & 2014 Waterfowl Encounter Surveys
- 2006 & 2008 Amphibian Auditory Surveys
- 2006, 2008, & 2012 Amphibian Pond Surveys
- 2005, 2006, 2008, 2009, & 2011 Bat Capture Surveys
- 2005, 2006, & 2008 Bat Detector Surveys
- 2006, 2008, & 2009 Bat Telemetry Studies

4.11 Function 11: Flora Species at Risk Habitat

Definition: Defined as the likelihood that a wetland habitat demonstrates the appropriate conditions to support the presence of a flora species at risk, this function takes into consideration both the primary and secondary habitat associations of flora species at risk recorded within the LAA.

Rationale: Unlike migratory birds, which have multiple categories of use (e.g., breeding, feeding, etc.) within wetland habitats, flora species at risk are either present or absent. Flora species at risk are particularly vulnerable because many are habitat specialists, adapting to their unique wetland environments over long periods of time (Haeussler 1998). These rare species are of importance because further loss of known occurrences may have impacts on their overall persistence. Wetland habitats also exhibit many unique conditions related to their hydrology and soils, which translates to numerous plant species that are specialists to these areas. Some wetland habitats such as fens support a wide variety of rare or unique plant species. Of 320 vascular plant species found within fens in Iowa, 44% were considered rare (Meyer et al. 2003). In the Manitoba boreal region, Locky and Bayley (2006) also found that a high diversity and rarity of plants occurred in some peatland types (e.g., wooded moderate-rich fens, Black Spruce swamps, and open moderate-rich fens), which would suggest they are important from a rare plant and conservation perspective.

For each of the 11 flora species at risk associated with wetland habitats (Table 6, Table 7), scientific literature was compiled to collect information on their growth characteristics, distribution and habitat in other similar regions to the LAA (see Appendix A). This information was used to confirm two methods that were selected to explore LAA flora species at risk associated with wetland habitats, and assess the flora species at risk use function across wetland habitat types: primary habitat associations and secondary habitat associations.

- **Primary habitat associations:** Primary habitat associations for flora species at risk consist of direct observations from the baseline survey data of flora species at risk in wetland habitat types (Table 6). This included both raw data from baseline inventories conducted within the LAA, as well as descriptions in the EIS (Hilton et al. 2013a; Bjork et al. 2009). In total, 8 of the 11 species have been directly linked to a wetland habitat type located in the LAA. The remaining 3 of the 11 species were either not linked to wetland habitat types found in the LAA (i.e., Meadow Willow), or were found as part of earlier studies in the Peace River Region (i.e., Slender Mannagrass, Rocky Mountain Willowherb).
- **Secondary habitat associations:** The primary habitat associations from the baseline data may not completely describe the extent of the rare species wetland habitat associations; therefore, secondary habitat associations were considered (e.g., a flora species at risk located in the LAA only in a fen may also use a marsh habitat) to fully evaluate the importance of wetland function for these species. This method considered the associated species found with flora species at risk during the baseline vegetation surveys in the LAA (Table 7), and evaluated the wetland habitat used by these associated species. For each associated species, their importance as an indicator of a particular wetland habitat type was considered (e.g., uncommon to dominant, in terms of presence in a wetland type), according to the Wetlands of British Columbia: A Guide to Identification (MacKenzie and Moran 2004; see 'Species Importance Tables' in MacKenzie and Moran 2004 and Excel file 'NPS_bchydro_siteC_floraspp_wetlandfunction_Oct2017.xlsx'). The importance of each associated species as an indicator ranged from infrequent (i.e., occurred sporadically within sites surveyed, usually <30% of plots surveyed) to dominant (i.e., occurred on all sites surveyed, at >25% cover and being the most abundant species surveyed). Data used to create these species-wetland habitat associations comes from approximately 2,600 survey plots conducted throughout British Columbia, collected as part of classification programs, mapping projects and theses (MacKenzie and Moran 2004). Caution was taken when interpreting the associated species that occurred with flora species at risk as an indication of a habitat type.

Associated species were not considered if they were generalists, invasive, not indicated in baseline observations (i.e., genus only given), or not described in MacKenzie and Moran (2004). This information was then used in the ranking process. The likelihood of an associated species to occur in a particular wetland habitat (from 0-100%; MacKenzie and Moran 2004) was weighted by the number of times the associated plant occurred with a rare plant in the field. This produced a secondary habitat association value, or an estimate of the likelihood that a rare plant will occur in a wetland type, based on its associated species (see Step a in Section 5.3 - Flora ranking protocol for a step-by-step example of how secondary habitat values are calculated). For the Iowa Golden-Saxifrage, its associated species were either generalists or invasive; therefore, no secondary habitat association was calculated. For Slender Mannagrass and Rocky Mountain Willowherb, because they were found as part of earlier studies in the Peace River Region, survey methods differed and no associated species were recorded.

Note that although insufficient information is available at this time for primary or secondary habitat ranks to be calculated for Slender Mannagrass and Rocky Mountain Willowherb, they have been left as placeholders in the model should habitat information be recorded during future surveys.

Relevant Site C EIS Datasets:

- 2005, 2006, 2008, 2011, & 2012 Rare Plant Surveys

Table 6. Primary habitat associations for flora species at risk occurrences in the EIS.

Flora Species at Risk Detected	**Primary Habitat Associations**[1]
Ochroleucous Bladderwort	SE
Hudson Bay Sedge, Hall's Willowherb, *Herzogiella turfacea,* White Adder's-mouth Orchid	TS
Slender wedgegrass	WH
White Adder's-mouth Orchid, Small-flowered Lousewort	BT
Iowa Golden-saxifrage	Tufa Seep

[1] Rare plant occurrences in habitat types taken from Hilton et al. 2013a; Bjork et al. 2009; Data from Rare Plant Surveys 2008, Data from Rare vascular plant 2005, 2006, 2008, 2011, 2012 (SE=Sedge wetland, TS=Tamarack-Sedge - Fen, WH=Willow – Horsetail – Sedge – Riparian wetland, WS = Willow – Sedge – wetland, BT = Black Spruce – Labrador Tea – Sphagnum).

Table 7. Associated species used to determine secondary habitat associations for flora species at risk.

Flora Species at Risk	**Associated Species**[1]
Hudson Bay Sedge	Tamarack, Labrador Tea, Black Spruce, Golden Fuzzy Fen Moss
Iowa Golden-saxifrage	N/A
Hall's Willowherb	Tamarack, Labrador Tea, Black Spruce, Prickly Rose, Drummond's Willow, Golden Fuzzy Fen Moss
Slender Mannagrass	No data
White Adder's-mouth Orchid	Glow Moss, Black Spruce, Balsam Poplar, Bilberry Willow, Golden Fuzzy Fen Moss
Small-flowered Lousewort	Crowberry, Tamarack, Labrador Tea, Black Spruce, Lingonberry
Meadow Willow	Drummond's Willow, Pacific Willow
Slender Wedgegrass	Bluejoint Reedgrass, Water Sedge, Awned Sedge, Nightshade, Tufted Hairgrass, Common Horsetail, Broadleaf Cattail, Stinging Nettle
Rocky Mountain Willowherb	No data
Ochroleucous Bladderwort	Awned Sedge, Beaked Sedge, Swamp Horsetail, Hemlock Water Parsnip, Bluejoint Reedgrass
Herzogiella turfacea	Bilberry Willow, Labrador Tea, Soft Leaved Sedge, Yellow Star-moss

[1] Associated species for flora species at risk, as indicators of a wetland habitat type in the LAA taken from Hilton et al. 2013a; rare vascular plant surveyes 2005, 2006, 2008, 2011, 2012 ; MacKenzie & Moran 2004. Associated species with flora species at risk were not considered if they were generalists (i.e., as for Iowa Golden-Saxifrage), invasive, if the level of genus was indicated only for associated species during baseline surveys, or if the species was not described in MacKenzie and Moran (2004) as an indicator of wetland habitat type. Note that Slender Mannagrass and Rocky Mountain Willowherb were recorded during surveys outside of the baseline studies, where associated species were not noted.

4.12 Function 12: Habitat for Species Important to Aboriginal Land Use

Definition: The ability of wetland habitat types to support plant and wildlife species that have a high traditional value to Aboriginal people, including sustenance and medicinal value.

Rationale: Wetland associated species identified as being used for traditional purposes by Aboriginal Groups in TLUS studies completed for the Project (See EIS Volume 2, Sections 13 and 14; BC Hydro 2013a). Loss of wetland habitat could affect the distribution of the species on the landscape and alter continued use by Aboriginal Groups.

Relevant Site C EIS Datasets:

- 2010, 2011, & 2012 Ungulate Radio-collar Data
- EIS, Volume 2, Sections 13 and 14

5.0 Determining Total Functional Loss Given Habitat Affected: Wetland Function Assessment Model Structure and Assumptions.

An evaluation process has been developed by Native Plant Solutions that considers the three components described above (i.e., indicator species, wetland habitat functions, and wetland type; see Figure 1) to quantify functional loss expected to occur within wetland habitat given the impacts linked with construction activities associated with the Site C project. Key components of the ranking process outlined below are:

- Indicator values: These values represent the use of each habitat by an indicator species (or assemblage) for a wetland function. For the most part, scientific literature was used as the primary source for assigning habitat use to indicator species and assemblages due to the shortage of raw data linked to specific wetland habitat types available from the region (see Section 4.0).
- Standardization: Standardization occurs at step b) in the ranking process (i.e., for both fauna and flora), so that calculated values remain comparable across all wetland functions examined (e.g., migratory bird feeding and bat roosting habitat).
- Total relative preference: Calculated within each function, this value summarizes the total habitat usage for all species or assemblages expected to occur within each wetland type, assuming all habitats are equally available on the landscape.
- Proportional Wetland Type Preference: Also known as the standardized habitat selection index (Manly et al. 2002), this is the relative expected use of each wetland type, if all were equally available on the landscape, standardized to allow for comparison across wetland functions.
- Total Functional Loss Given Habitat Affected: The function lost, per wetland type, for indicator species/assemblages, is a product of the Proportional Wetland Type Preference and the area to be affected by construction.
- Total Functional Gain Given Habitat Restored: The functional gain, per wetland type, for indicator species/assemblages. This value is a product of the Proportional Wetland Type Preference by the area to be restored, per wetland type. Using mitigation site area, the Total Gain Given Habitat Restored must meet Total Loss Given Habitat Affected, to address the loss of wetland area and function.

This ranking process can also be used in the future to quantify additional functional losses associated with indirect effects to wetlands along the transmission line documented during operations. Although the evaluation process is similar for each species group considered (i.e., migratory birds, amphibians, bats, fauna species at risk, flora species at risk and species important to Aboriginal land use), there are slight differences between methods for fauna and flora. A step by step process for calculating Total Functional Loss Given Habitat Affected is considered below, along with examples, for fauna and flora separately. For each example, a series of screenshots from the Excel files are presented (see Appendix D and Appendix E), in order to aid the reader in following along with the examples, in addition to a flow chart (Figure 4). It is recommended that the reader print the screenshots, flow chart and definitions given above, for reference while reading the examples, to allow for ease of comprehension. Note that the 'habitat values' calculated, as a measure of wetland function, have no units and are relative values for comparison purposes only.

5.1 Model Assumptions

In the case of the ranking process for fauna species, a number of assumptions are made to obtain an overall wetland habitat value:

1. The ranking process assumes that habitats where indicator species are found are equally preferred. For example, for nesting dabbling ducks, the process assumes that they would equally use WS, WH, SE, Wf02 or Wf13.
2. The ranking process assumes that species assemblages are equally valuable, in terms of mitigation for loss. For example, dabbling ducks are equally as valuable as cavity nesters.
3. Relative usages of wetland habitats do not change, regardless of the amount of habitat in the LAA, area affected, or area restored. For example, given equal habitat availability, migratory nesting birds would use SE at a rate three times the use of Wf02 (0.39 vs. 0.13) whether the area under consideration is 100ha or 1000ha.
4. Habitat quality and fragmentation of individual patches does not significantly impact usage rates.

For the above ranking process for flora species, similar assumptions are made to obtain an overall habitat value:

1. For primary habitat ranking, the ranking process assumes that habitats with a flora species at risk have an equal probability of having that plant present. For example, for Small-flowered Lousewort, the process assumes it equally prefers TS and BT.
2. The ranking process assumes that flora species at risk are equally valuable in terms of what is to be mitigated for wetland loss. For example, Hudson Bay Sedge is equally as valuable as Hall's Willowherb.
3. For primary habitat ranking, the ranking process assumes that equal sampling effort was conducted across all wetland habitat types during baseline rare plant species surveys.

While acknowledging the limitations associated with model assumptions, its ability to provide information on wetland function at a species-specific level across a variety of wetland types makes it a useful tool for estimating wetland area and functional loss supporting migratory birds, species at risk and species important to Aboriginal land use. In order to test the uncertainty in the model based on the assumptions made, a sensitivity analysis was completed (see Section 5.4 - Sensitivity Analysis).

5.2 Fauna Ranking Protocol for Wetland Habitat Value: Migratory Birds, Amphibians, Bats, Fauna Species at Risk and Species Important to Aboriginal Land Use

Refer to Excel file 'NPS_bchydro_siteC_faunaspp_wetlandfunction_Oct2017.xlsx' or Appendix I as a companion document to the step-by-step ranking protocol below. Screenshots from this spreadsheet are given in Appendix D, to aid the reader in following the examples provided. The flow chart in Figure 4 outlines the steps in the fauna ranking protocol. The Excel file also contains comments to demonstrate each step.

a) *Summarize the number of wetland habitat functions each wetland type provides to indicator species:* This step compiles the indicator species selected, their use of wetland habitats (see 'Species Habitat Use' tab in Excel file) and the existing wetland habitat functions that habitats provide (e.g., nesting, brood-rearing, feeding, etc.) for each assemblage (e.g., dabbling ducks). See 'Functional Loss per Habitat' tab in Excel file, which provides a summary of the wetland functions important to each species assemblage in each wetland type. By first organizing the applicable information, it can then be incorporated into the evaluation process.

For example: (see screenshot 1 & 2 in Appendix D) Dabbling ducks (represented by American Wigeon and Green-winged Teal as indicator species) may use wetland types WS, WH, SE, Wf02 and Wf13 for nesting.

b) *Standardize the indicator values for each species assemblage:* Some species use multiple wetland habitat types for one category of use, whereas other species are restricted to one habitat type. To consider the difference between species that are specialists, versus generalists, the use of each habitat by an indicator species (or assemblage) is referred to as its indicator value and is standardized to 1. This is considered for each wetland habitat function (refer to Section 4.0 for full list of wetland habitat functions).

For example (see 'Migratory Birds Nesting' tab in Excel file and screenshot 3 in Appendix D)**:** Dabbling ducks may use five different wetland habitat types for nesting; therefore, each wetland habitat gets an indicator value of 0.2 (1/5). On the other hand, swans and geese may only use one wetland habitat in the area for nesting; therefore, this wetland habitat gets an indicator value of 1 (1/1).

c) *Summarize indicator values for each wetland type, to calculate Total Relative Preference:* For each wetland habitat function, the indicator values for each species assemblage within a particular wetland type (e.g., SE, TS) are summed to calculate Total Relative Preference. This value summarizes habitat usage expected to occur within each wetland type assuming that all habitats are equally available within the landscape.

For example (see 'Migratory Birds Nesting' tab in Excel file and screenshot 4 in Appendix D)**:** The Total Relative Preference for Migratory Bird Nesting Habitat in wetland type WS is 1.3, this is a sum of the indicator values for dabbling ducks, forest-nesting shorebirds, deciduous songbirds, coniferous songbirds and aerial insectivores.

d) *Standardize total relative preference across all wetland habitat types:* This standardization is the final step for developing a standardized habitat selection index and is used to quantify habitat use over multiple habitat types. The Proportional Wetland Type Preference represents the relative expected use of each wetland type if all types are equally available on the landscape. Total Relative Preference is standardized so that selectivity indices remain comparable amongst all wetland habitat functions examined.

For example (see 'Migratory Birds Nesting' tab in Excel file and screenshot 5 in Appendix D): The Proportional Wetland Type- Preference for Migratory Bird Nesting Habitat in wetland type WS is 0.11. This is the Total Relative Preference for WS (1.3) divided by the sum of the Total Relative Preference values for each wetland type (12).

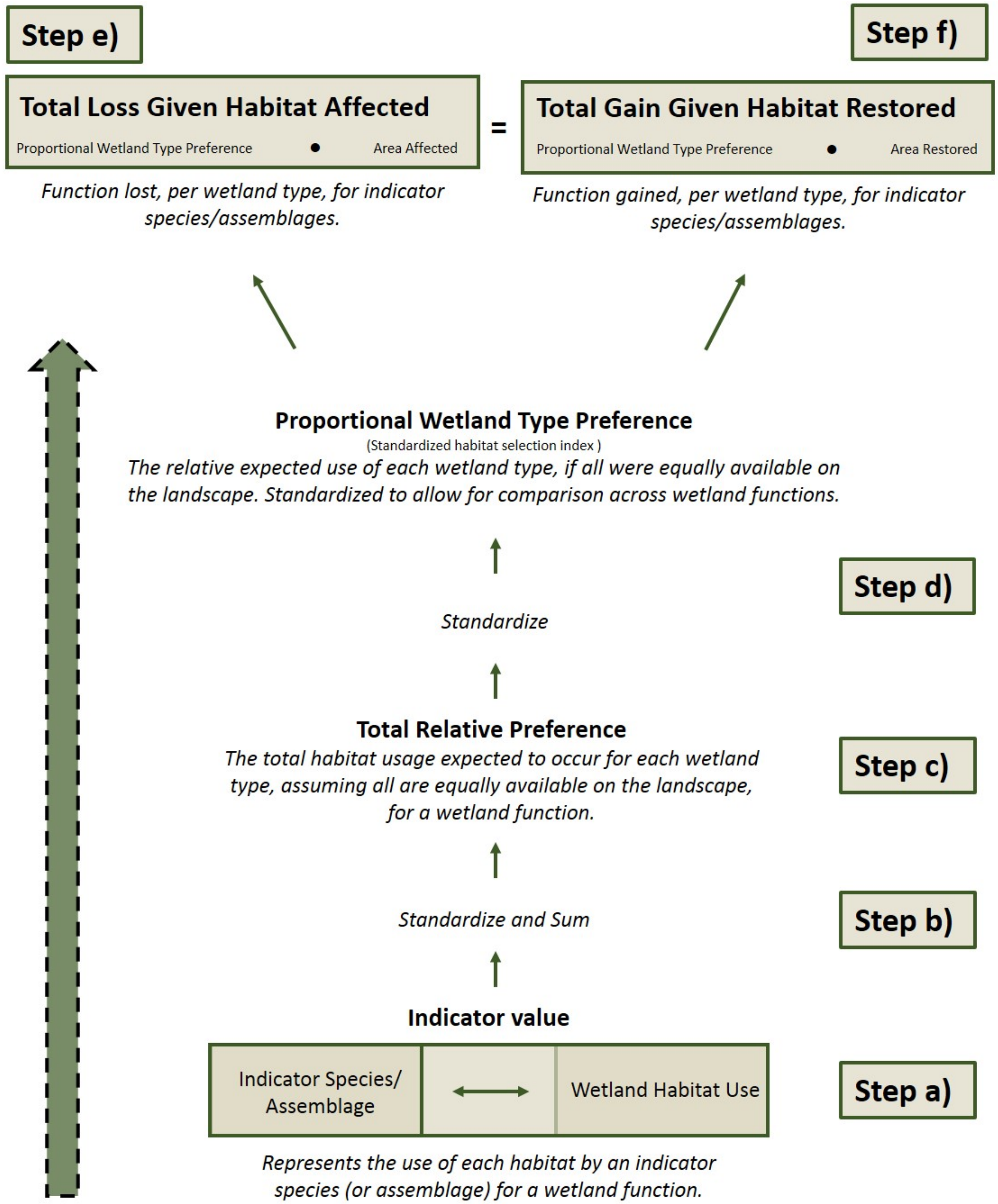
e) *Calculate Total Functional Loss Given Habitat Affected:* This is the product of value of services (i.e., Proportional Wetland Type Preference) and area affected (i.e., Construction), which are the two primary components of a Habitat Equivalency Analysis. Total Loss values are summed across each wetland type and this directly relates to Total Gain Given Habitat Restored (see step f). The overall goal is to achieve a balance between the two (i.e., Total Loss values = Total Gain values).

For example (see 'Migratory Birds Nesting' tab in Excel file and screenshot 6 in Appendix D)**:** WS has a Proportional Wetland Type Preference of 0.11 for migratory bird nesting habitat, and a total of 50ha of WS will be affected by construction activities. This leads to a Total Loss Given Habitat Affected of 5.42 for migratory bird nesting habitat in WS.

f) *Calculate Total Functional Gain Given Habitat Restored:* Wetland function is applied to Total Gain Given Habitat Restored using the same principles for calculating Total Loss. Total Gain is calculated by multiplying amount and type of wetland habitat being restored by value of services. Total Gain values are summed across each wetland type and this directly relates to Total Loss Given Habitat Affected (see step e). The overall goal is to achieve a balance between the two (i.e., Total Loss values = Total Gain values).

Hypothetical example (see screenshot 7): If 100ha of WS wetlands were restored, this is multiplied by the Proportional Wetland Type Preference to calculate a Total Gain Given Habitat Restored value of 10.83 for WS. If 100ha of WS, 100ha of SE and 100ha of BT were restored to compensate for habitat lost during construction you are nearly half way to meeting your mitigation goals for migratory bird nesting habitat (i.e., Total Gain Given Habitat Restored = 56.39, which is approximately half of Total Loss Given Habitat Affected = 114.98).

Figure 4. Flow chart outlining the step-by-step fauna ranking protocol. Refer to Excel file 'NPS_bchydro_siteC_faunaspp_wetlandfunction_Oct2017.xlsx', Appendix I (Functional Loss Ranking Tables) and the provided screenshots (Appendix D) as companion documents.



5.3 Flora Ranking Protocol for Wetland Habitat Value: Flora Species at Risk

Refer to Excel file 'NPS_bchydro_siteC_floraspp_wetlandfunction_Oct2017.xlsx', or Appendix I, as a companion document to the step-by-step function assessment protocol below. Screenshots from this spreadsheet are given in Appendix E, to aid the reader in following the examples provided. The Excel file also contains comments to demonstrate each step.

a) *Summarize the wetland type associations with flora species at risk by both primary and secondary habitat associations:* Flora species at risk are associated with wetland habitat types based on their presence or absence in a wetland type. Their associations with wetland types were considered based on recorded observations in the LAA (i.e., primary habitat associations), or based on associated species they were observed with in the field (i.e., secondary habitat associations; see description of how secondary habitat associations were calculated from Section 4.11 - Function 11: Flora Species at Risk Habitat). Habitat values are first ranked based on primary or secondary wetland habitat associations with particular wetland types. In the case of secondary habitat associations, wetland classification according to MacKenzie and Moran (2004) is then averaged where there may be more than one descriptor for a wetland type in the LAA (e.g., Fl01, Fl03 and Fl05 secondary habitat associations are averaged, to provide a value for WH).

   For example (for primary habitat associations; see 'Species associated habitats' tab and 'Primary habitat use' tab in Excel file and screenshot 8 in Appendix E): Hudson Bay Sedge was observed in TS, during baseline rare plant surveys in the LAA.

   For example (for secondary habitat associations; see 'Species associated habitats' tab and 'Secondary habitat use' tab in Excel file and screenshots 9-11 in Appendix E): Slender Wedgegrass was observed three times in the LAA. Eight plant species were observed with Slender Wedgegrass and were selected as associated species to help better indicate what their wetland habitat preference is in the LAA. The percent occurrence of the associated species with the rare plant in the field was multiplied by the likelihood of the associated species to occur in a certain wetland type (according to MacKenzie and Moran 2004).

   - For example (screenshot 9, Appendix E), Bluejoint Reedgrass occurred with Slender Wedgegrass in 1 out of 3 observations in the field (1/3 = 33%) and has an 80% chance of occurring within Fl05, a WH wetland habitat (MacKenzie and Moran 2004). Therefore the likelihood that Slender Wedgegrass would occur adjacent to Bluejoint Reedgrass in a WH wetland habitat is 0.33*0.80 = 0.26. These values are averaged across all associated species with Slender Wedgegrass to provide a secondary habitat use value for Fl05 (e.g., for Slender Wedgegrass, three of the eight associated species were indicators of Fl05, and these values were averaged to provide a secondary habitat value for Fl05 of 0.04 [0.26 + 0.05 + 0.05/8=0.05]; see 'Species Associated Habitats' tab in Excel file).
   - Screenshot 10 & 11, Appendix E: Wetland classification according to MacKenzie and Moran (2004) is then averaged where there may be more than one descriptor for a wetland type in the LAA. For example, Fl01, Fl03 and Fl05 secondary habitat associations are averaged ([0.02+0.01+0.05]/3, to provide an indicator value for WH for Slender Wedgegrass = 0.03). Note that this calculation is hidden in the Excel file (see 'Species Associated Habitats' tab and 'Secondary habitat use' tab in Excel file).

b) *Standardize the indicator values for each rare species:* Some species use multiple wetland habitat types, whereas other species are restricted to one habitat type. To consider the difference between species that are specialists, versus generalists, the importance of each habitat to a flora species at risk is referred to as an indicator value and is standardized to 1. The same process applies to the calculation of wetland functional loss using both primary habitat and secondary habitat associations.

For example (for primary habitat associations; see 'Primary habitat use' tab and 'Primary habitat rank' tab in Excel file and screenshots 12 & 13 in Appendix E)**:** based on primary habitat data collected in the LAA, Small-flowered Lousewort was found in TS and BT (screenshot 12); therefore each habitat gets an indicator value of 0.5 (1/2; screenshot 13).

For example (for secondary habitat associations; see 'Secondary habitat use' tab and 'Secondary habitat rank' tab in Excel file and screenshots 14 & 15 in Appendix E)**:** Based on secondary habitat data, Small-flowered Lousewort was associated with TS and BT, with a total secondary indicator value of 0.6183 (screenshot 14). Therefore, to standardize to 1, TS as an example, gets a standardized indicator value of 0.1833/0.6183 = 0.2965 (see screenshots 14 & 15).

c) *Summarize indicator values for each wetland type, to calculate Total Relative Preference:* The indicator values for each rare species occurring within a particular wetland type (e.g., SE, TS) are summed to calculate Total Relative Preference. This value summarizes habitat preference for flora species at risk, assuming that all habitats are equally available within the landscape. The same process applies to the calculation of wetland functional loss using both primary habitat and secondary habitat associations.

For example (see 'Primary habitat rank' tab in Excel file and screenshot 16 in Appendix E)**:** the total relative preference for TS is 3.5, which is the sum of indicator values for Hudson Bay Sedge, Hall's Willowherb, Small-flowered Lousewort and *Herzogiella turfacea*.

d) *Standardize Total Relative Preference across all wetland types:* This standardization is the final step for developing a standardized habitat selection index (i.e., Proportional Wetland Type Preference) and is used to quantify rare species occurrence over multiple habitat types. Proportional Wetland Type Preference represents the relative expected occurrence of flora species at risk within each wetland type if all types are equally available in the landscape. Total Relative Preference is standardized so that selectivity indices remain comparable amongst all wetland habitat functions examined. The same process applies to the calculation of wetland functional loss using both primary habitat and secondary habitat associations.

For example (see 'Primary habitat rank' tab in Excel file and screenshot 17 in Appendix E)**:** The Proportional Wetland Type Preference for rare plant primary habitat associations in wetland type TS is 0.438. This is the Total Relative Preference for TS (3.5) divided by the sum of the Total Relative Preference values for each wetland type (7). This means that if habitats were equally available on the landscape, 50% of rare plant primary habitat associations are predicted to occur in TS wetlands (does not include upland habitats).

e) *Average Primary and Secondary Proportional Wetland Type Preference:* Although wetland habitat value for flora species at risk can be explored based on primary habitat associations (i.e., based on field observations) or secondary habitat associations (i.e., based on associated species), Average Proportional Wetland Type Preference is calculated to summarize rare plant occurrence within the LAA, as both provide a representation of the same function – presence.

For example (see 'Summary habitat rank' tab in Excel file and screenshots 18 in Appendix E)**:** For flora species at risk, the Primary Proportional Wetland Type Preference for TS is 0.5 and the

Secondary Proportional Wetland Type Preference is 0.23. These two values are averaged to obtain the Average Proportional Wetland Type Preference, which is 0.36 for TS ([0.5 + 0.23]/2 = 0.36).

f) *Calculate Total Functional Loss Given Habitat Affected:* This is the product of value of services (i.e., Proportional Wetland Type Preference) and area affected (i.e., Construction), which are the two primary components of a Habitat Equivalency Analysis. Total Loss values are summed across each wetland type and this directly relates to Total Gain Given Habitat Restored (see step g). The overall goal is to achieve a balance between the two (i.e., Total Loss values = Total Gain values)

   For example (see 'Summary habitat rank' tab in Excel file and screenshot 19 in Appendix E)**:** TS has an Average Proportional Wetland Type Preference of 0.36, and a total area of 68ha of area to be affected by construction. This leads to a Total Loss Given Habitat Affected – Construction value for TS of approximately 24.75 for flora species at risk.

g) *Calculate Total Functional Gain Given Habitat Restored:* Wetland function is applied to Total Gain Given Habitat Restored using the same principles for calculating Total Loss. Total Gain is calculated by multiplying amount and type of wetland habitat being restored by value of services. Total Gain values are summed across each wetland type and this directly relates to Total Loss Given Habitat Affected (see step f). The overall goal is to achieve a balance between the two (i.e., Total Loss values = Total Gain values)

   Hypothetical example (see screenshot 20): If 100ha of TS wetlands are restored, this is multiplied by the Average Proportional Wetland Type Preference to calculate a Total Gain Given Habitat Restored value of 36.40 for TS. If 100ha of SE, 100ha of TS and 50ha of BT are restored to compensate for habitat lost during construction you are approximately half way to meeting your mitigation goals for rare plant habitat (i.e., Total Gain Given Habitat Restored = 59.24, which is approximately half of Total Loss Given Habitat Affected = 123.28).

5.4 Sensitivity Analysis

A sensitivity analysis is conducted to estimate the impacts of changes to model assumptions and model output (Pannell 1997). Statistical simulations were used to examine the sensitivity of calculated losses to changes in the preferences for habitats where indicator species are found. In the absence of good quality estimates of species usages or densities across habitats of interest, initial estimates considered habitats to be equally preferred by indicator species (i.e., model assumption #1 for both fauna and flora). For example, for nesting dabbling ducks, it was initially assumed that they would equally use WS, WH, SE, Wf02, and Wf13 where they are equally available.

The following process was used to 'perturb' the preference for one habitat at a time and then re-allocate preference equally among the remaining habitats. Perturbations of +/-20% and +/-50% were used on habitat preferences. If no habitats or only one was used, no perturbation was conducted.

Step 1: At a function and species or species-group level, randomly select one of the 'k' used habitats.

   For example (see 'Migratory Birds Nesting' tab in Excel file NPS_bchydro_siteC_faunaspp_wetlandfunction_Oct2017.xlsx or Table I1 in Appendix I): for nesting dabbling ducks, randomly select one of WS, WH, SE, Wf02, and Wf13.

Step 2: Perturb preference for the selected habitat by adding or subtracting a fixed percentage.

For example (see 'Migratory Birds Nesting' tab in Excel file NPS_bchydro_siteC_faunaspp_wetlandfunction_Oct2017.xlsx or Table I1 in Appendix I): Say we selected WH in step 1. If its preference is perturbed by increasing it by 20%, then preference for WH becomes = 1.2*(1/5) = 0.24. Preference for each of the remaining habitats (WS, WH, SE, Wf02, and Wf13) becomes = (1 – 0.24) / 4 = 0.19.

Step 3: For each species or assemblage, repeat steps 1 and 2.

For example (see 'Migratory Birds Nesting' tab in Excel file NPS_bchydro_siteC_faunaspp_wetlandfunction_Oct2017.xlsx or Table I1 in Appendix I): Perturb preference of one habitat for each of Diving Ducks, Cavity-Nesting Ducks, Swans & Geese, Waterbirds, Terns & Gulls, Forest-nesting Shorebirds, Marsh-nesting Shorebirds, Rails, Open Habitat Songbirds, Deciduous Songbirds, Coniferous Songbirds, Aerial Insectivores.

Step 4: Proceed to calculate total loss by habitat and across habitats for each species-group and function.

For example (see 'Migratory Birds Nesting' tab in Excel file NPS_bchydro_siteC_faunaspp_wetlandfunction_Oct2017.xlsx or Table I1 in Appendix I): For nesting dabbling ducks, compute loss attributed to each of the habitats (OW, WS, WH, SE, TS, Wf02, Wf13, BT). Sum across habitats to calculate total loss for nesting dabbling ducks.

Step 5: Repeat steps 1 to 4 1000 times.

For example (see 'Migratory Birds Nesting' tab in Excel file NPS_bchydro_siteC_faunaspp_wetlandfunction_Oct2017.xlsx or Table I1 in Appendix I): There will then be 1000 estimates of habitat-specific and total losses for nesting dabbling ducks as preference for a habitat is perturbed by 20%.

Step 6: Compute 2.5th and 97.5th percentiles of the 1000 estimates to obtain a probable range of total loss values, given up to x% change in habitat preference.

For example (see 'Migratory Birds Nesting' tab in Excel file NPS_bchydro_siteC_faunaspp_wetlandfunction_Oct2017.xlsx or Table I1 in Appendix I): For migratory bird nesting habitat, we estimated a loss value of 42.47 in WH habitat. If a preference is varied by up to 20%, we would expect loss for WH to fall somewhere in the range of (36.91, 48.02). Totalled across all wetland habitats, we would estimate a total loss of 114.98. If a preference is varied by up to 20%, we would expect total loss across all wetland habitats to fall somewhere in the range of (109.58, 120.14).

For flora, preferences for primary habitat rankings were perturbed as described above. For secondary habitat rankings, preference for a single habitat was perturbed and then all habitat preferences were rescaled to add to one, as secondary habitat rankings were based on secondary habitat data and did not assume equal use of a habitat across all wetland types for a particular species. Preference for any particular habitat was restricted to a maximum of 1. Range of total losses by habitat and across habitat were calculated for each of the primary and secondary habitat rankings. Primary and secondary losses were averaged to obtain a single summary estimated loss range for each habitat and totalled across habitats.

For example (see 'Secondary habitat rank' tab in Excel file NPS_bchydro_siteC_floraspp_wetlandfunction_Oct2017.xlsx or Table I13 in Appendix I): Say we selected TS to perturb for preference of Hudson Bay Sedge. If its preference is perturbed by increasing it by 20%, then raw preference for TS becomes = 1.2*(0.4068768) = 0.48825216. Rescaling so that all relative habitat preferences sum to 1, we obtain TS preference = 0.48825216 / (0.48825216 + 0.051576 + 0.5415473) = 0.4515; Wf13 preference = 0.051576 / (0.48825216 + 0.051576 + 0.5415473) = 0.0477; BT preference = 0.5415473 / (0.48825216 + 0.051576 + 0.5415473) = 0.5008.

Table 8 presents the 95% confidence intervals for a 50% perturbation for each functional group, in addition to the percent change in total functional loss values for each functional group (also see Appendix

F for the 95% confidence intervals for 20% and 50% perturbations for each functional group, including totals and perturbations by wetland type). Overall, a +/-50% perturbation to indicator species' habitat preferences had on average a +/-18% change to total functional loss values for each functional group. Functional groups that were most responsive to the 50% perturbation included migratory bird brood-rearing, amphibian wintering and bat roosting habitat. Generally, functional groups that were more responsive to a 50% perturbation had fewer species or assemblages that used wetland habitat for a particular function, and/or where a species or assemblage used fewer wetland types for a particular function (e.g., one or two wetland types for roosting). In comparison, the functional groups that were least responsive to perturbation were flora species at risk, bat feeding and amphibian feeding habitat. Functional groups that were less responsive to a 50% perturbation generally had more species or assemblages that used wetland habitat for a particular function, and/or where a species or assemblage used multiple wetland types for a particular function.

Overall, the results from the sensitivity analysis, considering a +/-18% change, on average, to total functional loss values for each functional group with a 50% perturbation, suggests that any uncertainty associated with assumption #1 for fauna and flora (i.e., habitats where indicator species are found are equally preferred; see Section 5.1 Model Assumptions) will have a small effect on the model output. To provide a range of 'Total Functional Loss Given Habitat Affected – Construction', and therefore a range in mitigation targets for restored wetland area to compensate for functional loss to migratory birds, fauna species at risk, flora species at risk and species important to Aboriginal land use, the 95% confidence intervals for a 50% perturbation have been included in all model spreadsheets. Taking a conservative approach (i.e., the upper end of the 95% confidence interval), particularly for functional groups more sensitive to the +/-50% perturbation, helps to compensate for the uncertainty in the model associated with assumption #1 for flora and fauna, as well as provide compensation for the estimate of indirect effects on wetland area (e.g., sensory disturbance, downstream effects) to wetland function and time delays related to the mitigation process.

Table 8. 95% confidence intervals for a 50% perturbation for each functional group, including the percent change in total functional loss values for each functional group.

Wetland Function	Baseline Function, Total	95% Confidence Interval, +/- 50% Perturbation	% Difference from Baseline
Migratory Bird Nesting Habitat	114.98	(101.48, 127.88)	(11.74%, 11.22%)
Migratory Bird Feeding Habitat	72.94	(59.89, 85.34)	(17.89%, 17.00%)
Migratory Bird Brood Rearing Habitat	36.31	(26.48, 46.11)	(27.07%, 26.99%)
Migratory Bird Migration Habitat	60.56	(50.99, 69.84)	(15.80%, 15.32%)
Amphibian Breeding Habitat	90.08	(72.66, 107.56)	(19.34%, 19.40%)
Amphibian Feeding Habitat	106.57	(95.31, 118.42)	(10.57%, 11.12%)
Amphibian Wintering Habitat	153.0	(96.0, 210.0)	(37.25%, 37.25%)
Bat Feeding Habitat	100.44	(92.73, 107.52)	(7.68%, 7.05%)
Bat Roosting Habitat	185.88	(123.02, 248.73)	(33.82%, 33.81%)
Fauna Species at Risk Habitat	141.07	(121.94, 157.06)	(13.56%, 11.33%)
Flora Species at Risk Habitat	123.28	(118.43, 126.60)	(3.93%, 2.69%)
Habitat for Species Important to Aboriginal Land Use	125.28	(100.56, 149.76)	(19.73%, 19.54%)

6.0 Collecting Baseline Data on the Biogeochemical, Hydrological and Ecological Functioning of the Project Area Wetlands.

Field verification of the wetland types along the transmission line right-of-way was conducted in August 2016. Field sampling and ground truthing was conducted on 20% of the number of wetland polygons of each wetland type that fall within the right-of-way. For wetland polygons that were noted during mapping to require further ground truthing, 100% visitation was targeted and achieved. Wetlands were classified using the methods in MacKenzie and Moran (2004) and guided by Resources Inventory Standards Committee methods for terrestrial ecosystem mapping (RISC 1998).

Baseline data collected during the field sampling include: wetland type; substrate type; size of the wetland (i.e., verification of imagery); water depth; organic substrate depth; current wetland status (i.e., has the wetland been impacted?); area of wetland to be lost; wetland hydrological function (i.e., inlet location, outlet location and requirements to maintain hydrological functioning of wetland); wetland complex description (i.e., is the wetland isolated or connected to other wetlands, and if so what types); cover type description (i.e., percent cover of vegetation, soil and water); mesoslope position; description of surrounding landscape (e.g., adjacent habitat types, general list of plant species) and identification of the wetland vegetation present.

In total, 58 of the 60 identified wetland polygons along the transmission line right-of-way were visited. Two could not be ground truthed due to access restrictions; therefore, aerial observations were used for field sampling instead. Of the 58 wetlands visited, 9 were confirmed to not be wetlands. Typically, these sites had grassy, herbaceous meadows surrounded by willows, which led to the misidentification. Following ground truthing, 21 wetlands were confirmed as to their classification, 12 were re-classified and 25 were classified, as they were previously identified during mapping as requiring field truthing (i.e., FTR). This information will be used to verify the '*Total Functional Loss Given Habitat Affected*' for wetland functions by confirming the wetland types in the areas to be affected by construction. In addition, baseline data collected during field sampling will be used to augment information from the Vegetation and Wildlife Mitigation and Monitoring Plan (June 2015) and the EIS, on wetland characteristics of each type to be lost. This is to ensure that characteristics important to the wetland functions for migratory birds, amphibians, bats, species at risk and species important to Aboriginal land use are replaced through the mitigation plan.

7.0 Summary

Overall, this process assessed 62 indicator species and their categories of use (e.g., nesting, feeding brood-rearing, and migration) in wetland habitats in order to evaluate the functional importance of wetland habitat in the LAA for migratory birds, amphibians, bats, species at risk, and species important to Aboriginal land use (Figure 5). An estimated 763 ha of wetland area will be lost or affected by construction. As the assessment process outlines above, functional importance for wetland habitat to be affected for these 62 species can be identified using a scientifically based process for estimating and evaluating wetland function.

Table 9 summarizes the results of the wetland function assessment process. Note that the total loss values for wetland function should only be compared within species indicator groups (i.e., migratory birds, amphibians, bats, fauna species at risk, flora species at risk and species important to Aboriginal land use), rather than across groups, as the habitat values for wetland function are relative. The greatest functional loss for migratory bird habitat was calculated to occur in sedge wetlands (SE) affected during construction. Willow-Horsetail-Sedge riparian wetlands (WH) affected during construction also contributed to functional loss for all migratory bird functions, except brood-rearing. Functional loss to migratory bird brood-rearing habitat will occur primarily in SE wetland types.

The greatest functional loss of amphibian breeding habitat as a result of construction activities was found to occur within SE wetlands. Construction activities also impacted WH and Labrador Tea-Sphagnum (BT) wetlands for amphibian breeding. Amphibian feeding functional loss in wetlands affected by construction activities was the most prevalent in WH, followed by SE and BT. Functional loss associated with amphibian wintering habitat that will be impacted by construction activities will be the greatest in WH wetland types, as well as Willow Sedge wetlands (WS) and open water wetlands (OW).

The functional loss of bat feeding habitat as a result of constructions activities will be the greatest in WH wetlands, followed by BT, SE, and TS wetlands. Bat roosting habitat will be affected the greatest by construction activities in WH wetlands, followed by WS, BT, and TS wetland types.

Functional loss for fauna species at risk as a results of construction activities was calculated to be the greatest for WH habitat, followed by SE, BT and TS.

Wetland functional loss caused by construction activities regarding their ability to support flora species at risk was calculated to be the greatest in WH, followed by BT, TS, and SE.

Functional loss associated with species important to Aboriginal land use and as a result of construction activities will be the greatest in WH and BT wetland types, followed by TS and SE habitats.

The results from this process will be used to inform implementation of the wetland mitigation compensation program and can be used to guide field-level wetland and species monitoring programs**.**

Table 9. Summary of Total Functional Loss Given Habitat Affected values for construction and representing wetland functions for migratory birds, amphibians, bats, species at risk, amphibians, bats, and species important to Aboriginal land use.

Wetland habitat type								
OW	WS	WH	SE	TS	Wf02	Wf13	BT	Total
Migratory Bird Nesting Habitat								
0	5.42	42.47	56.01	5.29	0	0.11667	5.68	114.98
Migratory Bird Feeding Habitat								
6.70	3.17	24.88	34.50	1.53	0	0.07628	2.09	72.94
Migratory Bird Brood-rearing Habitat								
9.56	0	0	26.63	0	0	0.125	0	36.31
Migratory Bird Migration Habitat								
8.66	3.49	27.39	16.29	1.96	0	0.07628	2.68	60.56
Amphibian Breeding Habitat								
4.25	4.17	32.67	35.50	5.67	0	0.08333	7.75	90.08
Amphibian Feeding Habitat								
0.00	7.14	56.00	20.29	9.71	0.00	0.14	13.29	106.57
Amphibian Wintering Habitat								
5.67	16.67	130.67	0.00	0.00	0.00	0.00	0.00	153.00
Bat Feeding Habitat								
1.59	6.25	49.00	13.31	12.75	0	0.09375	17.44	100.44
Bat Roosting Habitat								
0	18.75	147.00	0	8.50	0	0	11.63	185.88
Fauna Species at Risk Habitat								
1.35808	2.98	81.81	32.38	10.61	0	0.06836	11.86	141.07
Flora Species at Risk Habitat								
0	2.10	57.89	12.83	24.75	0	0.03021	25.68	123.28
Habitat for Species Important to Aboriginal Land Use								
0	8.89	69.69	9.47	11.33	0	0.06667	25.83	125.28

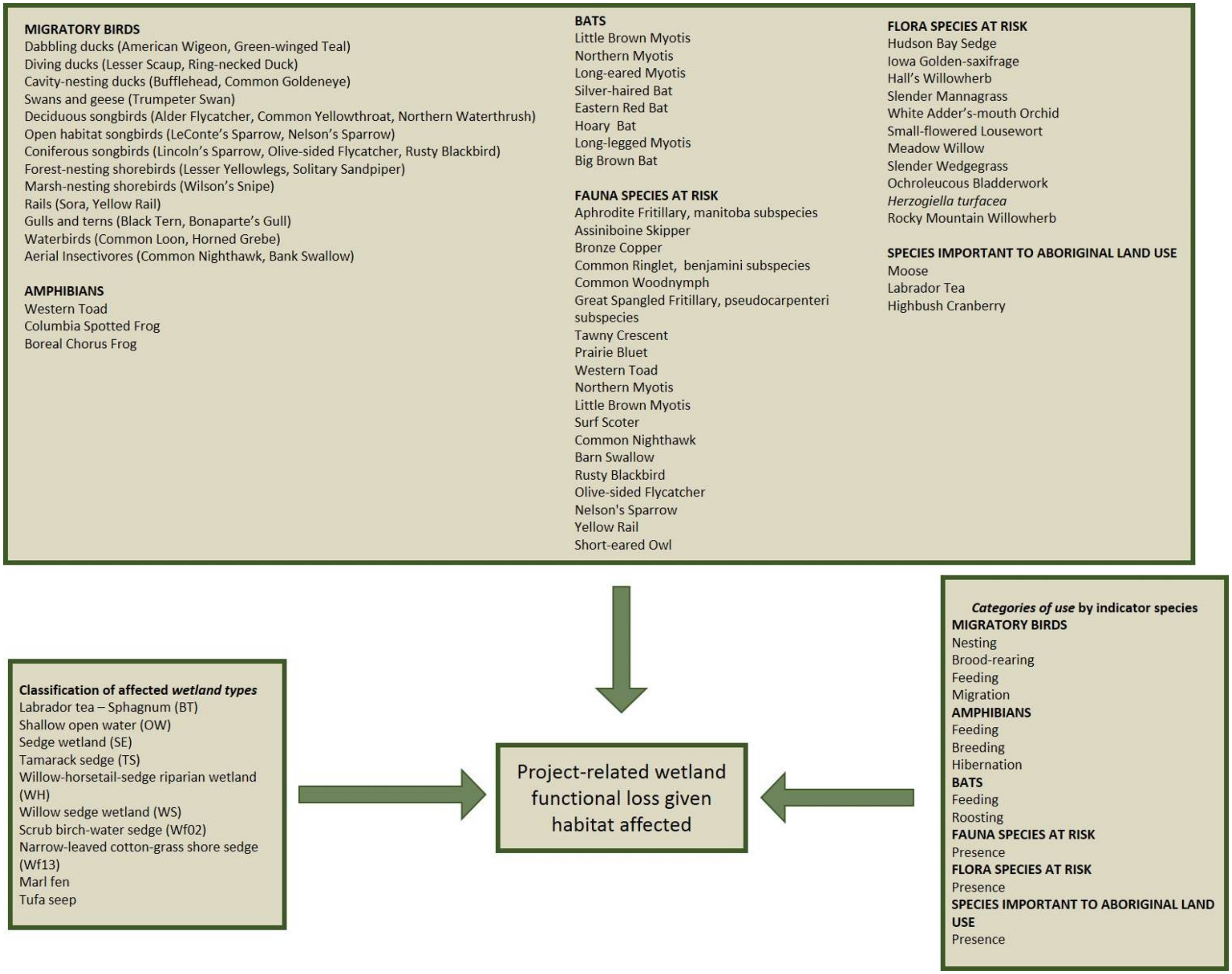


Figure 5. Components of the wetland function assessment process for the BC Hydro Site C Clean Energy Project.

8.0 Record keeping

Table 10. Record keeping detail, as per federal condition 18. For data sources utilized, see Appendix A and Hilton et al. 2013a, b, c.

Sampling Location	N/A
Date of Sampling	N/A
Time of sampling	N/A
Name of sampler(s)	N/A
Analyses Performed	Wetland function assessment: literature review and analysis
Date of analyses	October 2014 to December 2016
Person(s) who collected sample(s)	N/A
Person(s) who conducted analysis	Native Plant Solutions/Ducks Unlimited Canada (Lisette Ross, Phil Rose, Jade Raizenne, Lynn Dupuis)

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Appendix A: BC Hydro Site C Baseline Data Investigated

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1.1 Ecosystem Mapping

1.1.2 Results

1.1.2.1 Habitats within the LAA

1.2 At-risk and Sensitive Ecological Communities

1.2.2 Results

1.2.2.3 Wetland Function

Appendix A Terrestrial Ecosystem Mapping Expanded Legend

Appendix G Rare Plant Species Accounts

G.6 *Carex heleonastes* (Hudson Bay sedge)

G.12 *Chrysosplenium iowense* (Iowa golden-saxifrage)

G.16 *Epilobium halleanum* (Hall's willowherb)

G.17 *Epilobium saximontanum* (Rocky Mountain willowherb)

G.19 *Glyceria pulchella* (slender mannagrass)

G.24 *Malaxis brachypoda* (white adder's-mouth orchid)

G.27 *Pedicularis parviflora* ssp. *parviflora* (small-flowered lousewort)

G.32 *Salix petiolaris* (meadow willow)

G. 37 *Sphenopholis intermedia* (slender wedgegrass)

G.38 *Symphotrichum puniceum* var. *puniceum* (purple-stemmed aster)

G.40 *Utricularia ochroleuca* (ochroleucous bladderwort)

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1.1 Amphibians

1.1.3 Field Survey Results

1.1.3.1 Pond Breeding Surveys

1.1.3.2 Auditory Surveys

A.1 Species – Habitat Model for Western Toad

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1.1 Bats

1.1.3 Results

1.1.3.1 Bat Capture

1.1.3.2 Radio-telemetry

1.1.3.3 Acoustic Sampling

1.4 Ungulates

1.4.3 Results

1.4.3.1 Radio-collaring

1.4.3.3 Birthing Site Investigations

1.4.3.8 Moose

A.1 Species – Habitat Model for Bats

C.1 Summary of Ungulates, Pregnancy Status, and Relocations

C.3 Resource Selection Function Models

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1.1 Dragonflies

1.1.1 Species

1.1.2 Field Survey Methods

1.1.3 Field Survey Results

1.2 Butterflies

1.2.1 Species

1.2.2 Field Survey Methods

1.2.3 Field Survey Results

A.2 Species Model: Aphrodite Fritillary (*manitoba* subspecies)

A.5 Species Model: Assiniboine Skipper

A.6 Species Model: Bronze Copper

A.7 Species Model: Common Ringlet (*benjamini* subspecies)

A.8 Species Model: Common Woodnymph (*nephele* subspecies)

A.10 Species Model: Great Spangled Fritillary (*pseudocarpenteri* subspecies)

A.13 Species Model: Tawny Crescent

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1.2 Broad-winged Hawk

1.2.1 Species

1.2.2 Field Survey Methods

1.2.3 Field Survey Results

1.5 Owls

1.5.1 Species

1.5.2 Field Survey Methods

1.5.3 Field Survey Results

A.1 Species Habitat Model: Broad-winged Hawk

D.5 Species Habitat Model: Short-eared Owl

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Appendix B: Sources used to identify individual species' habitat preferences

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Appendix C: Evaluation of existing datasets and their ability to inform the Wetland Function Assessment

Dataset	Years Available	Description	Applicable to Wetland Function Assessment	Rationale	Limitations[1]
Amphibian_AuditorySurveys_2006_2008	2006 2008	Record of breeding adults calling from point count locations	Yes	Provides data on the diversity, relative abundance, and frequency of breeding amphibian species and the habitats they were detected in (i.e. habitat can be determined by overlaying UTM coordinates with mapping data)	a
Amphibian_PondSurveys_2006_2008_2012	2006 2008 2012	Record of amphibian life stages (eggs, tadpoles, juveniles, adults) observed at wetlands surveyed	Partial	Provides data on the diversity, relative abundance, life stage, and frequency of amphibian species and the habitats they were detected in (i.e. habitats could be determined by overlaying transects with mapping data)	b
Amphibian_RoadSurveys_2006_2008	2006 2008	Record of migrating amphibians encountered along roadway transects	No	Provides data on amphibian (specifically western toad) movements throughout the study area following metamorphosis, but does not provide any applicable habitat use data	
Bat_Capture_2005_2006_2008_2009_2011	2005 2006 2008 2009 2011	Record of bats captured during mist net sampling	Yes	Provides data on the diversity, relative abundance, gender, age class, reproductive stage, and site series code at bat capture sites (site series should be verified with map data)	e

Bat_Telemetry_2006_2008_2009	2006 2008 2009	Record of roost sites used by bats fitted with radio transmitters	Yes	Provides data on the specific roosts used by individual bats and the site series codes they were occurred in (site series should be verified with map data)	e
Dataset	**Years Available**	**Description**	**Applicable to Wetland Function Assessment**	**Rationale**	**Limitations[1]**
Bat_DetectorSurvey_2005_2006_2008	2005 2006 2008	Record of bat activity and the species groups using an area (i.e., Myotis, Big Bat, Hoary Bat)	No	Provides a measure of bat activity within a habitat type and provides site series code (site series should be verified with map data), but no measure of abundance (1 bat travelling through an area 4 times is recorded the same as 4 bats travelling through once)	c
Breeding_Bird_Point_Count_2006_2008 & Breeding_Bird_Point_Count_2011_2012	2006 2008 2011 2012	Record of breeding bird species detected at point count locations	Yes	Provides data on the diversity, relative abundance, and frequency of breeding bird species and the habitats they were detected in (i.e. habitat can be determined by overlaying UTM coordinates with mapping data)	a
Migratory_Encounter_2012	2012	Record of birds present during the fall migration period	Partial	Provides data on the diversity, relative abundance, and frequency of bird species during migration and the habitats they were detected in (i.e. habitats could be determined by overlaying transects with mapping data)	b
Waterfowl_Encounter_2006_2008 & 'Keystone waterfowl 2013 2014 data combined"	2006 2008 2013 2014	Record of waterfowl species detected during spring and fall	No	Provides data on the diversity and relative abundance of waterfowl species during migration and transect segments they were detected in (i.e.	b, d

		migration and the breeding season		habitats could be determined by overlaying transects with mapping data). 2006 & 2008 data stratified into: River, Backchannel, Wetland, and Lake	

Dataset	Years Available	Description	Applicable to Wetland Function Assessment	Rationale	Limitations[1]
CONI_Call_Playback_2010_2012	2010 2012	Record of common nighthawks detected at call playback locations	Yes	Provides data on the relative abundance, and frequency of common nighthawks and the habitats they were detected in (i.e. habitat can be determined by overlaying UTM coordinates with mapping data)	a
MarshBirds_Call_Playback_2008_2011_2012	2008 2011 2012	Record of marsh bird species detected at call playback locations	Yes	Provides data on the relative abundance, and frequency of marsh bird species and the habitats they were detected in (i.e. habitat can be determined by overlaying UTM coordinates with mapping data)	a
Swallow_NestCounts_2010	2010	Record of swallow nests detected along the Peace River	No	Provides data on the location of swallow nesting sites, but nests of targeted species restricted to habitat features associated with manmade structures or cliffs and banks along riparian areas and are not found in wetland habitats	d

Swallow_PointCount_2011_2012	2011 2012	Record of swallow detections at point count locations along the Peace River	Partial	Provides data on the relative abundance, and frequency of swallow species and the habitats they were detected in (i.e. habitat can be determined by overlaying UTM coordinates with mapping data)	a, d

[1] Limitations

a - habitats correspond to the ecosystem at the center of the point count station and may not represent the habitat in which the species was present (e.g., a bird survey station occurs in SE habitat and a bird is detected 100 m to the west of the station, but 100 m to the west could be a different habitat type)

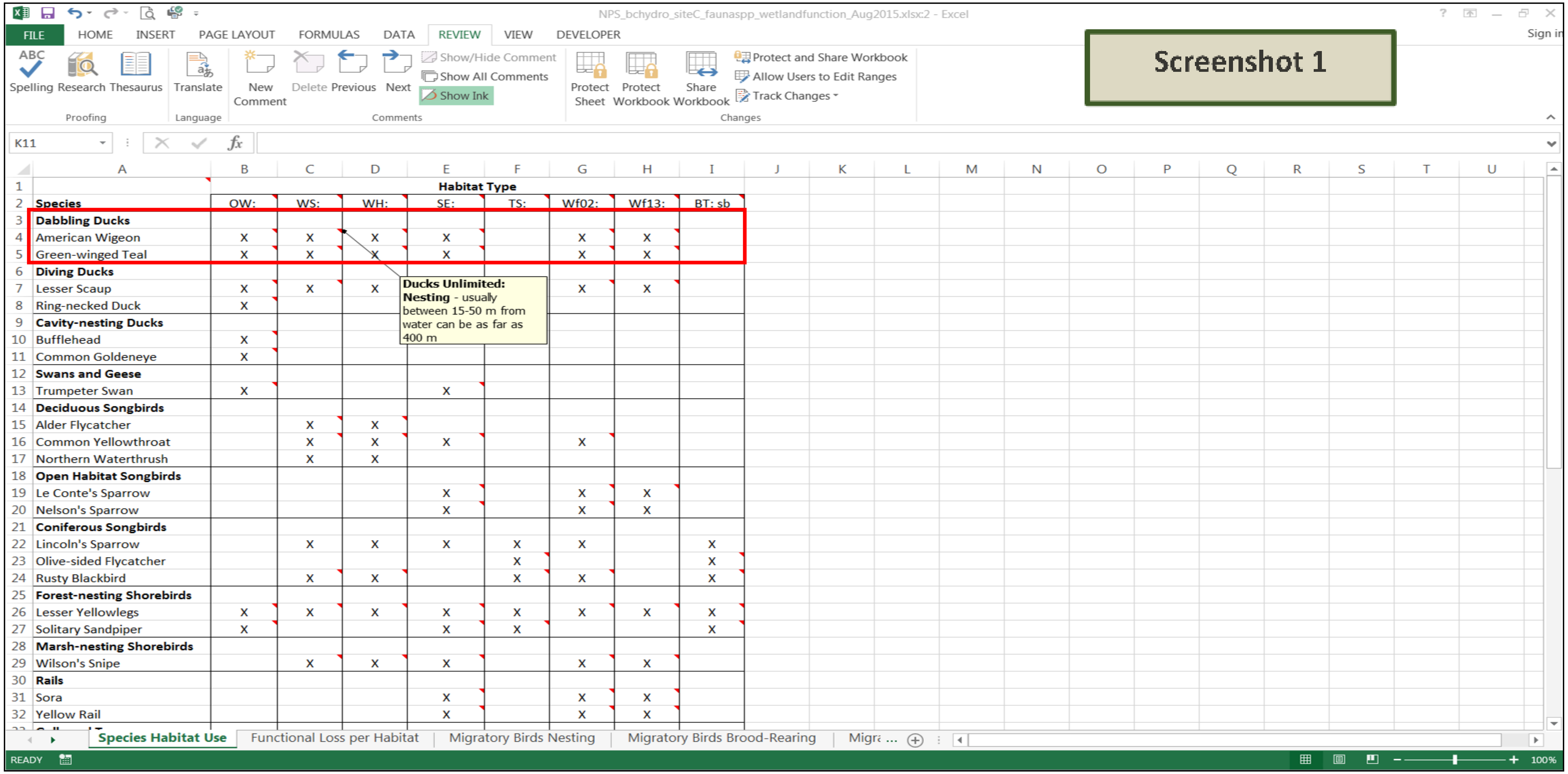
b – because most detections were made along transect surveys it makes it difficult to distinguish the actual habitat type the detection occurred in if transect routes passed through multiple habitat types

c - data can only be separated into species groups (i.e., Myotis, Big Bat, Hoary Bat) and not individual species

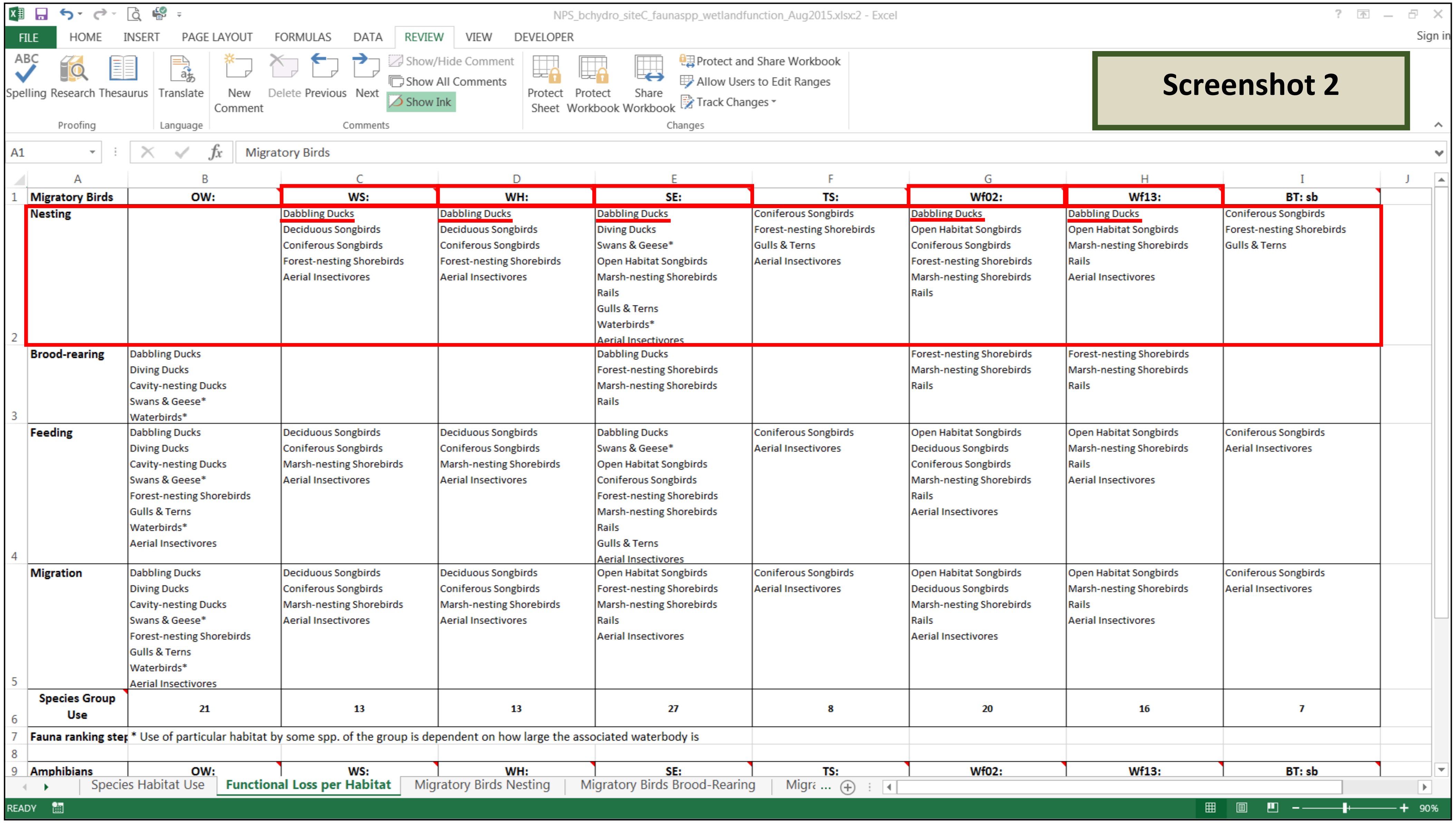
d - surveys were restricted to habitats adjacent to the river and do not sample off-system wetlands (this is not entirely true for waterfowl as some wetlands were also surveyed but a majority of the effort was focused on the Peace River)

e – potentially small sample size

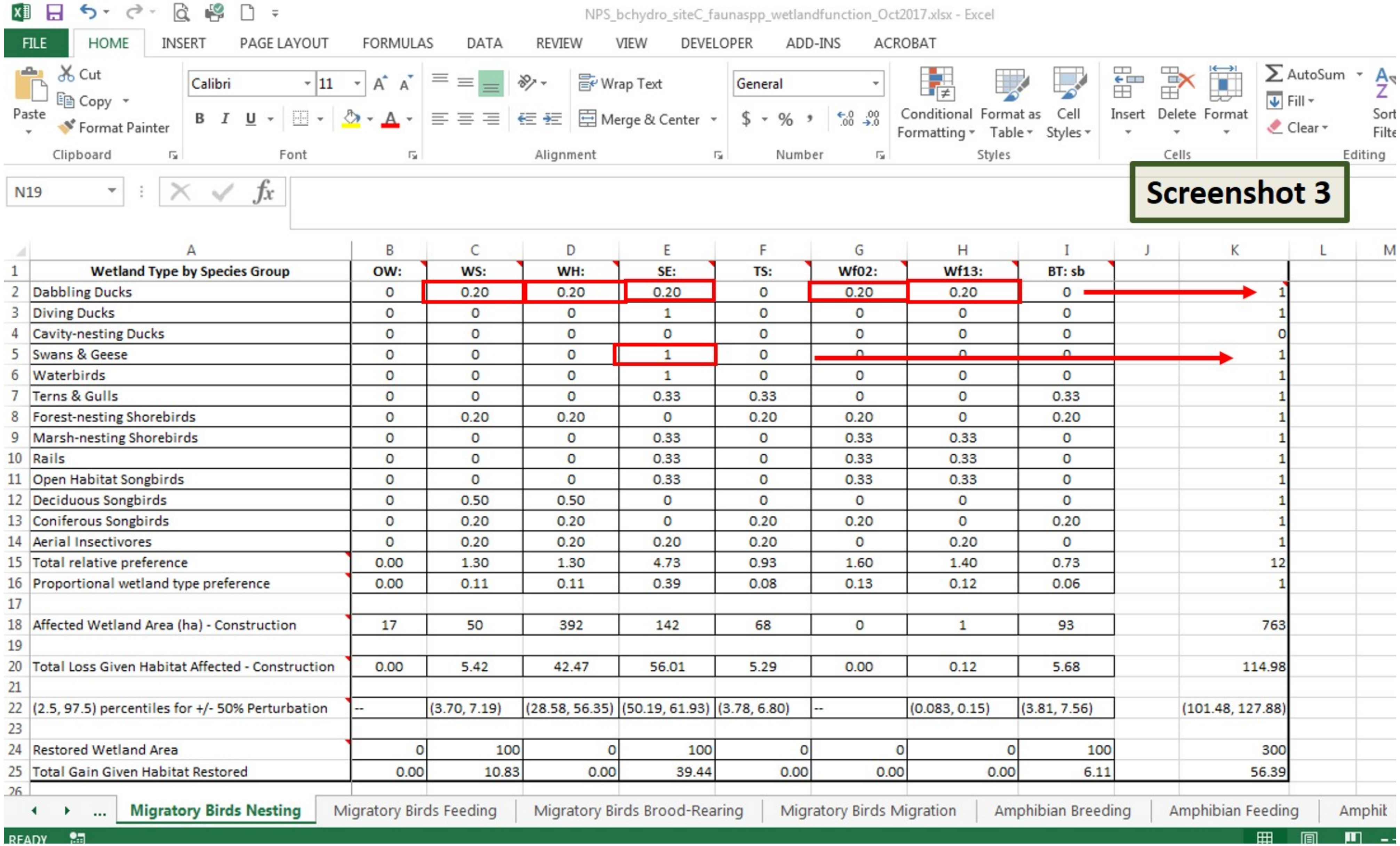
Appendix D: Screenshots for Fauna Ranking Examples



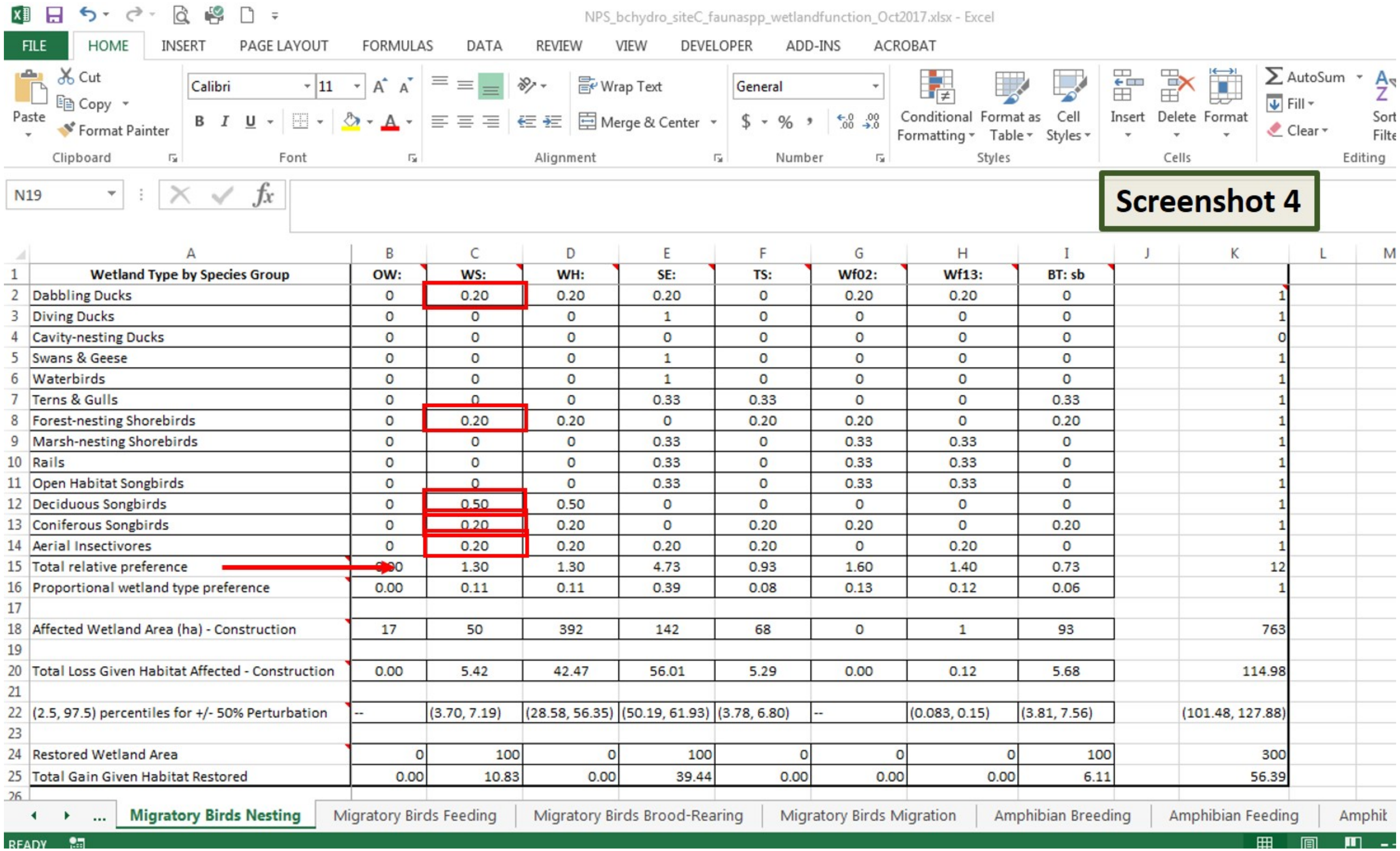
Species	Habitat Type							
	OW:	WS:	WH:	SE:	TS:	Wf02:	Wf13:	BT: sb
Dabbling Ducks								
American Wigeon	X	X	X	X		X	X	
Green-winged Teal	X	X	X	X		X	X	
Diving Ducks								
Lesser Scaup	X	X	X			X	X	
Ring-necked Duck	X							
Cavity-nesting Ducks								
Bufflehead	X							
Common Goldeneye	X							
Swans and Geese								
Trumpeter Swan	X			X				
Deciduous Songbirds								
Alder Flycatcher		X	X					
Common Yellowthroat		X	X	X		X		
Northern Waterthrush		X	X					
Open Habitat Songbirds								
Le Conte's Sparrow				X		X	X	
Nelson's Sparrow				X		X	X	
Coniferous Songbirds								
Lincoln's Sparrow		X	X	X	X	X		X
Olive-sided Flycatcher					X			X
Rusty Blackbird		X	X		X	X		X
Forest-nesting Shorebirds								
Lesser Yellowlegs	X	X	X	X	X	X	X	X
Solitary Sandpiper	X			X	X			X
Marsh-nesting Shorebirds								
Wilson's Snipe		X	X	X		X	X	
Rails								
Sora				X		X	X	
Yellow Rail				X		X	X	



Migratory Birds	OW:	WS:	WH:	SE:	TS:	Wf02:	Wf13:	BT: sb
Nesting		Dabbling Ducks Deciduous Songbirds Coniferous Songbirds Forest-nesting Shorebirds Aerial Insectivores	Dabbling Ducks Deciduous Songbirds Coniferous Songbirds Forest-nesting Shorebirds Aerial Insectivores	Dabbling Ducks Diving Ducks Swans & Geese* Open Habitat Songbirds Marsh-nesting Shorebirds Rails Gulls & Terns Waterbirds* Aerial Insectivores	Coniferous Songbirds Forest-nesting Shorebirds Gulls & Terns Aerial Insectivores	Dabbling Ducks Open Habitat Songbirds Coniferous Songbirds Forest-nesting Shorebirds Marsh-nesting Shorebirds Rails	Dabbling Ducks Open Habitat Songbirds Marsh-nesting Shorebirds Rails Aerial Insectivores	Coniferous Songbirds Forest-nesting Shorebirds Gulls & Terns
Brood-rearing	Dabbling Ducks Diving Ducks Cavity-nesting Ducks Swans & Geese* Waterbirds*			Dabbling Ducks Forest-nesting Shorebirds Marsh-nesting Shorebirds Rails		Forest-nesting Shorebirds Marsh-nesting Shorebirds Rails	Forest-nesting Shorebirds Marsh-nesting Shorebirds Rails	
Feeding	Dabbling Ducks Diving Ducks Cavity-nesting Ducks Swans & Geese* Forest-nesting Shorebirds Gulls & Terns Waterbirds* Aerial Insectivores	Deciduous Songbirds Coniferous Songbirds Marsh-nesting Shorebirds Aerial Insectivores	Deciduous Songbirds Coniferous Songbirds Marsh-nesting Shorebirds Aerial Insectivores	Dabbling Ducks Swans & Geese* Open Habitat Songbirds Coniferous Songbirds Forest-nesting Shorebirds Marsh-nesting Shorebirds Rails Gulls & Terns Aerial Insectivores	Coniferous Songbirds Aerial Insectivores	Open Habitat Songbirds Deciduous Songbirds Coniferous Songbirds Marsh-nesting Shorebirds Rails Aerial Insectivores	Open Habitat Songbirds Marsh-nesting Shorebirds Rails Aerial Insectivores	Coniferous Songbirds Aerial Insectivores
Migration	Dabbling Ducks Diving Ducks Cavity-nesting Ducks Swans & Geese* Forest-nesting Shorebirds Gulls & Terns Waterbirds* Aerial Insectivores	Deciduous Songbirds Coniferous Songbirds Marsh-nesting Shorebirds Aerial Insectivores	Deciduous Songbirds Coniferous Songbirds Marsh-nesting Shorebirds Aerial Insectivores	Open Habitat Songbirds Forest-nesting Shorebirds Marsh-nesting Shorebirds Rails Aerial Insectivores	Coniferous Songbirds Aerial Insectivores	Open Habitat Songbirds Deciduous Songbirds Marsh-nesting Shorebirds Rails Aerial Insectivores	Open Habitat Songbirds Marsh-nesting Shorebirds Rails Aerial Insectivores	Coniferous Songbirds Aerial Insectivores
Species Group Use	21	13	13	27	8	20	16	7
Fauna ranking step	* Use of particular habitat by some spp. of the group is dependent on how large the associated waterbody is							
Amphibians	OW:	WS:	WH:	SE:	TS:	Wf02:	Wf13:	BT: sb



Wetland Type by Species Group	OW:	WS:	WH:	SE:	TS:	Wf02:	Wf13:	BT: sb	K
Dabbling Ducks	0	0.20	0.20	0.20	0	0.20	0.20	0	1
Diving Ducks	0	0	0	1	0	0	0	0	1
Cavity-nesting Ducks	0	0	0	0	0	0	0	0	0
Swans & Geese	0	0	0	1	0	0	0	0	1
Waterbirds	0	0	0	1	0	0	0	0	1
Terns & Gulls	0	0	0	0.33	0.33	0	0	0.33	1
Forest-nesting Shorebirds	0	0.20	0.20	0	0.20	0.20	0	0.20	1
Marsh-nesting Shorebirds	0	0	0	0.33	0	0.33	0.33	0	1
Rails	0	0	0	0.33	0	0.33	0.33	0	1
Open Habitat Songbirds	0	0	0	0.33	0	0.33	0.33	0	1
Deciduous Songbirds	0	0.50	0.50	0	0	0	0	0	1
Coniferous Songbirds	0	0.20	0.20	0	0.20	0.20	0	0.20	1
Aerial Insectivores	0	0.20	0.20	0.20	0.20	0	0.20	0	1
Total relative preference	0.00	1.30	1.30	4.73	0.93	1.60	1.40	0.73	12
Proportional wetland type preference	0.00	0.11	0.11	0.39	0.08	0.13	0.12	0.06	1
Affected Wetland Area (ha) - Construction	17	50	392	142	68	0	1	93	763
Total Loss Given Habitat Affected - Construction	0.00	5.42	42.47	56.01	5.29	0.00	0.12	5.68	114.98
(2.5, 97.5) percentiles for +/- 50% Perturbation	--	(3.70, 7.19)	(28.58, 56.35)	(50.19, 61.93)	(3.78, 6.80)	--	(0.083, 0.15)	(3.81, 7.56)	(101.48, 127.88)
Restored Wetland Area	0	100	0	100	0	0	0	100	300
Total Gain Given Habitat Restored	0.00	10.83	0.00	39.44	0.00	0.00	0.00	6.11	56.39

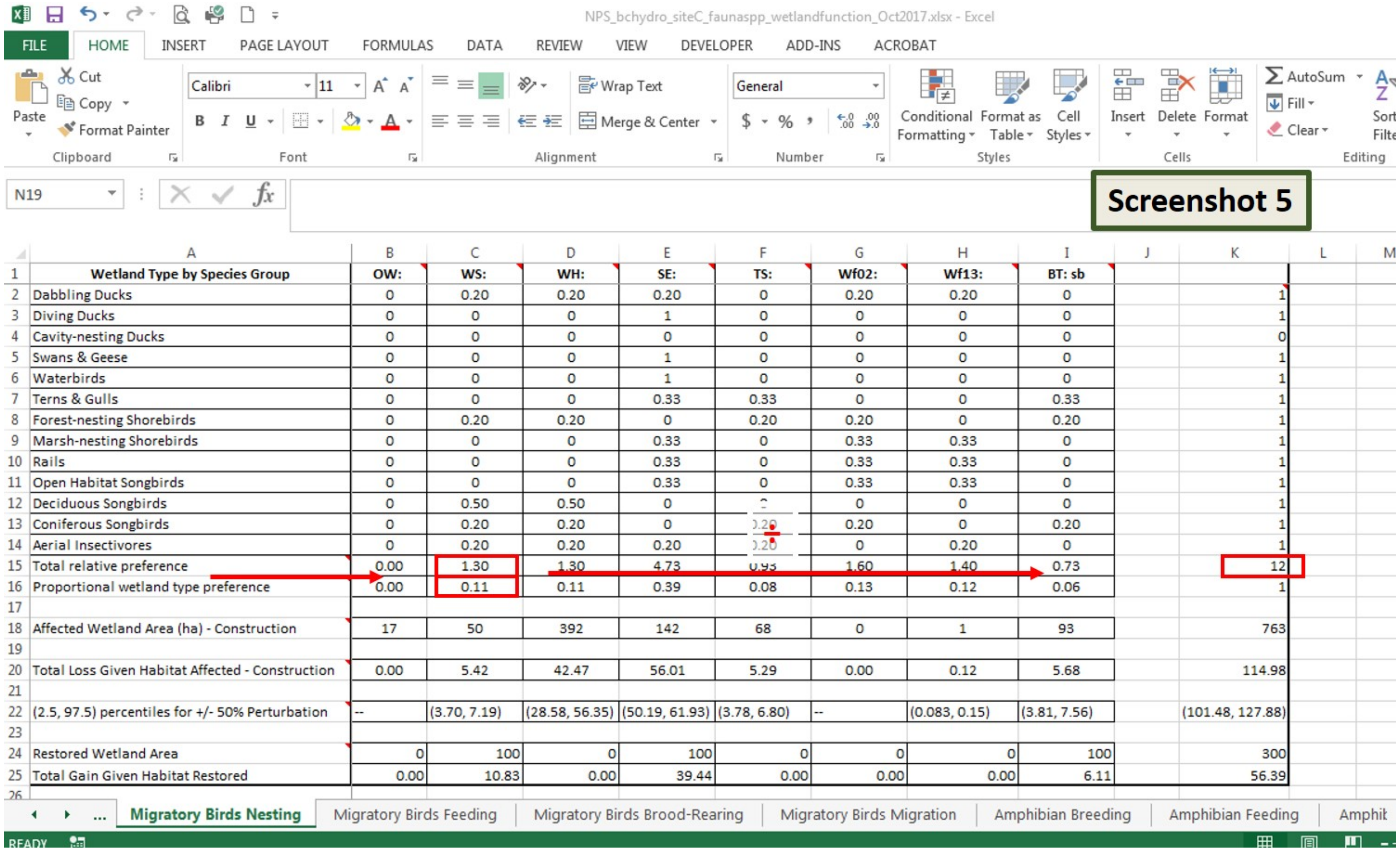


NPS_bchydro_siteC_faunaspp_wetlandfunction_Oct2017.xlsx - Excel

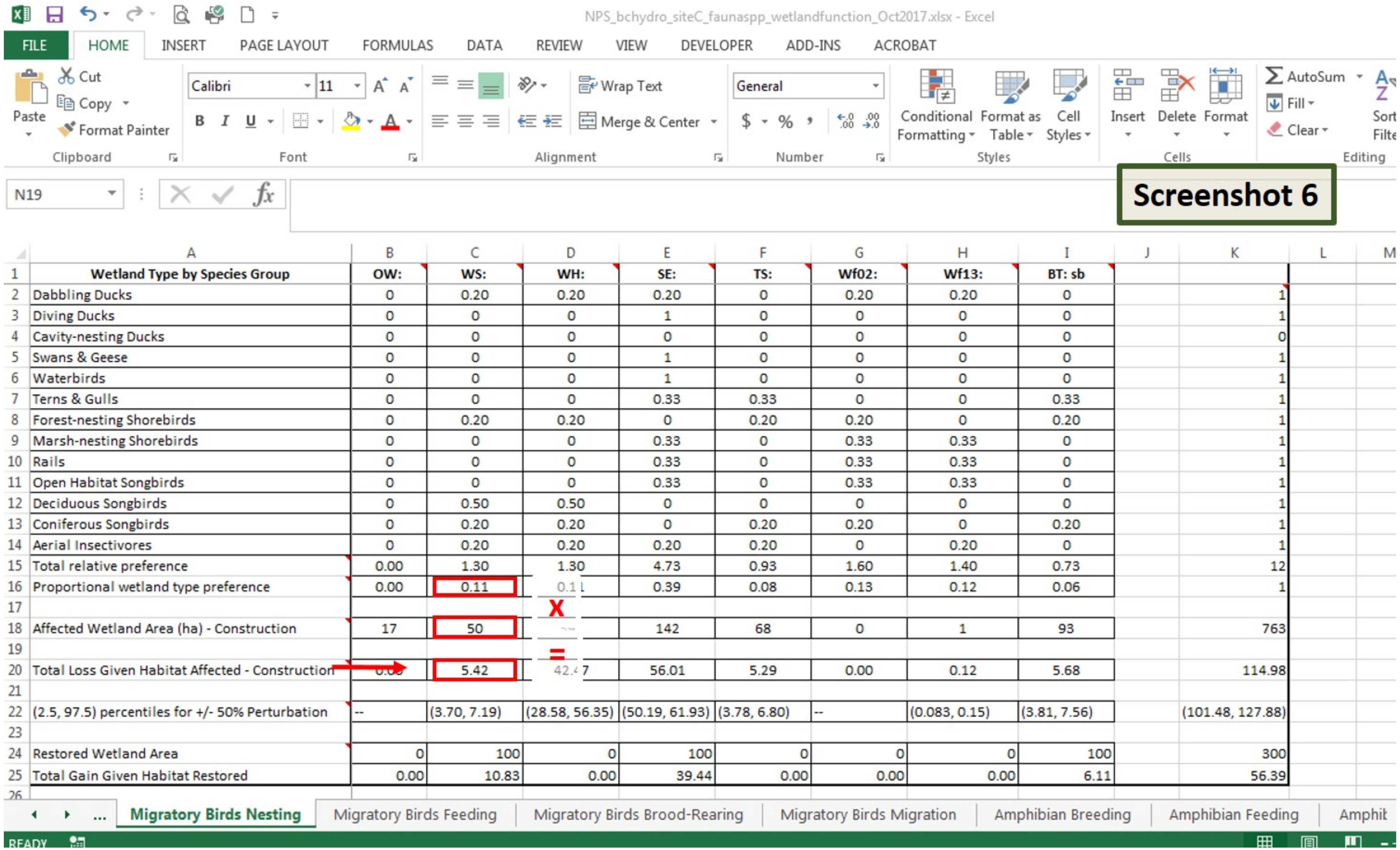
Screenshot 4

Wetland Type by Species Group	OW:	WS:	WH:	SE:	TS:	Wf02:	Wf13:	BT: sb		
Dabbling Ducks	0	0.20	0.20	0.20	0	0.20	0.20	0		1
Diving Ducks	0	0	0	1	0	0	0	0		1
Cavity-nesting Ducks	0	0	0	0	0	0	0	0		0
Swans & Geese	0	0	0	1	0	0	0	0		1
Waterbirds	0	0	0	1	0	0	0	0		1
Terns & Gulls	0	0	0	0.33	0.33	0	0	0.33		1
Forest-nesting Shorebirds	0	0.20	0.20	0	0.20	0.20	0	0.20		1
Marsh-nesting Shorebirds	0	0	0	0.33	0	0.33	0.33	0		1
Rails	0	0	0	0.33	0	0.33	0.33	0		1
Open Habitat Songbirds	0	0	0	0.33	0	0.33	0.33	0		1
Deciduous Songbirds	0	0.50	0.50	0	0	0	0	0		1
Coniferous Songbirds	0	0.20	0.20	0	0.20	0.20	0	0.20		1
Aerial Insectivores	0	0.20	0.20	0.20	0.20	0	0.20	0		1
Total relative preference	0.00	1.30	1.30	4.73	0.93	1.60	1.40	0.73		12
Proportional wetland type preference	0.00	0.11	0.11	0.39	0.08	0.13	0.12	0.06		1
Affected Wetland Area (ha) - Construction	17	50	392	142	68	0	1	93		763
Total Loss Given Habitat Affected - Construction	0.00	5.42	42.47	56.01	5.29	0.00	0.12	5.68		114.98
(2.5, 97.5) percentiles for +/- 50% Perturbation	--	(3.70, 7.19)	(28.58, 56.35)	(50.19, 61.93)	(3.78, 6.80)	--	(0.083, 0.15)	(3.81, 7.56)		(101.48, 127.88)
Restored Wetland Area	0	100	0	100	0	0	0	100		300
Total Gain Given Habitat Restored	0.00	10.83	0.00	39.44	0.00	0.00	0.00	6.11		56.39

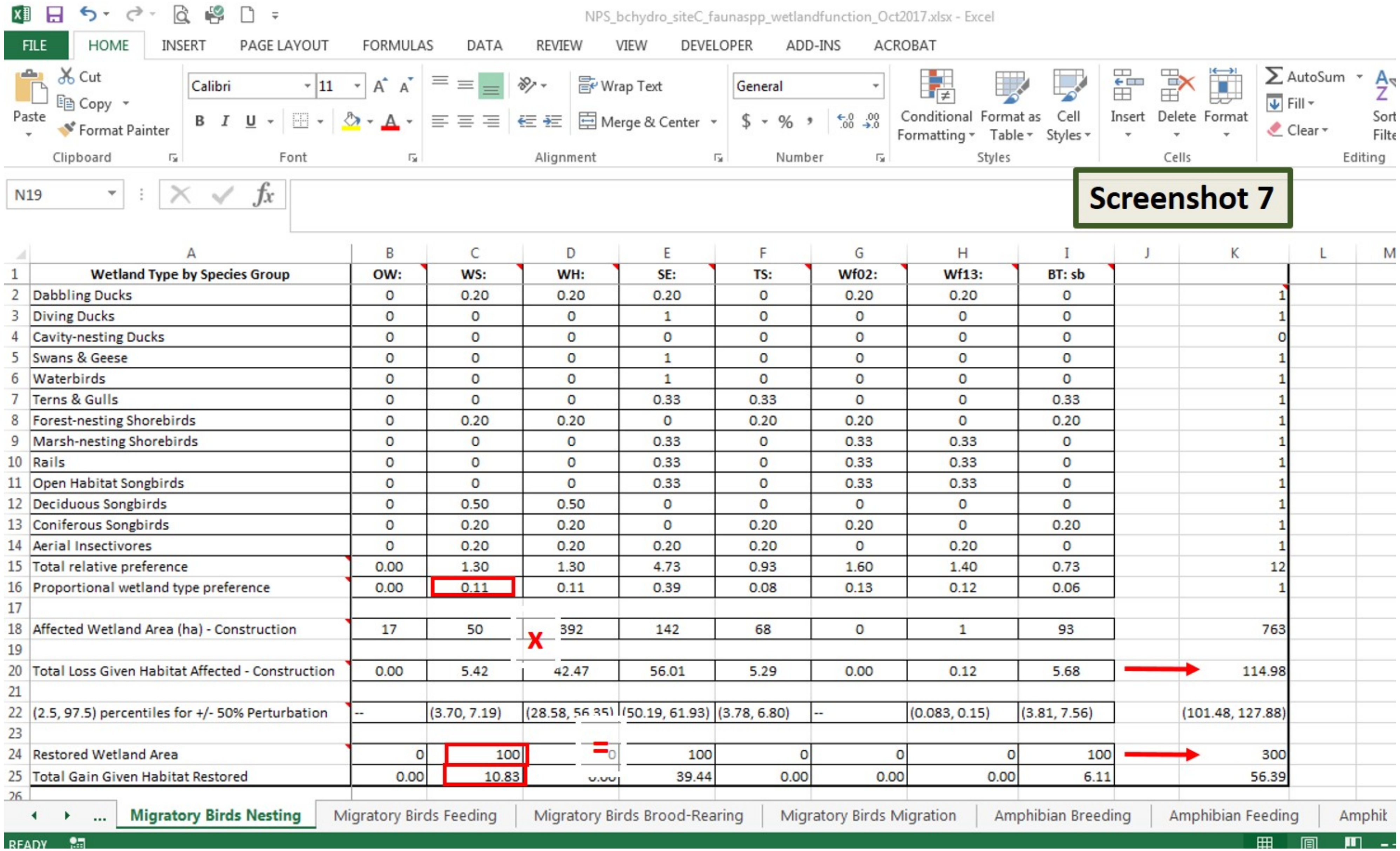
Migratory Birds Nesting | Migratory Birds Feeding | Migratory Birds Brood-Rearing | Migratory Birds Migration | Amphibian Breeding | Amphibian Feeding



	A	B	C	D	E	F	G	H	I	J	K
1	Wetland Type by Species Group	OW:	WS:	WH:	SE:	TS:	Wf02:	Wf13:	BT: sb		
2	Dabbling Ducks	0	0.20	0.20	0.20	0	0.20	0.20	0		1
3	Diving Ducks	0	0	0	1	0	0	0	0		1
4	Cavity-nesting Ducks	0	0	0	0	0	0	0	0		0
5	Swans & Geese	0	0	0	1	0	0	0	0		1
6	Waterbirds	0	0	0	1	0	0	0	0		1
7	Terns & Gulls	0	0	0	0.33	0.33	0	0	0.33		1
8	Forest-nesting Shorebirds	0	0.20	0.20	0	0.20	0.20	0	0.20		1
9	Marsh-nesting Shorebirds	0	0	0	0.33	0	0.33	0.33	0		1
10	Rails	0	0	0	0.33	0	0.33	0.33	0		1
11	Open Habitat Songbirds	0	0	0	0.33	0	0.33	0.33	0		1
12	Deciduous Songbirds	0	0.50	0.50	0	[illegible]	0	0	0		1
13	Coniferous Songbirds	0	0.20	0.20	0	0.20	0.20	0	0.20		1
14	Aerial Insectivores	0	0.20	0.20	0.20	0.20	0	0.20	0		1
15	Total relative preference	0.00	1.30	1.30	4.73	0.93	1.60	1.40	0.73		12
16	Proportional wetland type preference	0.00	0.11	0.11	0.39	0.08	0.13	0.12	0.06		1
17											
18	Affected Wetland Area (ha) - Construction	17	50	392	142	68	0	1	93		763
19											
20	Total Loss Given Habitat Affected - Construction	0.00	5.42	42.47	56.01	5.29	0.00	0.12	5.68		114.98
21											
22	(2.5, 97.5) percentiles for +/- 50% Perturbation	--	(3.70, 7.19)	(28.58, 56.35)	(50.19, 61.93)	(3.78, 6.80)	--	(0.083, 0.15)	(3.81, 7.56)		(101.48, 127.88)
23											
24	Restored Wetland Area	0	100	0	100	0	0	0	100		300
25	Total Gain Given Habitat Restored	0.00	10.83	0.00	39.44	0.00	0.00	0.00	6.11		56.39

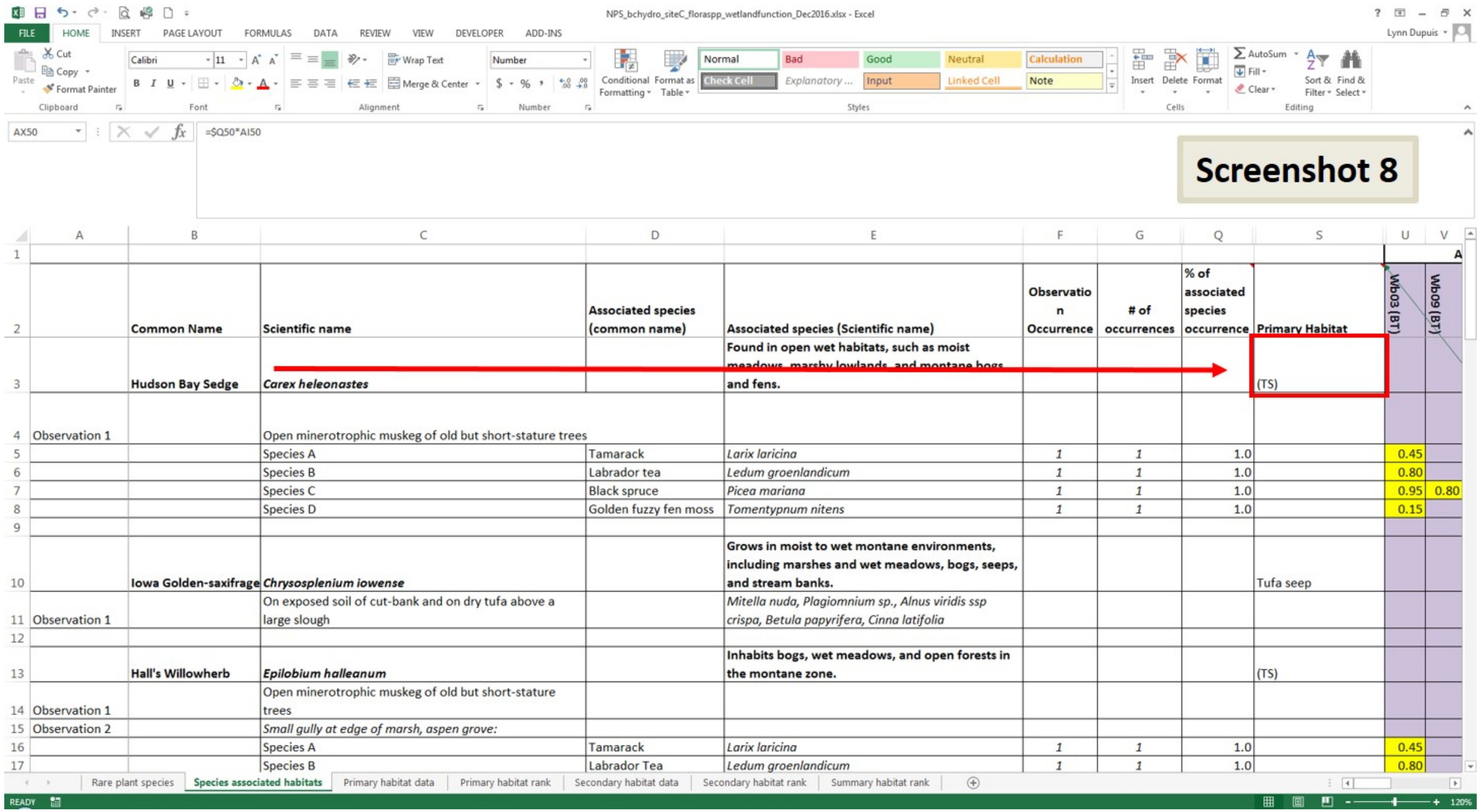


	A	B	C	D	E	F	G	H	I	J	K
1	Wetland Type by Species Group	OW:	WS:	WH:	SE:	TS:	Wf02:	Wf13:	BT: sb		
2	Dabbling Ducks	0	0.20	0.20	0.20	0	0.20	0.20	0		1
3	Diving Ducks	0	0	0	1	0	0	0	0		1
4	Cavity-nesting Ducks	0	0	0	0	0	0	0	0		0
5	Swans & Geese	0	0	0	1	0	0	0	0		1
6	Waterbirds	0	0	0	1	0	0	0	0		1
7	Terns & Gulls	0	0	0	0.33	0.33	0	0	0.33		1
8	Forest-nesting Shorebirds	0	0.20	0.20	0	0.20	0.20	0	0.20		1
9	Marsh-nesting Shorebirds	0	0	0	0.33	0	0.33	0.33	0		1
10	Rails	0	0	0	0.33	0	0.33	0.33	0		1
11	Open Habitat Songbirds	0	0	0	0.33	0	0.33	0.33	0		1
12	Deciduous Songbirds	0	0.50	0.50	0	0	0	0	0		1
13	Coniferous Songbirds	0	0.20	0.20	0	0.20	0.20	0	0.20		1
14	Aerial Insectivores	0	0.20	0.20	0.20	0.20	0	0.20	0		1
15	Total relative preference	0.00	1.30	1.30	4.73	0.93	1.60	1.40	0.73		12
16	Proportional wetland type preference	0.00	0.11	[illegible]	0.39	0.08	0.13	0.12	0.06		1
17			X								
18	Affected Wetland Area (ha) - Construction	17	50	[illegible]	142	68	0	1	93		763
19			=								
20	Total Loss Given Habitat Affected - Construction	[illegible]	5.42	[illegible]	56.01	5.29	0.00	0.12	5.68		114.98
21											
22	(2.5, 97.5) percentiles for +/- 50% Perturbation	--	(3.70, 7.19)	(28.58, 56.35)	(50.19, 61.93)	(3.78, 6.80)	--	(0.083, 0.15)	(3.81, 7.56)		(101.48, 127.88)
23											
24	Restored Wetland Area	0	100	0	100	0	0	0	100		300
25	Total Gain Given Habitat Restored	0.00	10.83	0.00	39.44	0.00	0.00	0.00	6.11		56.39

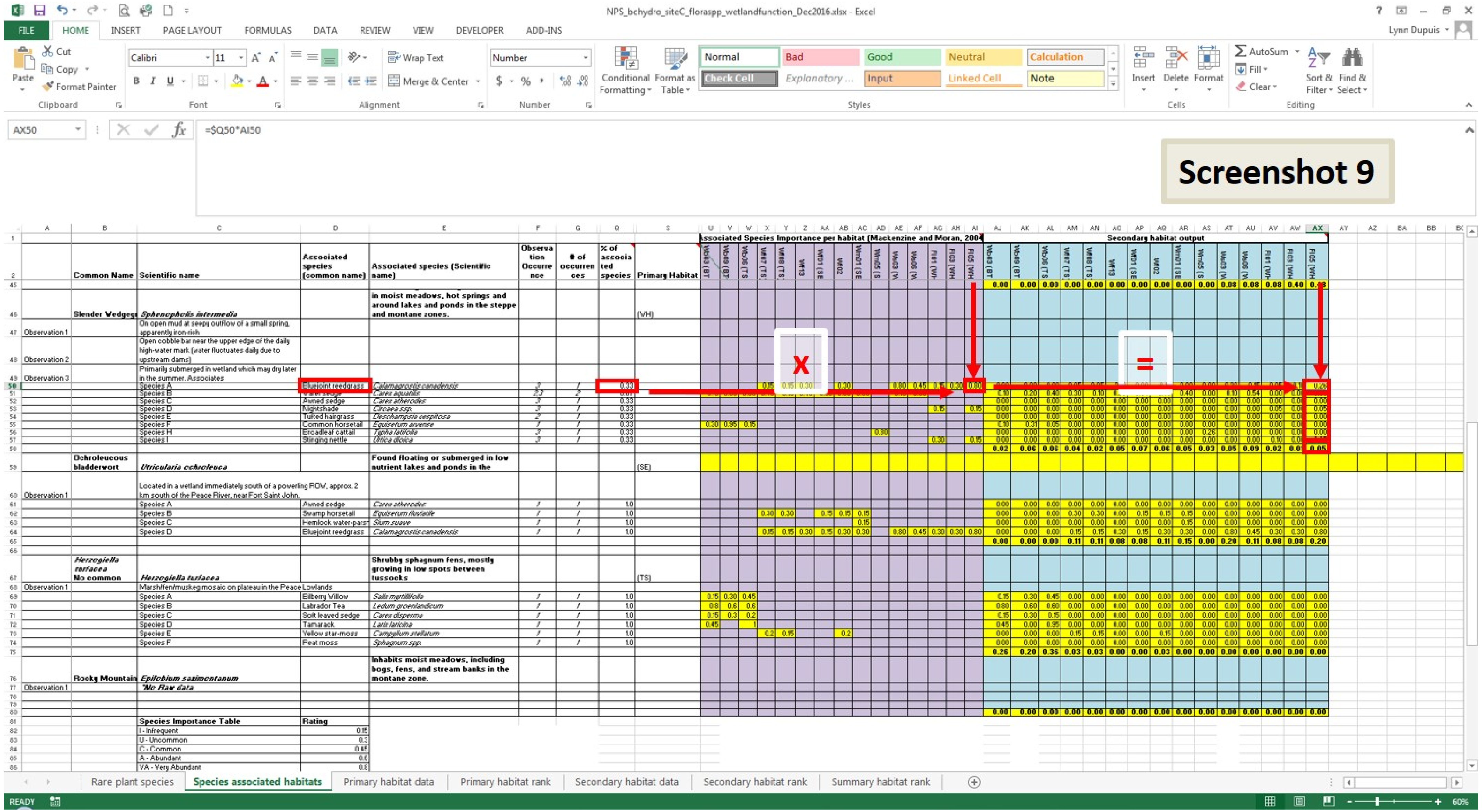


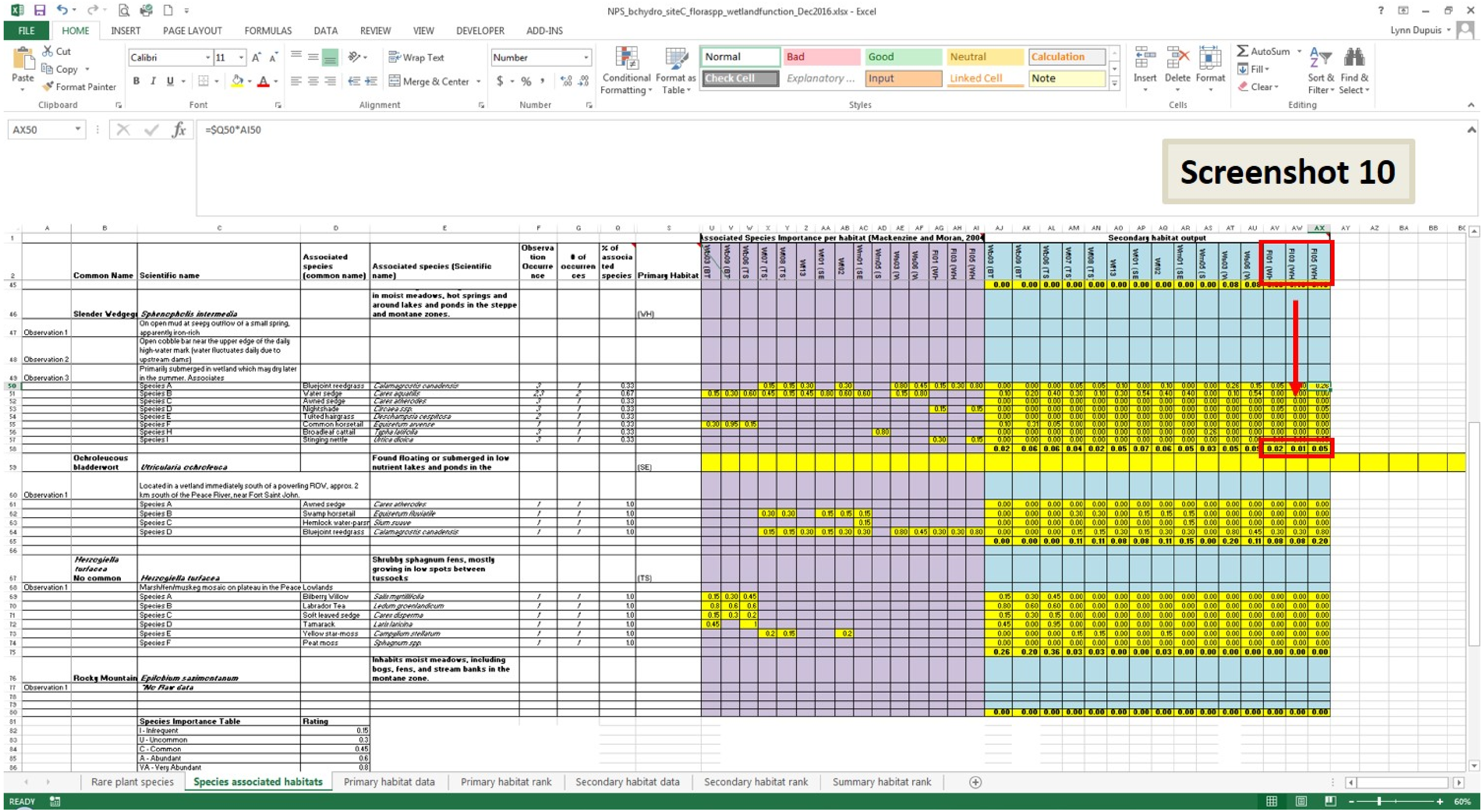
	A	B	C	D	E	F	G	H	I	J	K
1	**Wetland Type by Species Group**	**OW:**	**WS:**	**WH:**	**SE:**	**TS:**	**Wf02:**	**Wf13:**	**BT: sb**		
2	Dabbling Ducks	0	0.20	0.20	0.20	0	0.20	0.20	0		1
3	Diving Ducks	0	0	0	1	0	0	0	0		1
4	Cavity-nesting Ducks	0	0	0	0	0	0	0	0		0
5	Swans & Geese	0	0	0	1	0	0	0	0		1
6	Waterbirds	0	0	0	1	0	0	0	0		1
7	Terns & Gulls	0	0	0	0.33	0.33	0	0	0.33		1
8	Forest-nesting Shorebirds	0	0.20	0.20	0	0.20	0.20	0	0.20		1
9	Marsh-nesting Shorebirds	0	0	0	0.33	0	0.33	0.33	0		1
10	Rails	0	0	0	0.33	0	0.33	0.33	0		1
11	Open Habitat Songbirds	0	0	0	0.33	0	0.33	0.33	0		1
12	Deciduous Songbirds	0	0.50	0.50	0	0	0	0	0		1
13	Coniferous Songbirds	0	0.20	0.20	0	0.20	0.20	0	0.20		1
14	Aerial Insectivores	0	0.20	0.20	0.20	0.20	0	0.20	0		1
15	Total relative preference	0.00	1.30	1.30	4.73	0.93	1.60	1.40	0.73		12
16	Proportional wetland type preference	0.00	0.11	0.11	0.39	0.08	0.13	0.12	0.06		1
17											
18	Affected Wetland Area (ha) - Construction	17	50	392	142	68	0	1	93		763
19											
20	Total Loss Given Habitat Affected - Construction	0.00	5.42	42.47	56.01	5.29	0.00	0.12	5.68		114.98
21											
22	(2.5, 97.5) percentiles for +/- 50% Perturbation	--	(3.70, 7.19)	(28.58, 56.35)	(50.19, 61.93)	(3.78, 6.80)	--	(0.083, 0.15)	(3.81, 7.56)		(101.48, 127.88)
23											
24	Restored Wetland Area	0	100	0	100	0	0	0	100		300
25	Total Gain Given Habitat Restored	0.00	10.83	0.00	39.44	0.00	0.00	0.00	6.11		56.39

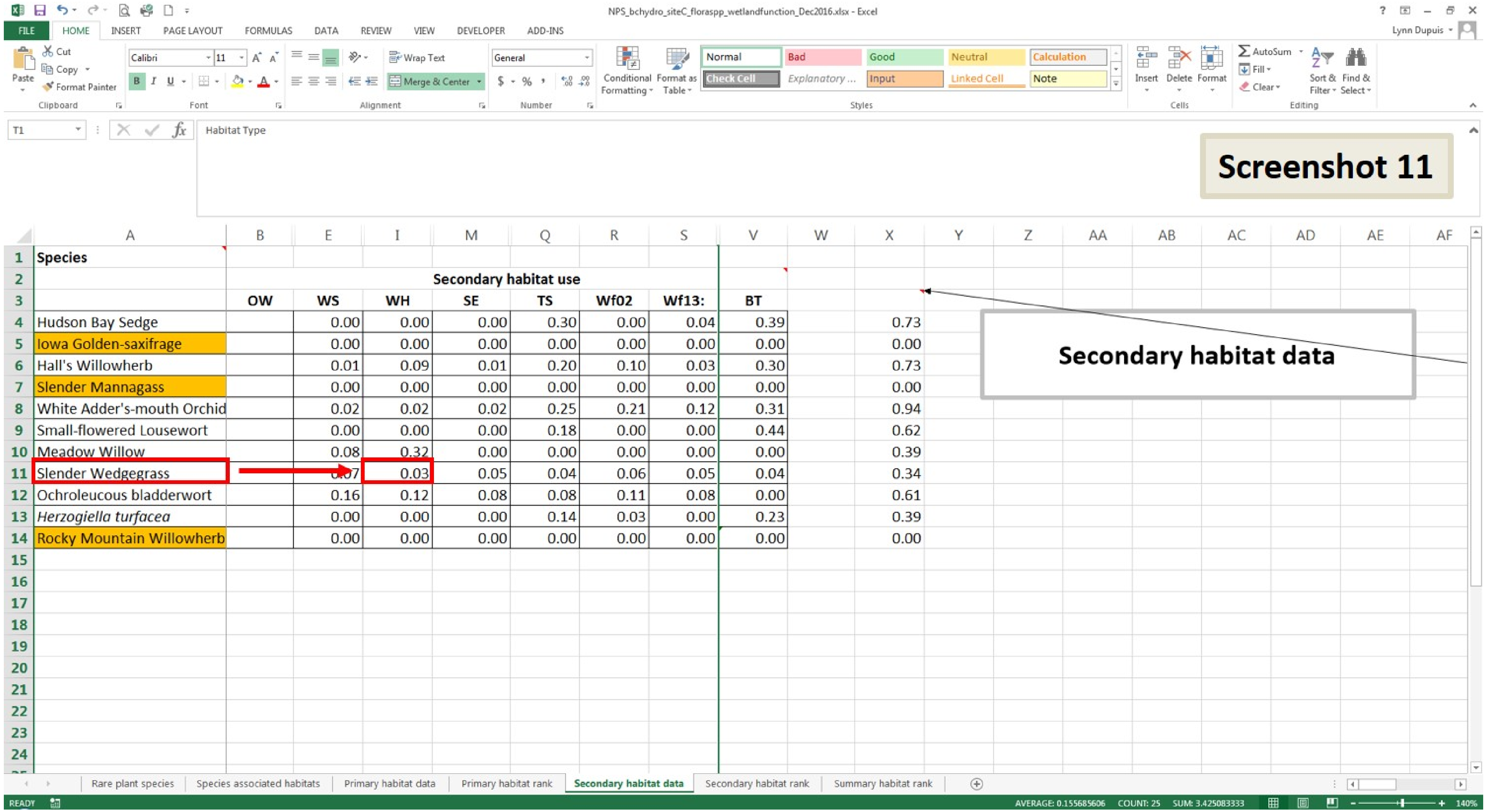
Appendix E: Screenshots for Flora Ranking Examples



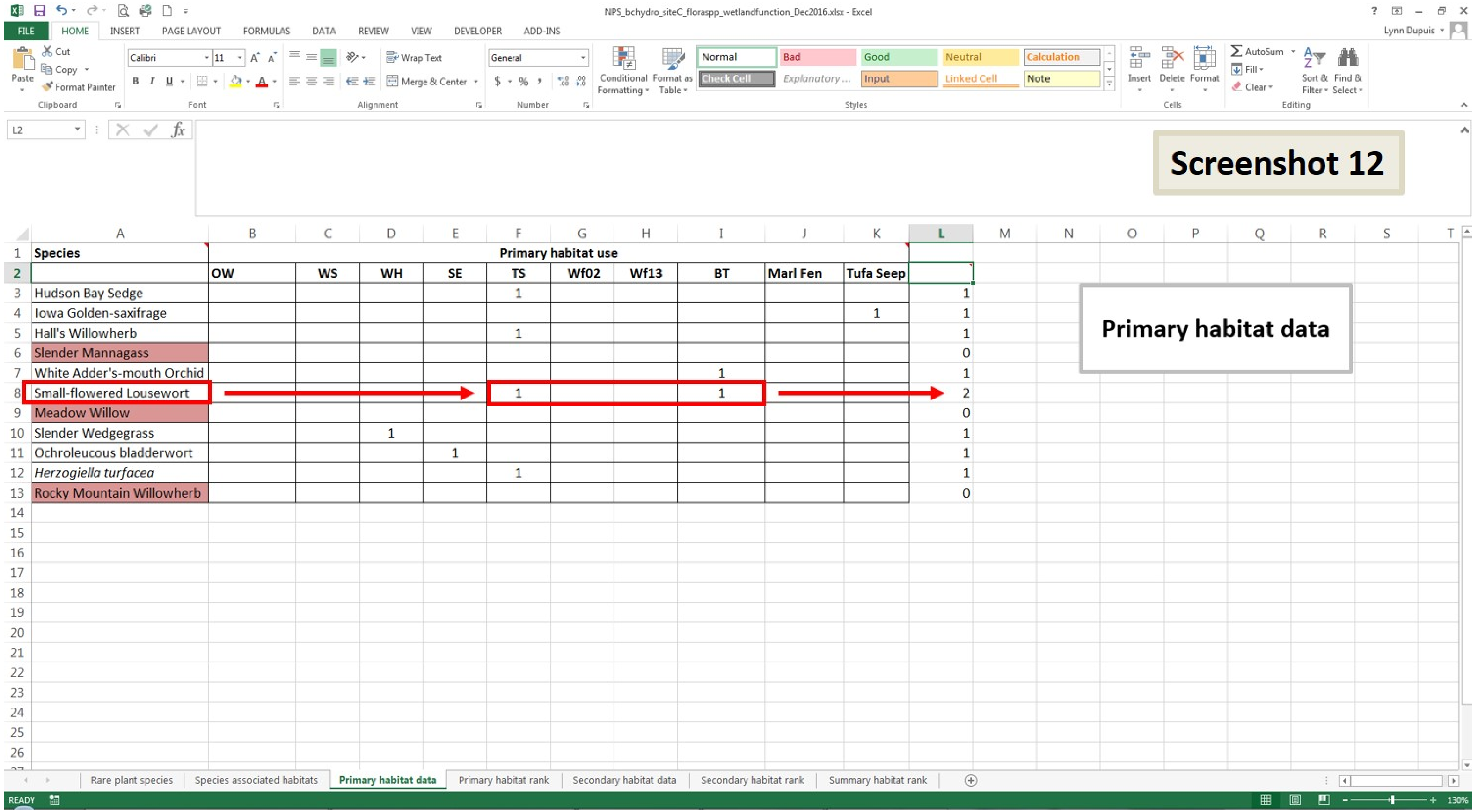
	A	B	C	D	E	F	G	Q	S	U	V
1											A
2		Common Name	Scientific name	Associated species (common name)	Associated species (Scientific name)	Observation Occurrence	# of occurrences	% of associated species occurrence	Primary Habitat	Wb03 (BT)	Wb09 (BT)
3		**Hudson Bay Sedge**	***Carex heleonastes***		**Found in open wet habitats, such as moist meadows, marshy lowlands, and montane bogs and fens.**				(TS)		
4	Observation 1		Open minerotrophic muskeg of old but short-stature trees								
5			Species A	Tamarack	*Larix laricina*	*1*	*1*	1.0		0.45	
6			Species B	Labrador tea	*Ledum groenlandicum*	*1*	*1*	1.0		0.80	
7			Species C	Black spruce	*Picea mariana*	*1*	*1*	1.0		0.95	0.80
8			Species D	Golden fuzzy fen moss	*Tomentypnum nitens*	*1*	*1*	1.0		0.15	
9											
10		**Iowa Golden-saxifrage**	***Chrysosplenium iowense***		**Grows in moist to wet montane environments, including marshes and wet meadows, bogs, seeps, and stream banks.**				Tufa seep		
11	Observation 1		On exposed soil of cut-bank and on dry tufa above a large slough		*Mitella nuda, Plagiomnium sp., Alnus viridis ssp crispa, Betula papyrifera, Cinna latifolia*						
12											
13		**Hall's Willowherb**	***Epilobium halleanum***		**Inhabits bogs, wet meadows, and open forests in the montane zone.**				(TS)		
14	Observation 1		Open minerotrophic muskeg of old but short-stature trees								
15	Observation 2		*Small gully at edge of marsh, aspen grove:*								
16			Species A	Tamarack	*Larix laricina*	*1*	*1*	1.0		0.45	
17			Species B	Labrador Tea	*Ledum groenlandicum*	*1*	*1*	1.0		0.80	


NPS_bchydro_siteC_floraspp_wetlandfunction_Dec2016.xlsx - Excel
Screenshot 9
=$Q50*AI50
X
=
Rare plant species
Species associated habitats
Primary habitat data
Primary habitat rank
Secondary habitat data
Secondary habitat rank
Summary habitat rank

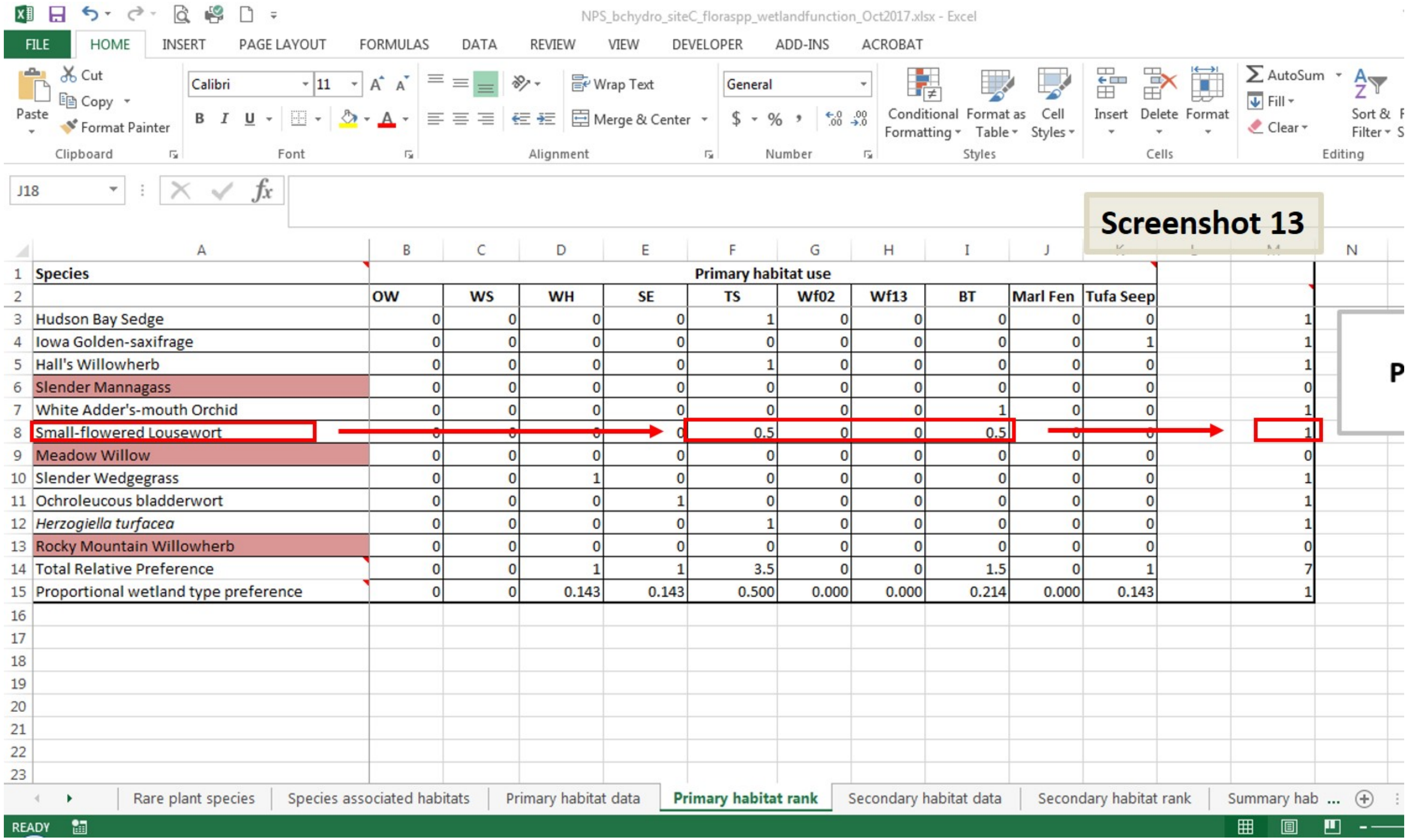

NPS_bchydro_siteC_floraspp_wetlandfunction_Dec2016.xlsx - Excel
Screenshot 10
AX50
=$Q50*AI50
Associated Species Importance per habitat (Mackenzine and Moran, 2004)
Secondary habitat output
Species Importance Table
Rating
I - Infrequent 0.15
U - Uncommon 0.3
C - Common 0.45
A - Abundant 0.6
VA - Very Abundant 0.8
Rare plant species
Species associated habitats
Primary habitat data
Primary habitat rank
Secondary habitat data
Secondary habitat rank
Summary habitat rank



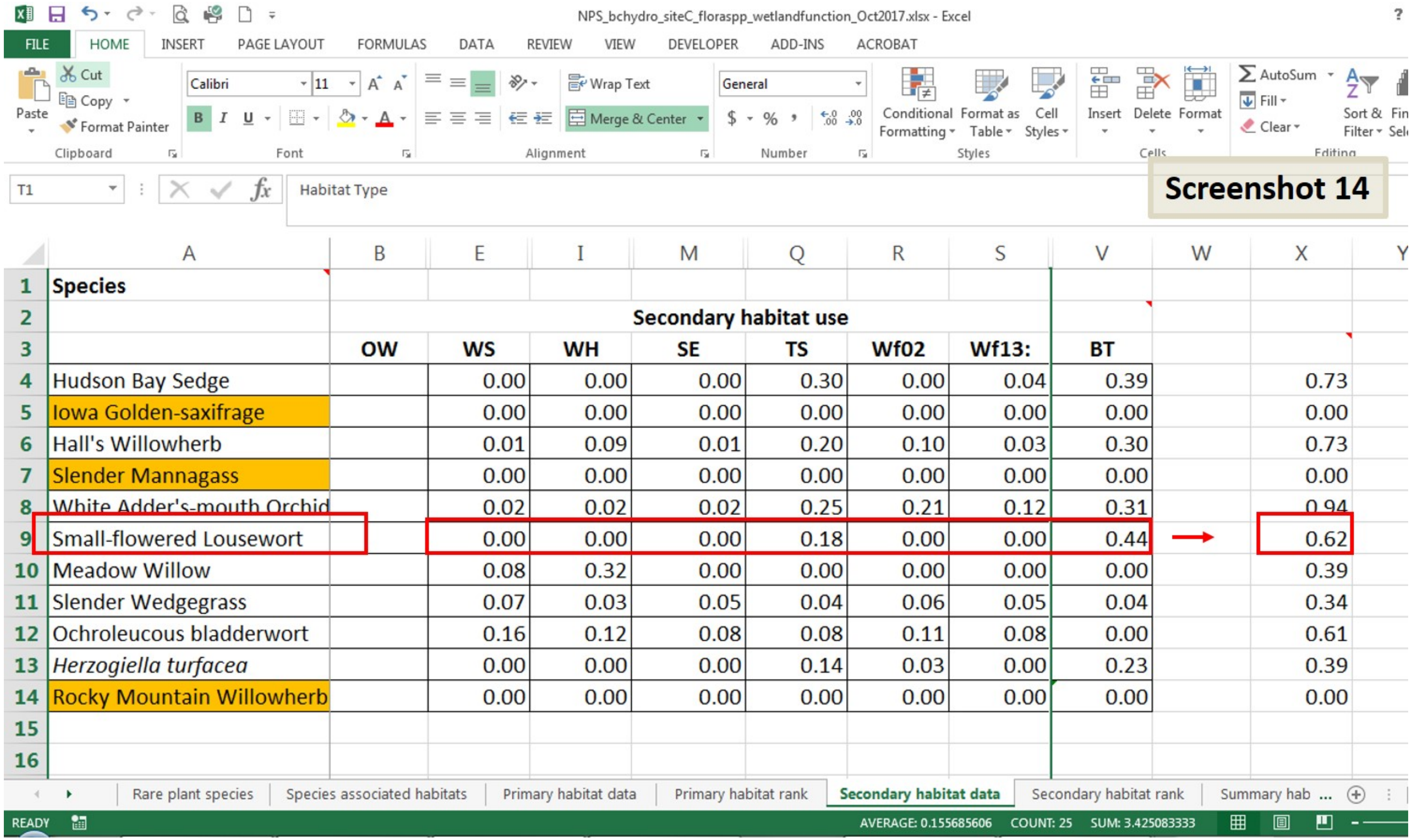
Species	OW	WS	WH	SE	TS	Wf02	Wf13:	BT		X
	Secondary habitat use									
Hudson Bay Sedge		0.00	0.00	0.00	0.30	0.00	0.04	0.39		0.73
Iowa Golden-saxifrage		0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
Hall's Willowherb		0.01	0.09	0.01	0.20	0.10	0.03	0.30		0.73
Slender Mannagass		0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
White Adder's-mouth Orchid		0.02	0.02	0.02	0.25	0.21	0.12	0.31		0.94
Small-flowered Lousewort		0.00	0.00	0.00	0.18	0.00	0.00	0.44		0.62
Meadow Willow		0.08	0.32	0.00	0.00	0.00	0.00	0.00		0.39
Slender Wedgegrass		0.07	0.03	0.05	0.04	0.06	0.05	0.04		0.34
Ochroleucous bladderwort		0.16	0.12	0.08	0.08	0.11	0.08	0.00		0.61
Herzogiella turfacea		0.00	0.00	0.00	0.14	0.03	0.00	0.23		0.39
Rocky Mountain Willowherb		0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00



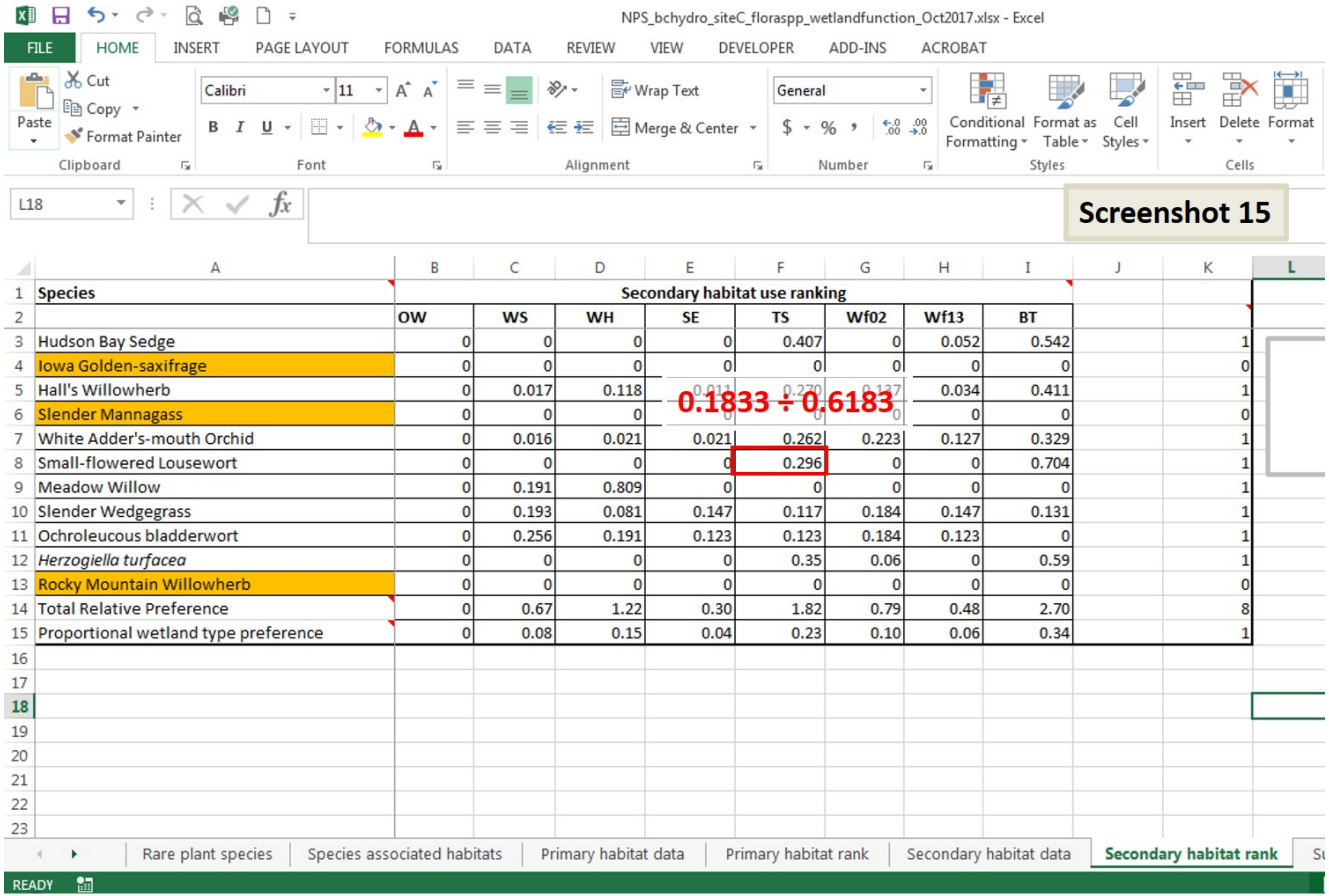
Species	Primary habitat use										
	OW	WS	WH	SE	TS	Wf02	Wf13	BT	Marl Fen	Tufa Seep	
Hudson Bay Sedge					1						1
Iowa Golden-saxifrage										1	1
Hall's Willowherb					1						1
Slender Mannagass											0
White Adder's-mouth Orchid								1			1
Small-flowered Lousewort					1			1			2
Meadow Willow											0
Slender Wedgegrass			1								1
Ochroleucous bladderwort				1							1
Herzogiella turfacea					1						1
Rocky Mountain Willowherb											0



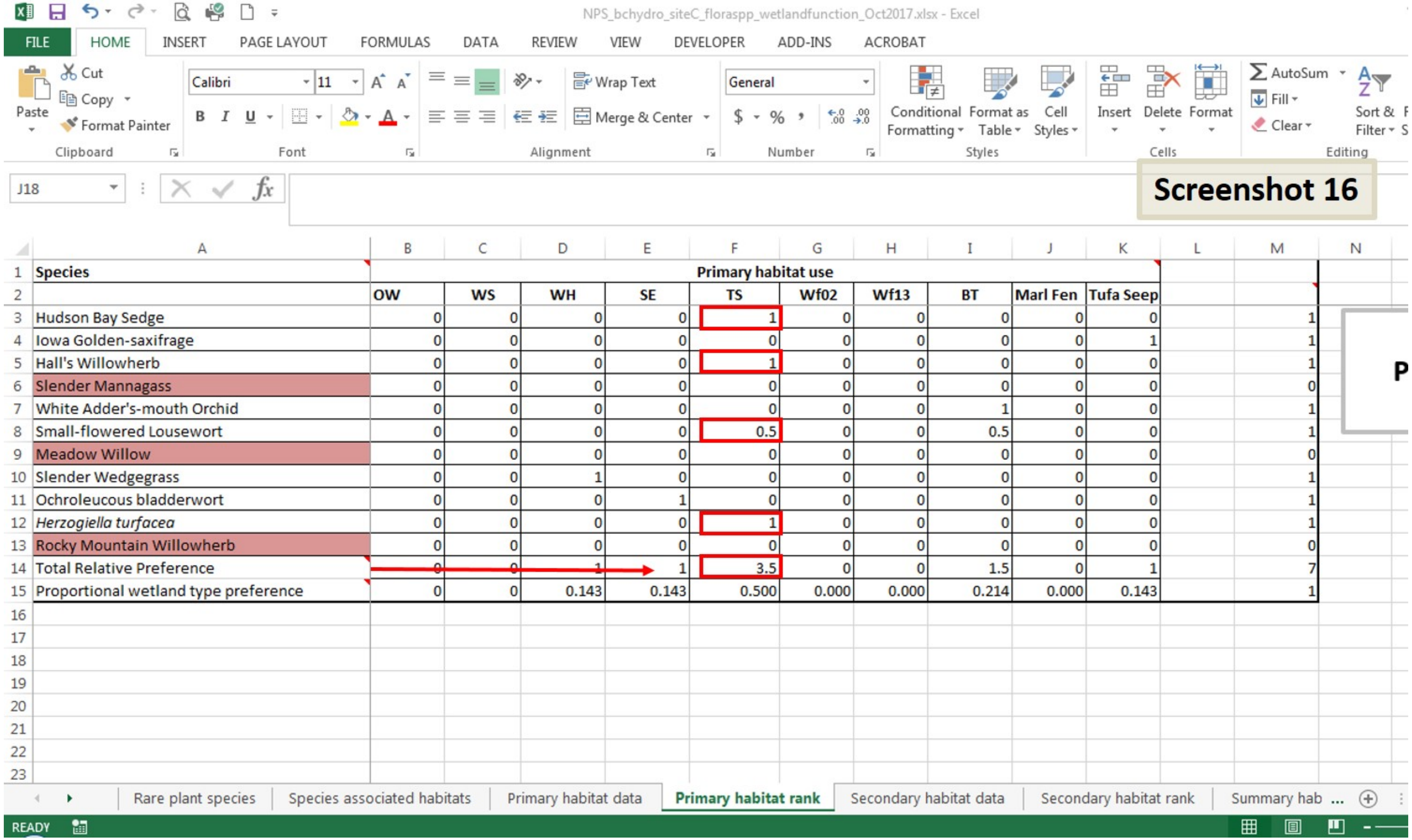
	Species	Primary habitat use										
2		OW	WS	WH	SE	TS	Wf02	Wf13	BT	Marl Fen	Tufa Seep	
3	Hudson Bay Sedge	0	0	0	0	1	0	0	0	0	0	1
4	Iowa Golden-saxifrage	0	0	0	0	0	0	0	0	0	1	1
5	Hall's Willowherb	0	0	0	0	1	0	0	0	0	0	1
6	Slender Mannagass	0	0	0	0	0	0	0	0	0	0	0
7	White Adder's-mouth Orchid	0	0	0	0	0	0	0	1	0	0	1
8	Small-flowered Lousewort	0	0	0	0	0.5	0	0	0.5	0	0	1
9	Meadow Willow	0	0	0	0	0	0	0	0	0	0	0
10	Slender Wedgegrass	0	0	1	0	0	0	0	0	0	0	1
11	Ochroleucous bladderwort	0	0	0	1	0	0	0	0	0	0	1
12	*Herzogiella turfacea*	0	0	0	0	1	0	0	0	0	0	1
13	Rocky Mountain Willowherb	0	0	0	0	0	0	0	0	0	0	0
14	Total Relative Preference	0	0	1	1	3.5	0	0	1.5	0	1	7
15	Proportional wetland type preference	0	0	0.143	0.143	0.500	0.000	0.000	0.214	0.000	0.143	1



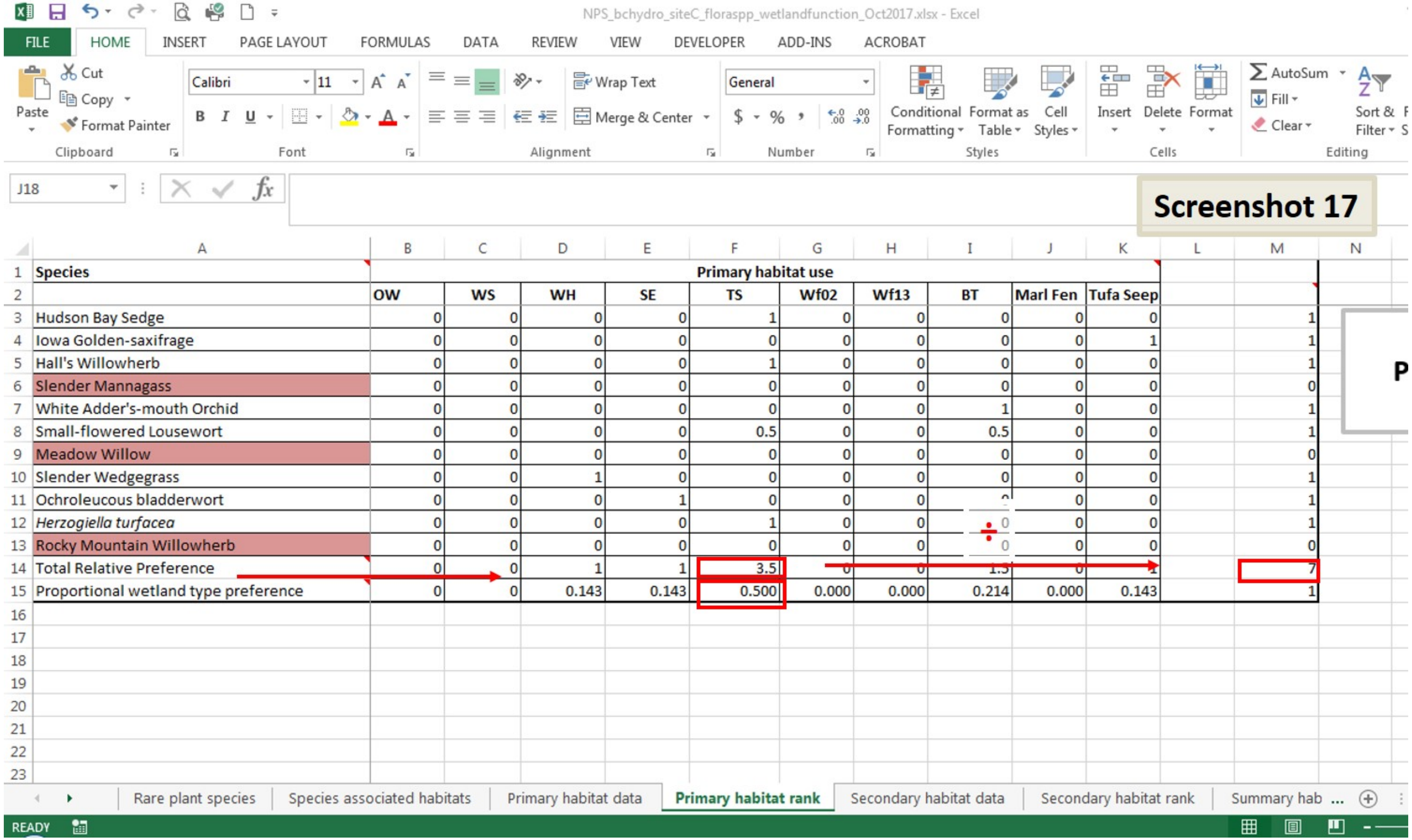
	A	B	E	I	M	Q	R	S	V	W	X
1	**Species**										
2		**Secondary habitat use**									
3		**OW**	**WS**	**WH**	**SE**	**TS**	**Wf02**	**Wf13:**	**BT**		
4	Hudson Bay Sedge		0.00	0.00	0.00	0.30	0.00	0.04	0.39		0.73
5	Iowa Golden-saxifrage		0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
6	Hall's Willowherb		0.01	0.09	0.01	0.20	0.10	0.03	0.30		0.73
7	Slender Mannagass		0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
8	White Adder's-mouth Orchid		0.02	0.02	0.02	0.25	0.21	0.12	0.31		0.94
9	Small-flowered Lousewort		0.00	0.00	0.00	0.18	0.00	0.00	0.44	→	0.62
10	Meadow Willow		0.08	0.32	0.00	0.00	0.00	0.00	0.00		0.39
11	Slender Wedgegrass		0.07	0.03	0.05	0.04	0.06	0.05	0.04		0.34
12	Ochroleucous bladderwort		0.16	0.12	0.08	0.08	0.11	0.08	0.00		0.61
13	*Herzogiella turfacea*		0.00	0.00	0.00	0.14	0.03	0.00	0.23		0.39
14	Rocky Mountain Willowherb		0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
15											
16											



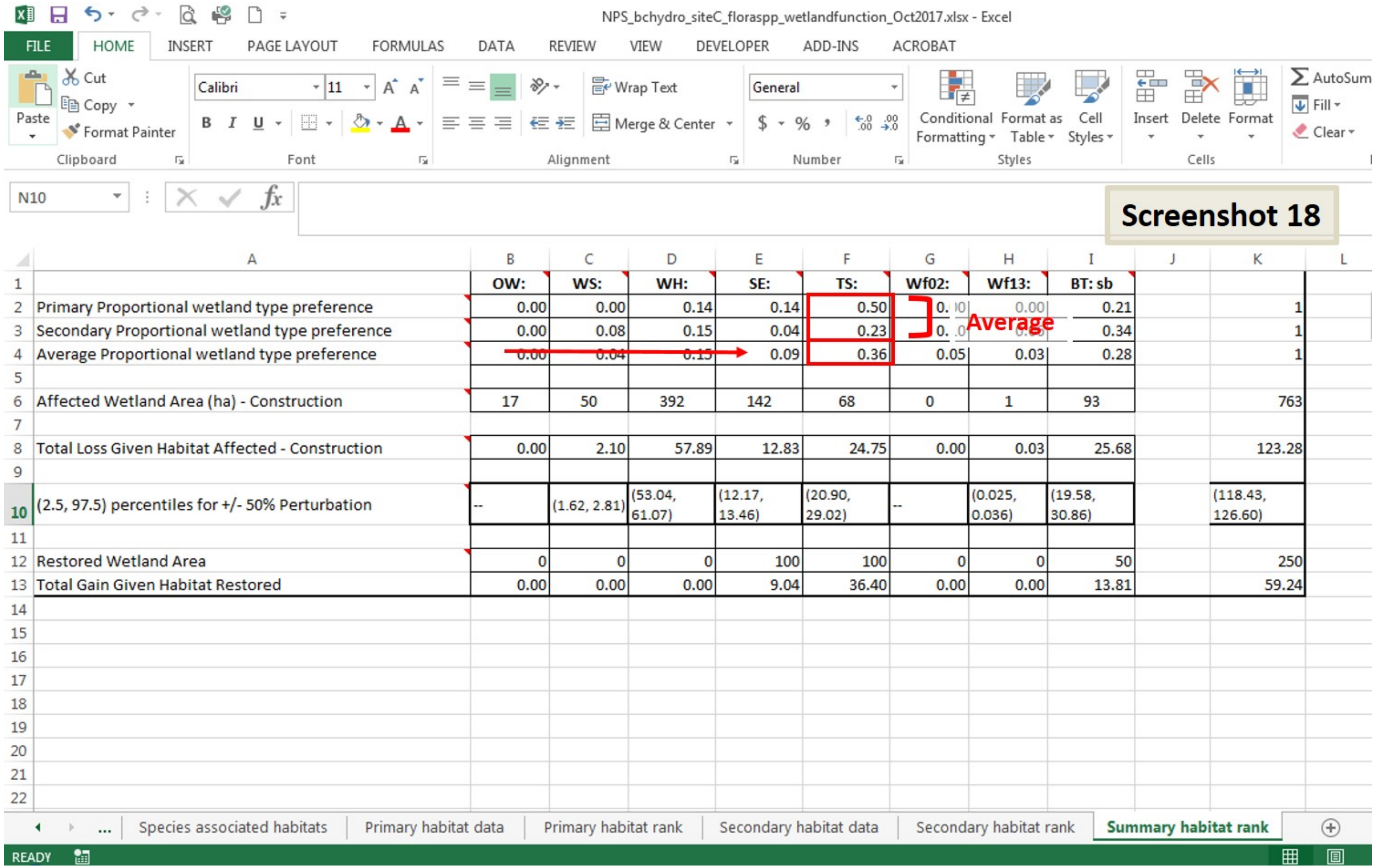
Species	Secondary habitat use ranking									
	OW	WS	WH	SE	TS	Wf02	Wf13	BT		
Hudson Bay Sedge	0	0	0	0	0.407	0	0.052	0.542		1
Iowa Golden-saxifrage	0	0	0	0	0	0	0	0		0
Hall's Willowherb	0	0.017	0.118	0.011	0.270	0.137	0.034	0.411		1
Slender Mannagass	0	0	0	0	0	0	0	0		0
White Adder's-mouth Orchid	0	0.016	0.021	0.021	0.262	0.223	0.127	0.329		1
Small-flowered Lousewort	0	0	0	0	0.296	0	0	0.704		1
Meadow Willow	0	0.191	0.809	0	0	0	0	0		1
Slender Wedgegrass	0	0.193	0.081	0.147	0.117	0.184	0.147	0.131		1
Ochroleucous bladderwort	0	0.256	0.191	0.123	0.123	0.184	0.123	0		1
Herzogiella turfacea	0	0	0	0	0.35	0.06	0	0.59		1
Rocky Mountain Willowherb	0	0	0	0	0	0	0	0		0
Total Relative Preference	0	0.67	1.22	0.30	1.82	0.79	0.48	2.70		8
Proportional wetland type preference	0	0.08	0.15	0.04	0.23	0.10	0.06	0.34		1



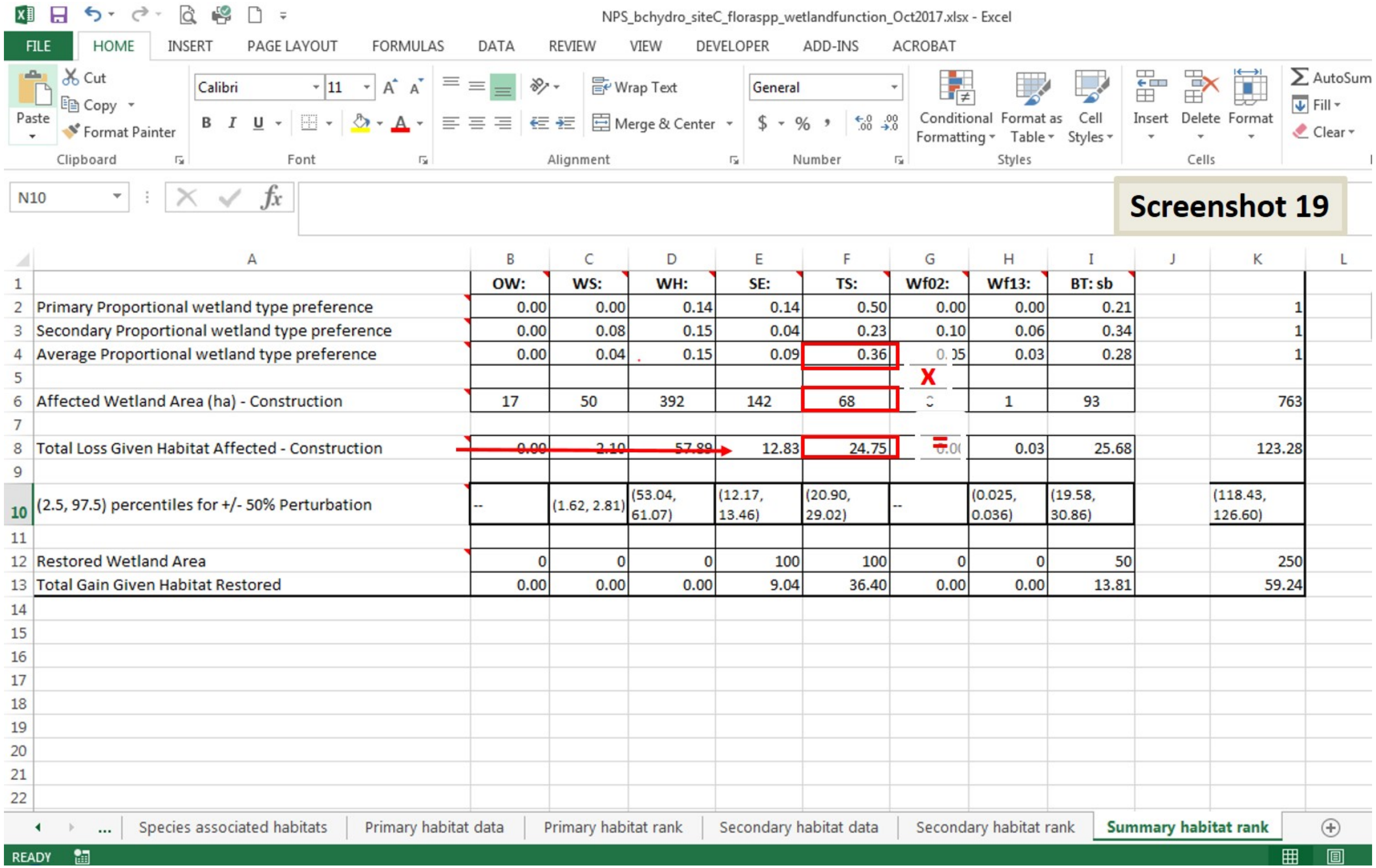
Species	Primary habitat use										
	OW	WS	WH	SE	TS	Wf02	Wf13	BT	Marl Fen	Tufa Seep	
Hudson Bay Sedge	0	0	0	0	1	0	0	0	0	0	1
Iowa Golden-saxifrage	0	0	0	0	0	0	0	0	0	1	1
Hall's Willowherb	0	0	0	0	1	0	0	0	0	0	1
Slender Mannagass	0	0	0	0	0	0	0	0	0	0	0
White Adder's-mouth Orchid	0	0	0	0	0	0	0	1	0	0	1
Small-flowered Lousewort	0	0	0	0	0.5	0	0	0.5	0	0	1
Meadow Willow	0	0	0	0	0	0	0	0	0	0	0
Slender Wedgegrass	0	0	1	0	0	0	0	0	0	0	1
Ochroleucous bladderwort	0	0	0	1	0	0	0	0	0	0	1
Herzogiella turfacea	0	0	0	0	1	0	0	0	0	0	1
Rocky Mountain Willowherb	0	0	0	0	0	0	0	0	0	0	0
Total Relative Preference	0	0	1	1	3.5	0	0	1.5	0	1	7
Proportional wetland type preference	0	0	0.143	0.143	0.500	0.000	0.000	0.214	0.000	0.143	1



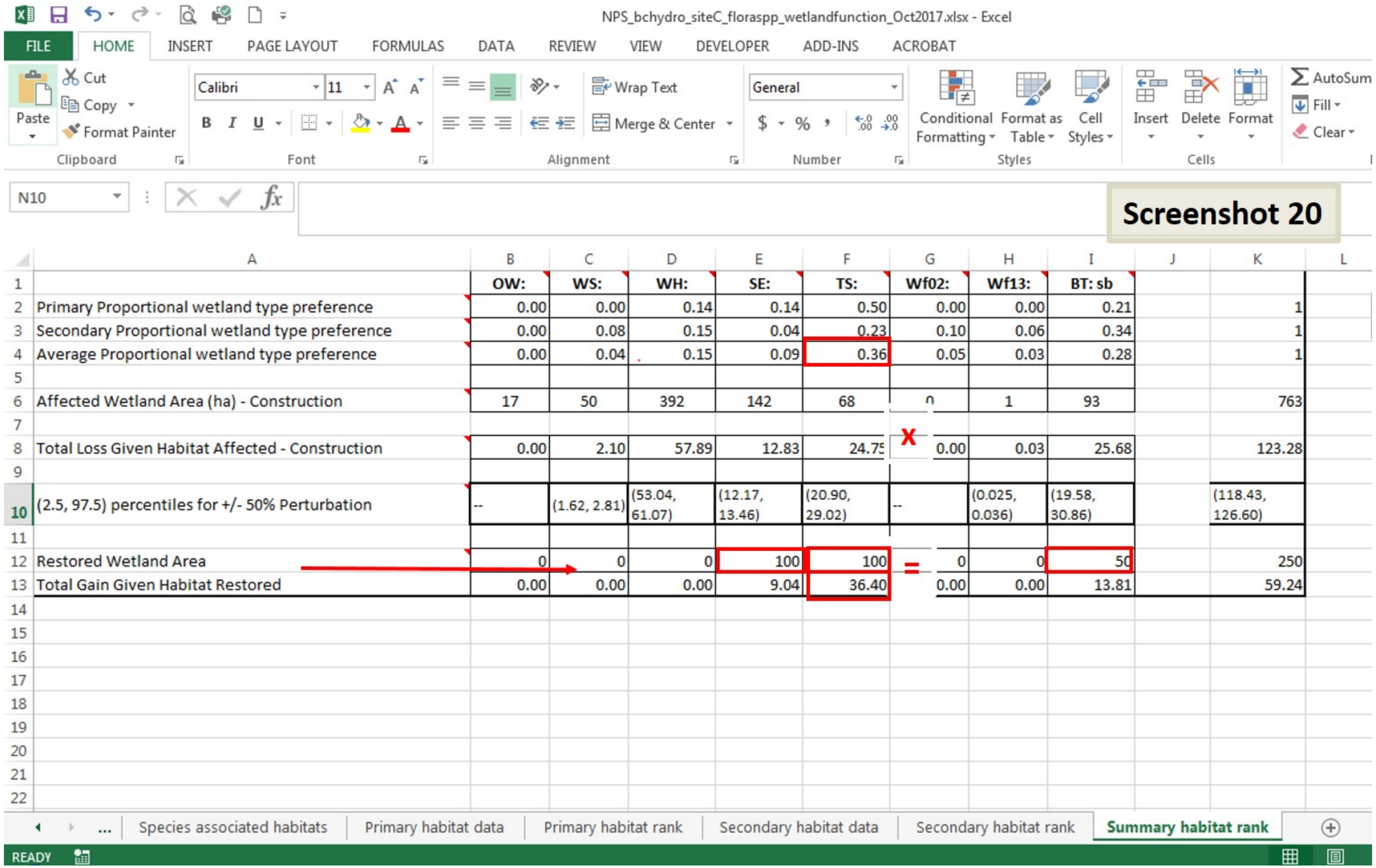
Species	OW	WS	WH	SE	TS	Wf02	Wf13	BT	Marl Fen	Tufa Seep		
	Primary habitat use											
Hudson Bay Sedge	0	0	0	0	1	0	0	0	0	0		1
Iowa Golden-saxifrage	0	0	0	0	0	0	0	0	0	1		1
Hall's Willowherb	0	0	0	0	1	0	0	0	0	0		1
Slender Mannagass	0	0	0	0	0	0	0	0	0	0		0
White Adder's-mouth Orchid	0	0	0	0	0	0	0	1	0	0		1
Small-flowered Lousewort	0	0	0	0	0.5	0	0	0.5	0	0		1
Meadow Willow	0	0	0	0	0	0	0	0	0	0		0
Slender Wedgegrass	0	0	1	0	0	0	0	0	0	0		1
Ochroleucous bladderwort	0	0	0	1	0	0	0	0	0	0		1
Herzogiella turfacea	0	0	0	0	1	0	0	0	0	0		1
Rocky Mountain Willowherb	0	0	0	0	0	0	0	0	0	0		0
Total Relative Preference	0	0	1	1	3.5	0	0	1.5	0	1		7
Proportional wetland type preference	0	0	0.143	0.143	0.500	0.000	0.000	0.214	0.000	0.143		1



	OW:	WS:	WH:	SE:	TS:	Wf02:	Wf13:	BT: sb		
Primary Proportional wetland type preference	0.00	0.00	0.14	0.14	0.50	0.[illegible]	0.00	0.21		1
Secondary Proportional wetland type preference	0.00	0.08	0.15	0.04	0.23	0.[illegible]	[illegible]	0.34		1
Average Proportional wetland type preference	0.00	0.04	0.15	0.09	0.36	0.05	0.03	0.28		1
Affected Wetland Area (ha) - Construction	17	50	392	142	68	0	1	93		763
Total Loss Given Habitat Affected - Construction	0.00	2.10	57.89	12.83	24.75	0.00	0.03	25.68		123.28
(2.5, 97.5) percentiles for +/- 50% Perturbation	--	(1.62, 2.81)	(53.04, 61.07)	(12.17, 13.46)	(20.90, 29.02)	--	(0.025, 0.036)	(19.58, 30.86)		(118.43, 126.60)
Restored Wetland Area	0	0	0	100	100	0	0	50		250
Total Gain Given Habitat Restored	0.00	0.00	0.00	9.04	36.40	0.00	0.00	13.81		59.24



	A	B	C	D	E	F	G	H	I	J	K
1		OW:	WS:	WH:	SE:	TS:	Wf02:	Wf13:	BT: sb		
2	Primary Proportional wetland type preference	0.00	0.00	0.14	0.14	0.50	0.00	0.00	0.21		1
3	Secondary Proportional wetland type preference	0.00	0.08	0.15	0.04	0.23	0.10	0.06	0.34		1
4	Average Proportional wetland type preference	0.00	0.04	0.15	0.09	0.36	0.05	0.03	0.28		1
5							X				
6	Affected Wetland Area (ha) - Construction	17	50	392	142	68	[illegible]	1	93		763
7											
8	Total Loss Given Habitat Affected - Construction	0.00	2.10	57.89	12.83	24.75	0.00	0.03	25.68		123.28
9											
10	(2.5, 97.5) percentiles for +/- 50% Perturbation	--	(1.62, 2.81)	(53.04, 61.07)	(12.17, 13.46)	(20.90, 29.02)	--	(0.025, 0.036)	(19.58, 30.86)		(118.43, 126.60)
11											
12	Restored Wetland Area	0	0	0	100	100	0	0	50		250
13	Total Gain Given Habitat Restored	0.00	0.00	0.00	9.04	36.40	0.00	0.00	13.81		59.24



	A	B	C	D	E	F	G	H	I	J	K
1		OW:	WS:	WH:	SE:	TS:	Wf02:	Wf13:	BT: sb		
2	Primary Proportional wetland type preference	0.00	0.00	0.14	0.14	0.50	0.00	0.00	0.21		1
3	Secondary Proportional wetland type preference	0.00	0.08	0.15	0.04	0.23	0.10	0.06	0.34		1
4	Average Proportional wetland type preference	0.00	0.04	0.15	0.09	0.36	0.05	0.03	0.28		1
5											
6	Affected Wetland Area (ha) - Construction	17	50	392	142	68	0	1	93		763
7							X				
8	Total Loss Given Habitat Affected - Construction	0.00	2.10	57.89	12.83	24.75	0.00	0.03	25.68		123.28
9											
10	(2.5, 97.5) percentiles for +/- 50% Perturbation	--	(1.62, 2.81)	(53.04, 61.07)	(12.17, 13.46)	(20.90, 29.02)	--	(0.025, 0.036)	(19.58, 30.86)		(118.43, 126.60)
11											
12	Restored Wetland Area	0	0	0	100	100	= 0	0	50		250
13	Total Gain Given Habitat Restored	0.00	0.00	0.00	9.04	36.40	0.00	0.00	13.81		59.24

Appendix F: Sensitivity Analysis Results

Results of the sensitivity analysis on the wetland function assessment models are presented below. Shown are the baseline values for 'Total Loss Given Habitat Affected – Construction', as compared to the 95% confidence intervals for a +/- 20% and +/- 50% perturbation.

	OW	WS	WH	SE	TS	Wf02	Wf13	BT	Total
	Migratory Birds Nesting								
Baseline	0.00	5.42	42.47	56.01	5.29	0.00	0.12	5.68	114.98
(2.5, 97.5) percentiles for +/- 20% Perturbation	--	(4.73, 6.13)	(36.91, 48.02)	(53.68, 58.38)	(4.68, 5.89)	--	(0.10, 0.13)	(4.93, 6.43)	(109.58, 120.14)
(2.5, 97.5) percentiles for +/- 50% Perturbation	--	(3.70, 7.19)	(28.58, 56.35)	(50.19, 61.93)	(3.78, 6.80)	--	(0.083, 0.15)	(3.81, 7.56)	(101.48, 127.88)
	Migratory Birds Feeding								
Baseline	6.70	3.17	24.88	34.50	1.53	0.00	0.08	2.09	72.94
(2.5, 97.5) percentiles for +/- 20% Perturbation	(6.17, 7.23)	(2.80, 3.54)	(21.91, 27.89)	(30.03, 38.93)	(1.33, 1.72)	--	(0.067, 0.087)	(1.82, 2.35)	(67.72, 77.9)
(2.5, 97.5) percentiles for +/- 50% Perturbation	(5.38, 8.02)	(2.25, 4.10)	(17.46, 32.40)	(23.33, 45.58)	(1.04, 2.01)	--	(0.052, 0.10)	(1.43, 2.75)	(59.89, 85.34)
	Migratory Birds Brood-rearing								
Baseline	9.56	0.00	0.00	26.63	0.00	0.00	0.13	0.00	36.31
(2.5, 97.5) percentiles for +/- 20% Perturbation	(9.35, 9.78)	--	--	(22.48, 30.77)	--	--	(0.11, 0.15)	--	(32.38, 40.23)
(2.5, 97.5) percentiles for +/- 50% Perturbation	(9.03, 10.09)	--	--	(16.27, 36.98)	--	--	(0.083, 0.17)	--	(26.48, 46.11)
	Migratory Birds Migration								
Baseline	8.66	3.49	27.39	16.29	1.96	0.00	0.08	2.68	60.56
(2.5, 97.5) percentiles for +/- 20% Perturbation	(8.50, 8.80)	(3.03, 3.91)	(24.28, 30.50)	(13.96, 18.69)	(1.68, 2.24)	--	(0.067, 0.087)	(2.30, 3.07)	(56.73, 64.27)
(2.5, 97.5) percentiles for +/- 50% Perturbation	(8.25, 9.00)	(2.34, 4.55)	(19.62, 35.16)	(10.46, 22.29)	(1.26, 2.66)	--	(0.052, 0.10)	(1.72, 3.64)	(50.99, 69.84)

	OW	WS	WH	SE	TS	Wf02	Wf13	BT	Total
	Amphibian Breeding								
Baseline	4.25	4.17	32.67	35.50	5.67	0.00	0.08	7.75	90.08
(2.5, 97.5) percentiles for +/- 20% Perturbation	(3.56, 4.96)	(3.69, 4.64)	(28.93, 36.4)	(29.41, 41.59)	(5.02, 6.31)	--	(0.074, 0.093)	(6.86, 8.64)	(83.11, 97.08)
(2.5, 97.5) percentiles for +/- 50% Perturbation	(2.53, 6.02)	(2.98, 5.36)	(23.33, 42.0)	(20.29, 50.71)	(4.05, 7.29)	--	(0.0007, 0.0015)	(5.54, 9.96)	(72.66, 107.56)
	Amphibian Feeding								
Baseline	0.00	7.14	56.00	20.29	9.71	0.00	0.14	13.29	106.57
(2.5, 97.5) percentiles for +/- 20% Perturbation	--	(6.51, 7.78)	(51.02, 60.98)	(18.48, 22.09)	(8.85, 10.58)	--	(0.13, 0.16)	(12.10, 14.47)	(102.07, 111.31)
(2.5, 97.5) percentiles for +/- 50% Perturbation	--	(5.56, 8.73)	(43.56, 68.44)	(15.78, 24.79)	(7.56, 11.87)	--	(0.11, 0.17)	(10.33, 16.24)	(95.31, 118.42)
	Amphibian Wintering								
Baseline	5.67	16.67	130.67	0.00	0.00	0.00	0.00	0.00	153
(2.5, 97.5) percentiles for +/- 20% Perturbation	(5.67, 5.67)	(13.33, 20.00)	(104.53, 156.8)	--	--	--	--	--	(130.2, 175.8)
(2.5, 97.5) percentiles for +/- 50% Perturbation	(5.67, 5.67)	(8.33, 25.00)	(65.33, 196)	--	--	--	--	--	(96, 210)
	Bats Feeding								
Baseline	1.59	6.25	49.00	13.31	12.75	0.00	0.09	17.44	100.44
(2.5, 97.5) percentiles for +/- 20% Perturbation	(1.50, 1.70)	(5.80, 6.73)	(45.5, 52.15)	(12.43, 14.07)	(11.41, 14.09)	--	(0.088, 0.10)	(15.51, 19.35)	(97.35, 103.27)
(2.5, 97.5) percentiles for +/- 50% Perturbation	(1.37, 1.86)	(5.13, 7.46)	(40.25, 56.88)	(11.09, 15.21)	(9.41, 16.09)	--	(0.078, 0.11)	(12.63, 22.21)	(92.73, 107.52)

	OW	WS	WH	SE	TS	Wf02	Wf13	BT	Total
					Bats Roosting				
Baseline	0.00	18.75	147.00	0.00	8.50	0.00	0.00	11.63	185.88
(2.5, 97.5) percentiles for +/- 20% Perturbation	--	(15.00, 22.50)	(117.6, 176.4)	--	(6.8, 10.2)	--	--	(9.3, 13.95)	(160.73, 211.02)
(2.5, 97.5) percentiles for +/- 50% Perturbation	--	(9.38, 28.13)	(73.50, 220.50)	--	(4.25, 12.75)	--	--	(5.81, 17.44)	(123.02, 248.73)
					Fauna Species at Risk				
Baseline	1.36	2.98	81.81	32.38	10.61	0.00	0.07	11.86	141.07
(2.5, 97.5) percentiles for +/- 20% Perturbation	(1.39, 1.50	(2.47, 3.27)	(70.84, 90.617)	(29.48, 35.22)	(9.07, 11.67)	--	(0.061, 0.076)	(10.11, 13.43)	(132.14, 146.66)
(2.5, 97.5) percentiles for +/- 50% Perturbation	(1.35, 1.54)	(2.26, 3.57)	(57.27, 104.73)	(25.21, 39.29)	(7.19, 13.52)	--	(0.051, 0.087)	(7.65, 15.87)	(121.94, 157.06)
					Flora Species at Risk				
Baseline	0.00	2.10	57.89	12.83	24.75	0.00	0.03	25.68	123.28
(2.5, 97.5) percentiles for +/- 20% Perturbation	--	(1.88, 2.35)	(56.27, 59.33)	(12.57, 13.09)	(21.73, 27.80)	--	(0.028, 0.032)	(21.43, 29.8)	(121.12, 125.415)
(2.5, 97.5) percentiles for +/- 50% Perturbation	--	(1.62, 2.81)	(53.04, 61.07)	(12.17, 13.46)	(20.90, 29.02)	--	(0.025, 0.036)	(19.58, 30.86)	(118.43, 126.60)
					Species Important to Aboriginal Land Use				
Baseline	0.00	8.89	69.69	9.47	11.33	0.00	0.07	25.83	125.28
(2.5, 97.5) percentiles for +/- 20% Perturbation	--	(7.61, 10.17)	(59.67, 79.71)	(7.57, 11.36)	(9.07, 13.6)	--	(0.053, 0.08)	(20.67, 31.0)	(115.39, 135.07)
(2.5, 97.5) percentiles for +/- 50% Perturbation	--	(5.69, 12.08)	(44.64, 94.73)	(4.73, 14.20)	(5.67, 17.0)	--	(0.033, 0.10)	(12.92, 38.75)	(100.56, 149.76)

Appendix G. Sampling Effort Results

In order to estimate the effort required to populate the functional assessment approach with field collected data for all species of interest, Native Plant Solutions (NPS) used statistical power analyses to estimate the sampling efforts required to detect differences in species densities among wetland habitats. From the raw data provided, NPS estimated an average number of detections and standard deviation of detections. Per common guidelines, NPS assumed an alpha significance level of 0.05 and statistical power of 80%. These values were used as inputs for statistical power analyses in SAS software (PROC POWER). Resulting estimates represented the smallest sampling efforts that would permit detecting practical differences on the order of 20, 50, 100, 200, 250% from baseline with 80% statistical power and an alpha significance level of 0.05 (Table G1).

Table G1. Sampling effort per habitat type required to be able to detect magnitude differences in species group-densities among wetland habitats.

Species Group / Wetland Habitat Classification	Baseline Density	Difference from baseline density					
		20%	50%	100%	150%	200%	250%
Amphibian Calls							
PSMA / Broad Habitat	0.57	756	122	46	18	10	6
PSMA / Detailed Habitat	1.14	765	124	32	15	9	7
Marshbird Surveys							
Forest-nesting Shorebirds / Broad Habitat	0.19	2352	378	95	43	25	17
Forest-nesting Shorebirds / Detailed Habitat	0.58	361	59	16	8	5	4
Dabbling Ducks / Broad Habitat	0.38	4594	736	185	83	47	31
Dabbling Ducks / Detailed Habitat	2.08	629	100	26	12	8	6
Diving Ducks / Broad Habitat	1.31	3515	564	142	64	37	24
Diving Ducks / Detailed Habitat	3.11	992	159	41	19	11	8
Cavity-nesting Ducks / Broad Habitat	0.37	2375	381	96	44	25	17
Cavity-nesting Ducks / Detailed Habitat	0.83	724	117	30	14	8	6
Species Group / Wetland Habitat Classification	**Baseline Density**	**Difference from baseline density**					
		20%	**50%**	**100%**	**150%**	**200%**	**250%**
Marshbird Surveys (cont.)							
Swans & Geese / Broad Habitat	0.057	6391	1024	257	115	65	42
Swans & Geese / Detailed Habitat	0.44	615	100	26	12	8	6
Waterbirds / Broad Habitat	0.087	6353	1018	256	114	65	42
Waterbirds / Detailed Habitat	--	--	--	--	--	--	--
Terns & Gulls / Broad Habitat	1.25	4798	769	193	87	49	32
Terns & Gulls / Detailed Habitat	8.56	857	139	36	17	10	7

Marsh-nesting Shorebirds / Broad Habitat	0.21	1647	265	67	31	18	12
Marsh-nesting Shorebirds / Detailed Habitat	0.31	394	60	16	8	5	4
Rails / Broad Habitat	0.25	1832	294	75	34	20	13
Rails / Detailed Habitat	0.29	875	132	34	15	9	6
Open-habitat Songbirds / Broad Habitat	0.23	2165	348	88	40	23	15
Open-habitat Songbirds / Detailed Habitat	--	--	--	--	--	--	--
Deciduous Songbirds / Broad Habitat	0.17	2875	461	116	53	30	20
Deciduous Songbirds / Detailed Habitat	0.75	244	39	11	6	4	3
Coniferous Songbirds / Broad Habitat	0.39	1266	204	52	24	14	10
Coniferous Songbirds / Detailed Habitat	0.46	252	42	12	6	4	3
Breeding Bird Surveys							
Forest-nesting Shorebirds / Broad Habitat	0.07	2167	348	88	40	23	16
Species Group / Wetland Habitat Classification	**Baseline Density**	**Difference from baseline density**					
		20%	**50%**	**100%**	**150%**	**200%**	**250%**
Breeding Bird Surveys (cont.)							
Forest-nesting Shorebirds / Detailed Habitat	--	--	--	--	--	--	--
Dabbling Ducks / Broad Habitat	0.143	984	156	40	18	11	7
Dabbling Ducks / Detailed Habitat	--	--	--	--	--	--	--
Diving Ducks / Broad Habitat	0.265	3224	513	129	58	33	22
Diving Ducks / Detailed Habitat	--	--	--	--	--	--	--
Cavity-nesting Ducks / Broad Habitat	0.182	2390	375	94	42	24	16
Cavity-nesting Ducks / Detailed Habitat	--	--	--	--	--	--	--
Swans & Geese / Broad Habitat	0.055	3461	555	140	63	36	24
Swans & Geese / Detailed Habitat	--	--	--	--	--	--	--
Waterbirds / Broad Habitat	--	--	--	--	--	--	--
Waterbirds / Detailed Habitat	--	--	--	--	--	--	--
Terns & Gulls / Broad Habitat	0.06	3846	616	155	69	40	26
Terns & Gulls / Detailed Habitat	--	--	--	---	--	--	--
Marsh-nesting Shorebirds / Broad Habitat	0.44	341	55	14	7	4	3

Marsh-nesting Shorebirds / Detailed Habitat	0.325	465	73	19	9	6	4
Rails / Broad Habitat	0.17	666	108	28	13	8	5
Rails / Detailed Habitat	0.062	1946	313	79	36	21	14
Open-habitat Songbirds / Broad Habitat	0.026	1898	305	77	35	20	14
Species Group / Wetland Habitat Classification	**Baseline Density**	**Difference from baseline density**					
		20%	**50%**	**100%**	**150%**	**200%**	**250%**
Breeding Bird Surveys (cont.)							
Open-habitat Songbirds / Detailed Habitat	--	--	--	--	--	--	--
Deciduous Songbirds / Broad Habitat	0.96	91	15	4	2	2	2
Deciduous Songbirds / Detailed Habitat	0.79	190	30	8	4	3	2
Coniferous Songbirds / Broad Habitat	0.825	44	7	2	2	2	2
Coniferous Songbirds / Detailed Habitat	0.95	91	16	5	3	2	2

-- = In the original dataset, individuals were counted in only one or zero habitats and therefore no estimates were possible.

Table 1 can be used to plan sampling efforts required in order to detect differences between wetland habitats of a given magnitude. Alternatively, it may be used to understand the magnitudes of differences one would be able to detect given restricted sampling efforts.

Example 1

Biologists often feel that a doubling in density of amphibians (PSMA) is a biological meaningful difference among two wetland habitats. For this example, this is equivalently expressed as a difference of 100% between broad habitat, which for PSMA would be a difference of (1.0)*(0.57) = 0.57 PSMA per station. In order to be able to detect that magnitude of difference, we need to survey anywhere from 32 to 46 wetlands of each wetland type in Site C footprint.

Example 2

In example 2, the biologist's team has a limited budget or limited number of wetland areas available for future sampling efforts. For example, if in this case we are only able to survey 30 stations per wetland habitat type in order to estimate the density of forest-nesting shorebirds then the field study will only be able to detect differences on the order of 150%-200% of baseline density for broad habitat classifications. For forest-nesting shorebirds, this is a difference between wetland habitats of at minimum (1.50)*(0.19) = 0.285 forest-nesting shorebirds per station.

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Appendix H. External Review of the Wetland Function Assessment Report

Listed below is feedback received on the November 2015 and December 2016 versions of the wetland function assessment report from Environment and Climate Change Canada (ECCC), Ministry of Forests, Lands and Natural Resource Operations (FLNRO) and Ministry of Environment (MOE) in July 2016 and June 2017 respectively. Note that in the June 2017 round of responses received from reviewers, some chose to also reply to BC Hydro's (BCH) response from December 2016. These have been listed in the 'Reply, June 2017' column, to which BC Hydro responded in the 'BCH response to June 2017 Reply' column.

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
1	ECCC: July 8, 2016	Nov 2015 report version	2	1	ECCC expresses a concern that the Report and associated WFA may not meet requirements as laid out under Federal Condition 11. The Department nevertheless continues to engage, along with provincial environmental and resources ministries, in BC Hydro's consultation process, including providing expert advice as and where requested.	Baseline data requested in 11.4.1 was provided in the Vegetation and Wildlife Mitigation and Monitoring Plan. In response to comments received at the January 2016 meeting, BC Hydro conducted additional field-truthing of wetlands along the transmission line right-of-way. 58 of 60 areas identified as wetlands on the transmission line right-of-way were visited and their classification confirmed. This information will be used to record wetland characteristics of each type to be lost, in order to ensure that wetland characteristics are being replaced through the mitigation plan.	To confirm, the model does not provide outputs in terms of wetland class size and species needs such this aspect of the assessment/evaluation is dependent entirely upon professional judgement	The model provides outputs in terms of wetland class size (e.g., number of ha of SE wetland type, according to provincial wetland classification) and species needs (e.g., number of ha of SE wetland to support the functional needs of breeding amphibians). Small components of the model were based on professional judgement (i.e., migratory birds and their functional needs); however, the majority of the wetland function assessment is based on information from peer-reviewed literature and data collected by BC Hydro, where it can inform the model.

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
2	ECCC: July 8, 2016	Nov 2015 report version	2	3	Because it relies on non-habitat associated presence data, the WFA model requires certain assumptions, which are not based on sound ecological principles. For example, the model assumes that indicator species have no preference between wetland types in which they are found; that relative indicator species usage of habitats is proportional to habitat availability; and that wetland condition does not significantly impair usage.	Where available from the baseline data, the approach has used wetland habitat-associated presence data (e.g., rare plants). To test the assumption that indicator species have no preference between wetland types, the approach now includes a sensitivity analysis that estimates the uncertainty associated with this assumption (see section 'Model assumptions and sensitivity analysis Page 44 in the Function Assessment). While the usage of habitat is proportional depending on the number of wetland types preferred, species preference for one wetland type compared to another wetland type is represented in the model.		
3	ECCC: July 8, 2016	Nov 2015 report version	2	4	In support of Federal Condition 11, ECCC recommends that the Report describe how baseline data on biogeochemical and hydrological wetland functions will be collected and used to address uncertainty in the WFA model.	At this time, general characteristics of habitat features for the different wetland types have been inferred from descriptions for the project area (Hilton et al. 2013d) and across the province (Mackenzie and Moran 2004). Further information on the wetland habitat features, as per Federal condition 11.4.1, were collected along the transmission line right-of-way in August of 2016. The following data were recorded at each wetland: wetland type, elevation, slope aspect, terrain, exposure, site disturbance, site attributes, soil texture, surficial material, vegetation present and percent cover. Additional site specific data on wetland characteristics will be recorded as part of the wetland monitoring program (see Step 5 on Page 47 of the function assessment).	The response does not indicate what, if any, baseline hydrological and biochemical data has been collected (in support of FDS 11.4.1)	In response to comments received at the January 2016 meeting, BC Hydro conducted additional field-truthing of wetlands along the transmission line right-of-way. 58 of 60 areas identified as wetlands on the transmission line right-of-way were visited and their classification confirmed. This information will be used to record wetland characteristics of each type to be lost.

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
4	ECCC: July 8, 2016	Nov 2015 report version	2	5	Pre-construction surveys which rely exclusively on desk surveys through literature reviews and remote mapping exercises are, in ECCC's opinion, insufficient to assess wetland function, at the scale at which Project activities occur, or to protect species at risk and current use of lands and resources for traditional purposes. ECCC recommends site specific ground surveys be conducted to assess the numbers, size and functions of wetlands that will be lost; this work is a critical step by which to avoid, mitigate, and compensate Project impacts.	As part of this approach to assessing wetland function and our ability to use field collected data to inform all components of the approach (see Appendix C for Site C data sets used), an analysis was done using Site C's existing data sets in order to understand the effort required to populate the Functional Wetland Assessment (FWA) model with real data for all the migratory and rare species of interest (see Appendix G). The model for rare plant species incorporated field collected data into the model. Field collected data was used to indicate For most migratory species, the data set analysis presented in Appendix G indicated that the number of wetlands, by type, needed to inform the model with the degree of biological accuracy required for the species groups of interest was not feasible. As presented at the January 2016 meeting: sample size requirements to provide species abundance and density data that would verify indicator species habitat use, to a marginal quality compared to existing baseline data (i.e., +/- 50%), would require tripling to quadrupling of the previous sample effort. For most migratory species groups the number of wetlands needed to be investigated by wetland type in order to inform the model do not exist within the Site C Project Area.	The response reflects potential shortcomings with the model; for example, that '*there is an insufficient number of wetlands within the project necessary to inform the model'*. For this and other reasons, a conservative approach is appropriate in implementation of the model to support compensation measures, in particular in relation to species at risk.	BC Hydro agrees that a conservative approach is warranted to assist in addressing uncertainty with the model. BC Hydro will work with the VWTC to determine how model outputs will be used to quantify wetland mitigation works.
5	ECCC: July 8, 2016	Nov 2015 report version	2	5	The WFA (at time of writing) is based on the same data that BC Hydro collected for the Project environmental assessment; therefore, it does not include the additional data input identified in Federal Condition 11.4.1. The WFA can be used to set compensation targets; however, those targets will not be based on the type of data identified in Federal Condition 11.4.1.	Baseline data requested in 11.4.1 was provided in the Vegetation and Wildlife Mitigation and Monitoring Plan dated June 5, 2015. In response to comments received at the January 2016 Wetland Function Assessment meeting BC Hydro conducted additional field truthing of wetlands along the transmission line right-of-way.		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
6	ECCC: July 8, 2016	Nov 2015 report version	2-3	6&1	It would be helpful if the Report clarified the term 'Indicator Species'. An Indicator Species is typically used in situations where a measure of a specific aspect of a very complex biological phenomenon is being sought. For the WFA model, Indicator Species will not achieve this purpose but rather serve to: o reduce to manageable levels the numbers of species inputs to the model; and, o represent, in very broad terms only, habitat use of larger bird groups.	A definition of how the term 'indicator species' is applied in this process is already provided in the report: "*Indicator species is a species whose presence in a given area is used to indicate suitable conditions for a broader group of additional species."* We have referenced this definition again in Step 2 of the report where it is first applied. Our use of indicator species fits with the definition provided – indicator species used are being used as measures of wetland function for migratory birds, species at risk and species important to Aboriginal land use – a complex biological phenomenon that is difficult to measure. The second bullet point provided by the reviewer is already included in the definition provided.	The term 'Model Species' (referenced by taxonomic group) might have been better/clearer so as to avoid confusion given traditional use of the '*Indicator Species'* term	As the selected species are indicators of broader wildlife and vegetation communities, we feel that the use of the term indicator species is appropriate as applied in the WFA.
7	ECCC: July 8, 2016	Nov 2015 report version	3	2	Along the above lines, it would be helpful to ECCC to have a more fulsome understanding of the Indicator Species selection process. For example: o why were certain habitat generalists (Mallard) included in the model and others not (Ring-necked Duck)? o is there bias introduced to the WFA model based on rare species selection criteria (of 100 individuals or less of rare species)? In particular, given the nature of the baseline data, does removing rare species decrease wetland function scores, which in turn reduce compensation habitat area targets? o why were species such as Spotted Sandpiper, Common Loon, and Canada Goose not selected?	To clarify the decision-making process for migratory bird indicator species, we have added a flow chart to accompany the text. The mallard was not included in the model, the ring-necked duck was included in the model. Based on expert consultation, we do not consider the ring-necked duck, in terms of wetland habitat type selection, a generalist. The rare species selection criteria does not introduce bias into the model. Excluding 'species with low abundance documented during baseline surveys that are not species at risk is reasonable. Species seen once over four years of baseline surveys would not be good indicators of functional use for wetland habitat types. The common loon was included in the model. Spotted sandpiper and Canada goose were not included in the model, as priority was first given to BCR6 species as recommended by CWS. The included flow chart should further clarify this decision process.		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
8	ECCC: July 8, 2016	Nov 2015 report version	3	3	The WFA model should account for both direct impacts (for example, but not limited to, filling and grading of wetlands, vegetation removal, building footprints, and changes in water levels and drainage patterns) and indirect impacts (for example, but not limited to, deposition of sediments to downstream wetlands, fragmentation of a wetland from a contiguous wetland complex, loss or alterations in recharge area, disturbance arising from increased public access and use, and elevated noise and light levels) that result in the impairment of wetland functions supporting migratory birds and species at risk. In relation to indirect impacts, the Report needs to identify and describe the data and how it is being applied to support the WFA model.	No monitoring is planned to estimate the extent of indirect wetland impacts on wetland function. The sensitivity analysis now included in the current version of the document will address direct and indirect effects to wetland functions. In addition, buffers are to be applied as per recommendations in the Forest and Range Protection Act. This information has now been included in Step 5 (monitoring section).	The extent to which the sensitivity analysis captures an indirect effect is not entirely clear, at least in ecological terms. It seems the model is quite insensitive to changes in species' habitat preferences as this relates to function losses, which puts into questions how well the model will perform in the real world terms, in particular for habitat specialists/species at risk.	We cannot be certain that this will provide adequate compensation for indirect effects; however, we feel the 95% CI presents a conservative approach to account for direct and indirect effects. Although information in the literature may exist on the effect of indirect effects to migratory birds or species at risk at a general level, this information is not available at a species-level, for each function and wetland type found in the LAA, as required to inform the wetland function assessment. Appendix G provides an example of required sampling effort in the LAA to inform the model with accurate and reliable information. A conservative approach is warranted to assist in addressing uncertainty with the model, including indirect effects. BC Hydro will work with the VWTC to determine how model outputs will be used to quantify wetland mitigation works.

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
9	ECCC: July 8, 2016	Nov 2015 report version	3	4	Based on Decision Statement Condition 11 (refer to conditions 11.1, 11.2, and 11.4.1), ECCC recommends that: o all federally- and provincially-listed at risk wildlife should be considered and incorporated, on a species-specific basis, into the WFA model; and, o species at risk should not be grouped unless there is otherwise a strong scientifically-based rationale for doing so.	We have now included all species at risk that were: 1. Found in the LAA 2. Are wetland-associated (i.e., use a wetland habitat for an important function, such as nesting) in the LAA 3. Were not transients to the LAA and found in low numbers during baseline studies These species at risk are considered on an individual basis and have been included into the model. A description for this step has also been included.		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
10	ECCC: July 8, 2016	Nov 2015 report version	3	5	One important aspect of the WFA model to note is that the functional scores are readily manipulated simply by changing species inputs, for example, the number of indicator species used in the model, and the proportion of these that are habitat obligates or habitat generalists. A chapter needs to be dedicated in the Report to describing model assumptions and the implications of each, in particular, how and the extent to which they influence functional scores. This discussion should include, amongst other things, the implications of how wetland productivity and patch size are not accounted for in the model and how they will be addressed. Examples of other areas of uncertainties include in relation to: o the habitat rankings; o how the baseline data was used to identify Indicator Species; o measures of biodiversity, rarity and abundance; o the lack of model validation; and, o how compensation outcomes will be verified against the baseline condition.	Habitat generalists have not been included in the model. A clear decision-making process has been made to include indicator species in the model (further detail on this has been added). The habitat information has been based on extensive research in peer-reviewed literature, as well as where species-specific information was available from Site C baseline studies. We have now separated all information on model assumptions into its own section (see 'Model assumptions and sensitivity analysis') and conducted a sensitivity analysis to test the uncertainty related to one of the model assumptions. BC Hydro is working on an accounting framework to quantify the mitigation.	See [reply to] Comment #8	We have now moved the 'Model assumptions' to the head of the model description (Section 5.0). A conservative approach is warranted to assist in addressing uncertainty with the model, including application of the sensitivity analysis in the accounting framework. BC Hydro will work with the VWTC to determine how model outputs will be used to quantify wetland mitigation works.

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
11	ECCC: July 8, 2016	Nov 2015 report version	4	2	While the use of Indicator Species generates functions-based indices, the supporting data are not sufficiently robust to assess and quantify the errors associated with each index. The WFA model does not incorporate measures of variance nor is a discussion offered on the implications of this on compensation targets. Options to address uncertainty could include (amongst others) undertaking a sensitivity analysis, and introducing statistical measures of variance, i.e. standard error, confidence intervals, etc. ECCC's assumption is that the uncertainty associated with each index is likely to be quite large and is that this uncertainty is highly relevant to the setting of compensation and mitigation goals and programs.	We have conducted a sensitivity analysis to test the uncertainty related to one of the model assumptions and have now included it in the report. This provides at 95% confidence interval for 'Total Loss Given Habitat Affected – Construction', following a 20% and 50% 'perturbation' to species-habitat associations. Overall, a +/-50% perturbation to indicator species' habitat preferences had on average a +/-10% change to total functional loss values for each functional group. This suggests that uncertainty associated with Assumption #1 for fauna and flora will have limited effect on the model output.		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
12	ECCC: July 8, 2016	Nov 2015 report version	4	3	The WFA model does not account for the time delays between when the functions would be lost and when replaced. An analysis of the 'costs' associated with functions losses until they are fully replaced is warranted, and a description of how these delays are to be incorporated into the compensation targets would be appropriate, i.e. application of 'discount rates'.	The time-lag between will not be incorporated into the assessment as it is outside the scope of the mitigation requirements. FDS 11.8 requires BC Hydro to initiate wetland mitigation within 5 years of the start of construction. BC Hydro initiated wetland mitigation in 2014 and continues to work on identifying and adding additional lands to the program.	The issue of time lags is well described in the literature, recognized in practice, and therefore in our view not '*out of scope'*. Time lags are inevitable and various approaches are available to BC Hydro to address them (for example, through the use of compensation ratios of >1 supported by discount rates, etc).	BCH acknowledges and understands the VWTC's concerns related to time lags. However, the wetland function assessment is not intended to consider the effects of time lags, and focusses instead on the loss and gain of wetland functions in an absolute sense. Concerns related to time lags can be dealt with outside the framework of the WFA on a case by case basis for wetland creation, restoration or enhancement opportunities.
13	ECCC: July 8, 2016	Nov 2015 report version	4	4	In support of Federal Condition 11.3, the Report should include an assessment of how the mitigation hierarchy has been considered.	This is discussed in Section 7.3.2.2 of the Vegetation and Wildlife Mitigation and Monitoring Program Plan submitted to agencies in June 2015. The document can be found at the link below: https://www.sitecproject.com/sites/default/files/Veg_and_Wildlife_Mit_and_Mon_Plan.pdf		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
14	ECCC: July 8, 2016	Nov 2015 report version	4	5	ECCC's advice regarding no-net-loss of wetland functions is grounded within a 'like for like' ('in kind') approach for achieving habitat compensation targets. For clarity, the 'like for like' approach applies to both the functions and the wetland habitats that provide the functions. The WFA model, on the other hand, is based on 'out of kind' such that impact and compensation targets can - and perhaps likely will - be different (as noted above, the WFA uses wetland functions as the currency for replacement, not habitat). ECCC recognizes the need for flexibility in approach, in particular for complex projects such as Site C. Specifically, while a like-for-like approach is preferred, other approaches to achieving a no-net-loss of wetland functions are appropriate (as determined in the development of programs under which habitat and functions assessments are completed).	Thank you for this comment. FDS 11.4.4 requires BC Hydro to identify compensation measures to address the unavoidable loss of wetland areas and functions…in support of the objective of full replacement of wetlands in terms of area and function. The function assessment and wetland mitigation plan has been developed to comply with the requirements of this condition.		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
15	ECCC: July 8, 2016	Nov 2015 report version	5	1	Because the WFA model function outputs are not like-for-like, there is no indication of the number or size of wetlands that would be subject to compensation. This creates uncertainty (refer to the first bullet under the WFA Model heading) in terms of how the model outcomes will be translated into conservation programs. BC Hydro describes the mechanism through which compensation targets will be set from the functions assessment. Further explanations are needed to determine how the model compensation targets generated link with the functional needs, by habitat and habitat area, for each Indicator Species under each Species Group (for example, for any species that nest only on large wetlands such as the Trumpeter Swan).	The WFA model allows for the calculation of wetland functions replaced by wetland hectares restored or protected by BC Hydro, based on the species of interest and the type of wetland being restored or preserved. This approach can be used for reporting and tracking purposes. The WFA model also allows for separate calculations by each individual guild or category, so that as hectares of wetlands are being restored one can calculate the functions replaced for breeding migratory birds or overwintering amphibians, etc.		
16	ECCC: July 8, 2016	Nov 2015 report version		Recom. 1	Regardless of whether BC Hydro proceeds with the current proposed approach or alternate procedure, that species abundance and density data be collected on an ongoing basis to reduce uncertainty associated with assessment outcomes and to meet Federal Condition 11.	As presented at the January 2016 meeting (see Appendix G for that analysis): sample size requirements to provide species abundance and density data needed to verify indicator species habitat use to reduce uncertainty in the existing FWA model, to a marginal quality compared to existing baseline data (i.e., +/- 50%), would require tripling to quadrupling of the previous sample effort. For many species groups the number of wetlands required by wetland type needed to be sampled in order to inform the model do not exist within the Site C Project footprint.	See [reply to] Comment #4	BC Hydro agrees that a conservative approach is warranted to assist in addressing uncertainty with the model. BC Hydro will work with the VWTC to determine how model outputs will be used to quantify wetland mitigation works.
17	ECCC: July 8, 2016	Nov 2015 report		Recom. 2	The functional needs of all federally- and provincially-listed species be incorporated into the WFA model.	This information is included in the function assessment (See Step 3).		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
18	ECCC: July 8, 2016	Nov 2015 report version		Recom. 3	The WFA explicitly account for both direct and indirect effects to wetland functions	The sensitivity analysis now included in the current version of the document will address direct and indirect effects to wetland functions.	See [reply to] Comment #8	We cannot be certain that this will provide adequate compensation for indirect effects; however, we feel the 95% CI presents a conservative approach to account for direct and indirect effects. Although information in the literature may exist on the effect of indirect effects to migratory birds or species at risk at a general level, this information is not available at a species-level, for each function and wetland type found in the LAA, as required to inform the wetland function assessment. Appendix G provides an example of required sampling effort in the LAA to inform the model with accurate and reliable information. A conservative approach is warranted to assist in addressing uncertainty with the model, including application of the sensitivity analysis in the accounting framework. BC Hydro will work with the VWTC to determine how model outputs will be used to quantify wetland mitigation works

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
19	ECCC: July 8, 2016	Nov 2015 report		Recom. 4	The WFA model incorporate measures of variance in support of accounting for and addressing uncertainty.	Measures of variance have been included in the function assessment (See Excel spreadsheets)		
20	ECCC: July 8, 2016	Nov 2015 report version		Recom. 5	Uncertainty associated with: a. each WFA model assumption and input; and, b. the technical effectiveness of wetland enhancement, restoration, and creation, be accounted for through identification of appropriate compensation ratios.	FDS 11.4.4 requires BC Hydro to "*identify compensation measures to address the unavoidable loss of wetland areas and functions…in support of the objective of full replacement of wetlands in terms of area and function.*" The function assessment and wetland mitigation plan has been developed to comply with the requirements of this condition. A ratio for mitigating wetland loss is not within the scope of FDS 11.4.4.	As advised regularly and to date, in not identifying a compensation ratio ignores the realities of compensation implementation on the ground. A key motivation of the pertinent federal condition is not to ignore reality but, on the contrary, to achieve it to the most reasonable feasible extent.	FDS 11.4.4 requires BC Hydro to "*identify compensation measures to address the unavoidable loss of wetland areas and functions…in support of the objective of full replacement of wetlands in terms of area and function*". The function assessment and wetland mitigation plan has been developed to comply with the requirements of this condition. The determination of a compensation ratio is of course connected to wetland mitigation and therefore the WFA, but also separate. It is important that we clarify details related directly to the WFA, and it would likely be best if that process not be bogged down by a focus on the details of a compensation ratio.

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
21	ECCC: July 8, 2016	Nov 2015 report version		Recom. 6	Wetlands be replaced on a like-for-like basis in terms of wetland area and wetland function to the extent technically feasible. In relation to wetland area and for all wetland types, a like-for-like approach should reflect the wetland class sizes present and the number of wetlands in each class size.	Replacing wetland area using a like-for-like approach is outside the scope of FDS 11.4.4. FDS 11.4.4 requires BC Hydro to "*identify compensation measures to address the unavoidable loss of wetland areas and functions…in support of the objective of full replacement of wetlands in terms of area and function*". The function assessment and wetland mitigation plan has been developed to comply with the requirements of this condition and allow BC Hydro to quantify function lost, then addressed through the mitigation program.	while achieving a like-for-like approach may not be technically feasible, we recommend that a hierarchical approach where like-for-like be given preference before consideration to alternate next best options	A like-for-like approach ultimately differs from the direction of the VWTC to date, which has resulted in a WFA that focusses on ecological functions rather than wetland type. A wetland type-focussed assessment (i.e., like-for-like) would be simple by comparison, as it would not require the specific details of the value of each wetland type for each species group and life requisite. With a function-focussed assessment, it is ultimately the replacement of function loss that will be the focus, and therefore the wetlands most likely to be effective at replacing lost functions would be prioritized.
1	FLNRO- October	Nov 2015 report	8	assessment of wetland functions	"…a modified Habitat Equivalency Analysis is then used…". What aspect(s) of the HEA has been "modified" and why?	The terminology in the document has been changed from modified to simplified because the assessment process calculates area to restore based on value (i.e., wetland function) lost. This wetland function assessment process does not incorporate discount rates.		
2	FLNRO- October 29,	Nov 2015 report	9	Step 1	"Classification of wetland types in the LAA followed the structure of mapping and terrestrial ecosystem classification…". Assuming probable	BC Hydro conducted wetland field verification of wetlands within the transmission line right-of-way in 2016 to verify the inferences being made and further characterize the wetland types. 58 of 60 areas identified as wetlands on the transmission line right-of-way were visited and their classification confirmed.		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
					wetland ecosystems were initially identified during TEM polygon delineation, what was the level (if any) of subsequent field work to verify subject delineation….particularly for those wetlands that would be physically impacted by the project?	A paragraph on the wetland monitoring has been added, to provide this information (see Step 5).		
3	FLNRO-October 29, 2016	Nov 2015 report version	9		"Baseline information on the biogeochemical, hydrological and ecological functioning…was inferred based on general descriptions of the habitat types in the EIS…". How was this information "inferred" in the context of this function assessment?	BC Hydro conducted wetland field verification of wetlands within the transmission line right-of-way in August 2016 to verify the inferences being made and further characterize the wetland types. 58 of 60 areas identified as wetlands on the transmission line right-of-way were visited. In addition to confirming each wetland's classification the following data were recorded: elevation, slope aspect, terrain, exposure, site disturbance, site attributes, soil texture, surficial material, vegetation present and percent cover. Additional site specific data on wetland characteristics will be recorded as part of the wetland monitoring program (see Step 5 on Page 47 of the function assessment). A paragraph on the wetland monitoring has been added, to provide this information (see Step 5).Further information on the wetland habitat features, as per Federal condition 11.4.1, will be recorded as part of the wetland monitoring program. A paragraph describing this monitoring has been added to the document (see Step 5).		
4	FLNRO-October 29, 2016	Nov 2015 report version	10		Table 1 includes wetland area affected by construction and operations. The function assessment focuses solely on the construction phase with no information regarding the impact to wetlands during the operational phase. EAC condition #12 stipulates in part "The EAC holder must monitor construction and operation activities that could cause changes in wetland functions" (underline mine). Hence, the wetland function assessment should include anticipated functional loss of non-physically impacted wetlands during operations.	The area that is to be affected by operations is included in the area to be affected by construction, they are not additive. This information is included in the EIS.		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
5	FLNRO-October 29, 2016	Nov 2015 report version	11	Step 2	Migratory bird species that "have broad or generalized habitat preference" were not selected as indicator species for this function assessment. How is "broad" and "generalized" defined in the context of this function assessment?	The following sentence in the report defines how 'generalized' was applied in the function assessment: *"Species with generalized habitat preferences were not selected because they would diminish the importance of wetland habitats in terms of assessing their functional value as many generalist species use a wide array of habitat types."*		
6	FLNRO-October 29, 2016	Nov 2015 report version	15		Table 2 includes common loon and horned grebe within the "Gulls and Terns" assemblage. However, in the December 2014 wetland function assessment the two noted species are included in the "Waterbirds" assemblage. A table formatting error in the November 2015 draft?	This is a formatting error and has been corrected.		
7	FLNRO-October 29, 2016	Nov 2015 report version	21		Table 5: · what does the acronym "FACU" mean?....or should it be FACW? · for those plant species that have a "wetland status" of OBL and FACW, which of the wetland types identified in Table 1 do they occur within?...and if this has not been determined, why?	We have added the terminology for the acronym FACU to the footnote. The wetland types that they occur within are indicated in the Excel spreadsheet (NPS_bchydro_siteC_Aboriginalspp_wetlandfunction _Dec2016.xlsx), along with further description as to why these associations were made.		
8	FLNRO-October 29, 2016	Nov 2015 report version	22		When ascertaining the relationship of habitat functions to wetland type: "Scientific literature was used as the primary source …due to the shortage of raw data linked to specific wetland habitat types…baseline surveys…were never intended to evaluate habitat use…sampling efforts within wetland habitat types and the inability to confidently associate habitat type with observation makes them inadequate for the purpose…". Hence, a combination of reviewing relevant literature and existing baseline data was used to assign one or more wildlife habitat functions (Table 6) that "may" be provided by a particular wetland type noted in table 1. The use of the term "may" implies a degree of uncertainty. What is the	To test the uncertainty associated with species-habitat associations, we conducted a sensitivity analysis and include its results in the report (see section 'Model assumptions and sensitivity analysis').		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
					confidence level (e.g. low to high) of the wildlife and rare plant habitat functions assigned linkage to wetland types, primarily those associations detailed in Screenshots 1 & 2 (Appendix D)? Furthermore, suggest it is valuable to include in the function assessment identification of information that is presently lacking (e.g. data gaps) but if available would increase the level of confidence for the said determination.			
9	FLNRO-October 29, 2016	Nov 2015 report version	general		Potentially useful information available in the Provincial Environmental Mitigation Policy for British Columbia publicly available at: http://www.env.gov.bc.ca/emop/, particularly the May 2014 document - Provincial document Procedures for Mitigating Impacts on Environmental Values (Environmental Mitigation Procedures)	BC Hydro has reviewed the 2014 document and will consult the documents as the mitigation plan is implemented.		
10	FLNRO-October 29, 2016	Nov 2015 report version	general		The process of ascertaining the ecological functional value/score of wetlands for specific wildlife groups during important periods in their lifecycles seems to primarily (if not solely) be determined by the preliminary assignment of habitat function to wetland type as depicted in screenshots 1& 2. To improve the subject ecological function output, it is essential the initial subject assignment stage is undertaken with the best available information as the remainder of determining functional value is a relatively straight forward mathematical exercise with fixed variables.	Site C field data sets (Appendix A) were investigated to assess the ability of the data to inform the FWA model, and to ascertain the filed data's ability to inform the FWA model in a direct way (Appendix G). In order to test the uncertainty associated with the species-habitat associations (as shown in screenshots 1 and 2) and their assumed equal use, we have now conducted a sensitivity analysis and include its results in the report (see section 'Model assumptions and sensitivity analysis' in Appendix F).		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
11	FLNRO-October 29, 2016	Nov 2015 report version	general		Will consideration be given to potential impacts to other existing environmental values from wetland compensation, particularly the creation of new wetlands on potentially previously non-disturbed areas?	Currently areas identified for wetland creation are limited to Area A which will be used as a material source for dam construction, the impacts of which were assessed in the EIS. Additional opportunities for wetland creation have been identified on private lands. Impacts from wetland creation on private lands will be considered as projects are designed and constructed but will be positive for wildlife.		
12	FLNRO-October 29, 2016	Nov 2015 report version	general		If a premise of the assessment is the functional value of wetlands that is directly physically lost, what of the possible impact to wildlife use of wetland habitat that is not physically impacted but proximal to project related sensory disturbance? Should the "habitat effectiveness" of existing wetlands during both construction and operations be considered when determining wetland functional value(s)? Would there be a difference between the construction and operation phases?	It is not possible for literature, methodology or monitoring to be used to define or inform the 'habitat effectiveness' of associated or nearby wetland habitats. A study of this magnitude would require years of sampling across multiple wetlands of the same type in order to inform the model for all migratory species of interest. Appendix G provides the level of effort required to inform the WFA model with new field data. For example, in the case of dabbling ducks, in order to detect a 20% difference in the wetland habitat preference of dabbling ducks between the various Site C wetland types it would require more than 4500 wetlands of each wetland type in order to successfully inform the WFA model with field collected data (Appendix G). Wetland area to be affected by operations is included in wetland area to be affected by construction. No monitoring is planned for the effect of sensory disturbance on wetland usage by migratory birds, species at risk and species of importance to Aboriginal land use. Sensory disturbance, if considered to affect wetland function more than what baseline sensory disturbance might be, could be accounted for in the 95% confidence interval now provided to a 50% perturbation to species-habitat use (Appendix F).		
13	FLNRO-October 29,	Nov 2015 report version	general		Does/will the function assessment account for the inevitable time lag in the provision of ecological functions particularly in constructed/restored wetlands?	Time lag is not assessed. The accounting system being developed by the VWTC will allow for tracking of gains and losses both in terms of area and function.		
1	MOE (reviewer #1)	Nov 2015 report version	5	1	This process attempts to address some aspects of the certificate conditions but is completely silent on water quality and quantity.	We have added a paragraph discussing on the wetland monitoring program to be conducted, which addresses data collection as part of Federal condition 11.4.1, and its part in informing the wetland function assessment (see Step 5). Functional approach was asked to address wetland function as it relates to wetland-dependant migratory and species at risk communities. Water quantity is through quantifying wetland loss. Water quality for the wetlands that remain intact will not be affected.		
2	MOE (reviewer	Nov 2015 report	5	2	What does a "scientifically-based system" really mean? Do you mean data driven, statistical rigor, error documentation, ….??	We have reworded this and the following paragraph to emphasize why the wetland function assessment process is scientifically based.		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
3	MOE (reviewer	Nov 2015 report	6	4	What is an HGM - this is used as an acronym without any introduction.	Full wording has been added to the document.		
4	MOE (reviewer #1)	Nov 2015 report version	7	1	I am challenged to understand where the selection index comes from. I understand the availability part (area of wetland by wetland type) but it is not clear what the use data is? Secondly in no place in this document, in spite of the use of a selection index to alter the importance values, is there any documentation of analyses and results of selectivity - what assumptions were or were not violated, what was the significance values for selection (which were significant and which were not. Typically selection analyses are fraught with analyses issues if expected use values for any category are under 5% or if there are multiple categories with zero use expected values which appear to be the case here. It is not clear to me if these selection indices are real or not.	Assumptions, with respect to flora and fauna analysis were provided in the report. This information has now been provided in its own section (see 'Model assumptions and sensitivity analysis'). In terms of significance values, we are making assumptions on which habitats are used and that they're used equally, so no significance values are associated. As a result of the above assumption, a sensitivity analysis has now been included (Appendix F), which looks at addressing the effect of making an error in the FWA model. Statistical simulations were used to examine the sensitivity of calculated losses to changes in the preferences for habitats where indicator species are found. In the absence of good quality estimates of species usages or densities across wetland habitats of interest, initial estimates considered habitats to be equally preferred by indicator species (i.e., model assumption #1 for both fauna and flora). For example, for nesting dabbling ducks, it was initially assumed that they would equally use WS, WH, SE, Wf02, and Wf13 where they are equally available. The following sensitivity analysis was used to 'perturb' the preference for one habitat at a time and then re-allocate preference equally among the remaining habitats. Perturbations of +/-20% and +/-50% were used on habitat preferences.. The sensitivity analysis was conducted since, in general, baseline data could not be used to inform the model. The only place in the model where baseline data has been included is plants, and this portion of the model (as with all others) is included in sensitivity analysis.		
5	MOE (reviewer #1)	Nov 2015 report version	9	3	Not clear how the secondary habitat association data from Mackenzie and Moran were driven. What data was used - dominance, presence, percent cover …. This is important given how this data are applied later on	Further description from Mackenzie and Moran (2004) has been added to the report ('Function 10: Rare Plant Use) to provide further information on the origin of the secondary habitat association data.		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
6	MOE (reviewer #1)	Nov 2015 report version			No references in this table which essentially is the one place that indicates why species were or were not selected (e.g., Connecticut Warbler - states "In the western part of its range habitat preferences shift towards upland deciduous types". There is no reference for this and I assume that this is why this species was not selected? Does the data from the BC Peace (EIA, eBird, Bird Atlas) bear this out?	All information used for species-habitat associations made can be found in Appendix B. To clarify what the decision-making process was for migratory bird indicator species, we have now added a flow chart to accompany the text.		
7	MOE (reviewer #1)	Nov 2015 report version	18	1	Is focussing the function assessment only on rare plant species a reasonable approach. Does there rarity cause any issues with the issues raised above re: selection indices? Is the data for them dense enough for this approach to be able to to document function for rare plants in general?	Focusing the function assessment on rare plants is a reasonable approach, as it matches with what has been requested in Federal condition 11.4.4: "*compensation measures to address the unavoidable loss of wetland areas and functions supporting migratory birds, species at risk, and the current use of lands and resources by Aboriginal people in support of the objective of full replacement of wetlands in terms of area and function*" and Provincial condition 12. As their rarity on the landscape may have caused issues with using solely baseline data from the LAA to determine the primary habitat associations, we have incorporated the secondary habitat associations that uses associated species to estimate the importance of wetland function to rare plants.		
8	MOE (reviewer #1)	Nov 2015 report version	18	1	The reference for (Government of BC ND is wrong. There is a recommended citation for BC Species and Ecosystems Explorer. The CDC list of rare plants does not get updated, the status of plant species updates and based on those statuses, the compostion of the red and blue lists may or may not change	We have corrected the citation and reworded the paragraph to improve the description of the conservation status rankings.		
9	MOE (reviewer #1)	Nov 2015 report version		Caption	Species are not "delisted" in BC. They are one list or another. They are assigned to red, blue, yellow lists based solely on their S rank. See the description in BCSEE	This correction has been made.		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
10	MOE (reviewer #1)	Nov 2015 report version	21	1	Last line on that page - I think that in this context that the functions for bat species are provided by the wetland (as opposed to performed by). Perhaps semantics but the language is a bit odd.	The recommended adjustment to wording has been made.		
11	MOE (reviewer #1)	Nov 2015 report version	22	1	This paragraph states that "these inventories were never intended to evaluate habitat use and therefore many of the datasets therefore .. Makes them inadequate for this purpose. However from all I can understand this data is used to drive the development of selection indices which seems to be completely contrary to this statement.	Scientific literature was used as the primary source of habitat use info for the wetland function assessment, rather than the existing inventories, due to the shortage of raw data linked to specific wetland habitat types in the region. We have reworded this paragraph to clarify this and added further information on how the raw baseline data was used in the function assessment.		
12	MOE (reviewer #1)	Nov 2015 report version			The Function 11 should be separated into at least 2 components - animal and plants.	The separation of Function 11 (Species important to Aboriginal land use) will not add value to how the plant and animal species are evaluated in the model (Step 4: Determining Total Loss Given Habitat Affected). The only reason rare plants were considered separately from migratory birds, amphibians and bats, is because additional data was utilized (i.e., secondary habitat associations) to try and eliminate any bias towards wetland habitat associations due to the rarity of the rare plant species on the landscape.		
13	MOE (reviewer	Nov 2015 report	22	Definition	This statement is pretty tautological - it doesn't really tell me anything the title doesn't.	We have re-worded the definition to provide further detail on the considerations being made for this functional value to migratory birds.		
14	MOE (reviewer	Nov 2015 report	22	3	I am not a waterfowl expert. Is the use of the term propogation for waterfowl appropriate or is production the appropriate term	Correction made.		
15	MOE (reviewer	Nov 2015 report	24	Definition	What does "scale of migration" mean - do you mean total numbers of birds? Use specific terms that tell the reader what you are really referring to.	We have re-worded the definition for clarity.		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
16	MOE (reviewer #1)	Nov 2015 report version	25	Definition	Do habitat features for amphibians include water quality and quantity and if so how is that accounted for (e.g., varying depths, freezing, turbity … I don't understand what the last sentence actually means in this definition. It is used in many definitions and its meaning is not evident.	At this time, general characteristics of habitat features for the different wetland types have been inferred from descriptions for the project area (Hilton et al. 2013d) and across the province (Mackenzie and Moran 2004). Further information on the wetland habitat features, as per Federal condition 11.4.1, will be recorded as part of the wetland monitoring program. A paragraph describing this monitoring has been added to the document (see Step 5). With respect to water quality and quantity, functional approach was asked to address wetland function as it relates to wetland-dependant migratory and species at risk communities. Water quantity is addressed through quantifying wetland loss. Water quality for the wetlands that remain intact will not be affected. We have removed this last sentence from this and other definitions.		
17	MOE (reviewer	Nov 2015 report	25		There are no relevant data sets so how were selection indices calculated??	Reference to selection indices unclear; however, peer-reviewed literature was used to assess suitable amphibian feeding habitat for each of the indicator species considered. This is indicated in 'Step 3: Identification of Important Wetland Habitat Functions', paragraph 1.		
18	MOE (reviewer #1)	Nov 2015 report version	26	1	How is the structural complexity evaluated for wetland types. Are there measure of central tendency and precision? Were these assessed for the wetlands in the LAA. This appears to be assuming that all wetlands have a similar structural complexity or that all wetlands of the same type do, both of which are not true.	At this time, general characteristics of habitat features (e.g., structural complexity) for the different wetland types have been inferred from descriptions for the project area (Hilton et al. 2013d) and across the province (Mackenzie and Moran 2004). Further information on the wetland habitat features, as per Federal condition 11.4.1, will be recorded as part of the wetland monitoring program. A paragraph describing this monitoring has been added to the document.	the response did not address the question that was asked re: how will structural complexity be evaluated for wetland types in the functional assessment process? Monitoring is not the answer?	For simplicity, the estimation of wetland function values per wetland type assume that all wetlands of that type share similar ecological characteristics, including complexity.
19	MOE (reviewer	Nov 2015 report	27	3	Does this process really rank rare plants importance to rare wetland function or vice versa?	This wording has been corrected.		
20	MOE (reviewer #1)	Nov 2015 report version	28	Caption	I think this should say "Rare plant occurrence primary habitat types …. This table I believe documents which habitat types rare plant occurrences were actually documented in.	We have corrected the table caption to match the description in the text.		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
21	MOE (reviewer #1)	Nov 2015 report version	29	Caption	Similarly I think this is wrong and should read "Rare plant secondary habitat associations identified … Were these truly identified in the EIS or by this process??	We have corrected the table caption to match the description in the text.		
22	MOE (reviewer	Nov 2015 report	29	Definition	These species are ??regarded?? - do you mean included??	We have reworded this definition for clarity.		
23	MOE (reviewer #1)	Nov 2015 report version	31	1	How is the use component measured. What are the assumptions of selectivity index analyses and were any violated. Where are the measures of significance and associated error. This appears to be taking a completely deterministic approach to a probabilistic analytical technique. This is where much relevant information may be lost or masked.	Functional 'Use' (e.g., nesting) by indicator species has been evaluated based on peer-reviewed literature, as well as baseline data where available (see 'Step 3: Identification of Important Wetland Habitat Functions'). The assumptions of the wetland function assessment model are provided at the end of both the fauna and flora ranking protocol. Data that was available from baseline studies was insufficient to inform the selection ratios. We have assumed equal use in literature supported and now have included a sensitivity analysis to inform 'what if' relevant information was lost or masked.		
24	MOE (reviewer #1)	Nov 2015 report version	32	1	Unless I am really lost, is not the proportional wetland type usage incorporated into the selectivity index (use/availability). If so why are you then multiplying these factors??	No, the 'proportional wetland type usage' represents relative expected usage if all wetland types are equally available on the landscape. Step f) modifies the 'proportional wetland type usage' to reflect how much habitat is actually available on the landscape at Site C.		
25	MOE (reviewer #1)	Nov 2015 report version	33	1	Any analyses needs to remain stratified by species group and wetland type. To do otherwise is to completely mask and lose any information relevant to function. An index that has no units that are relatable to the biological values being assessed does not help the process.	The wetland function assessment allows for function to remain stratified in order to be assessed by species group and wetland type, if needed. For example, should one be interested in replacing wetland function of nesting Trumpeter Swan, this process would provide the estimated wetland area required to support this function on the landscape. Although the index for function, 'standardized usage given habitat availability', has no units, it can be multiplied by wetland area to estimate 'total loss given habitat affected – construction' and 'total gain given habitat restored'. This allows for compensation measures to meet Federal condition 11.4.4: "*compensation measures to address the unavoidable loss of wetland areas and functions…"*		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
26	MOE (reviewer #1)	Nov 2015 report version	33	Assumptions	Bullet 1 and 2 - what are the implications if these are violated. How robust is this process to violation of these assumptions. What is the sensitivity of the model to that? This should be testable	In order determine how robust the process is should assumption #1 be violated, a sensitivity analysis has been completed and included in the report. For assumption #2, assuming equal value across all assemblages eliminates any bias that may be incorporated based on an expert option's preferential bias (e.g., a waterfowl biologist placing higher value on waterfowl, as compared to bats).		
27	MOE (reviewer	Nov 2015 report	33	Assumptions	Bullet 3 - is this supported by the available data - if not then what is the consequence	At this time, insufficient data is available from the baseline studies to answer this question; however, the collection of monitoring data could be used to evaluate this assumption in the future.		
28	MOE (reviewer #1)	Nov 2015 report version	33	Assumptions	Bullet 4 - this is the most aggregious of the assumptions and is almost certainly violated in almost all cases. As a foundational assumption it is key to the assessment tool. If this assumption cannot be tested or evaluated AND supported then the tool needs to become much more simplified or a completely different approach is required.	The wetland monitoring program by BC Hydro will record and evaluate landscape condition, positioning, size, connectivity and habitat complexity (in addition to other variables) for all the wetland types in order to inform the mitigation phase of this process. This information will be used in determining key wetland characteristics to restore on the landscape. In terms of habitat quality, fragmentation and the time it takes between wetland loss and wetland restoration, almost all compensation ratios approaches and other methods used to assess and compensate for wetland loss on the landscape are unable to directly consider these unknowns. These approaches often increase compensation ratios in order to account for these unknowns. The sensitivity analysis presented in Appendix F can be applied in this same manner for offsetting those wetland unknowns that are either too difficult, too costly or impossible to assess through field studies.		
29	MOE (reviewer #1)	Nov 2015 report version	34	5	The complexity of the analyses appear to be far beyond what the available data support. Is this really a valid approach?	The FWA model's utilization of both available species-specific habitat use information from the literature, as well as available information from baseline studies, is a balanced approach. This is compared to a rapid assessment technique of wetland function that makes generalizations and simplifications of wetland function, or a complex field investigation attempting to create a detailed understanding of wetland characteristics (e.g., hydrology, soils, water chemistry, plants, animals, etc.).		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
30	MOE (reviewer #1)	Nov 2015 report version	35	4	Total relative density of what? Is density plants/sq metre or ??? What is the metric here?	We have adjusted the terminology for this and other variables in the model to prevent confusion. Adjustments made are as follows: 'Total Habitat Type – Usage' to 'Total Relative Preference' (in fauna analysis) 'Proportional Habitat Type – Usage' to 'Proportional Wetland Type Preference' (in fauna analysis) 'Usage Given Habitat Availability' to 'Preference Given Habitat Availability' (in fauna analysis) 'Standardized Usage Given Habitat Availability' to 'Standardized Preference Given Habitat Availability' (in fauna analysis) Total Relative Density to Total Relative Preference (in flora analysis) Standardized Relative Density to Proportional Wetland Type Preference (in flora analysis) Density Given Habitat Availability to Preference Given Habitat Availability (in flora analysis)		
31	MOE (reviewer #1)	Nov 2015 report version	35	5	There are a lot of challenges using selection indices for species that are very rare. See my previous comments.	Focusing the function assessment on rare plants is a reasonable approach, as it matches with what has been requested in Federal condition 11.4.4: "*compensation measures to address the unavoidable loss of wetland areas and functions supporting migratory birds, species at risk, and the current use of lands and resources by Aboriginal people in support of the objective of full replacement of wetlands in terms of area and function"* and Provincial condition 12. As their rarity on the landscape may have caused issues with using solely baseline data from the LAA to determine the primary habitat associations, we have incorporated the secondary habitat associations that uses associated species to estimate the importance of wetland function to rare plants.		
32	MOE (reviewer	Nov 2015 report	36	6	which rare plants; how would you track this	'Standardized density given habitat availability' sums the wetland function of each habitat type to supporting all rare plants considered. Please see comment #30 re: term 'relative density' above, if this is the source of confusion.		
33	MOE (reviewer	Nov 2015 report	37	4	"Adjusted based on the wetland area that is expected to be affected". Is reflective of the proportion of that available in the LAA or ???"	Understanding of comment is not clear, however (Yes?) the 'total loss given habitat affected – construction' reflects not only the affected wetland area by construction, but also the wetland habitat availability in the LAA (i.e., standardized density given habitat availability is the product of the standardized relative density per habitat type, and the habitat type's baseline area)		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
34	MOE (reviewer #2)	Nov 2015 report version	40		How would you interpret these number biologically? What do they mean to the values you are concerned about here? This is why these needs to remain stratified at the species group and wetland type scale.	The wetland function assessment allows for function to remain stratified in order to be assessed by species group and wetland type, if needed. For example, should one be interested in replacing wetland function of nesting Trumpeter Swan, this process would provide the estimated wetland area required to support this function on the landscape. Although the index for function, 'standardized usage given habitat availability', has no units, it can be multiplied by wetland area to estimate 'total loss given habitat affected – construction' and 'total gain given habitat restored'. This allows for compensation measures to meet Federal condition 11.4.4: "*compensation measures to address the unavoidable loss of wetland areas and functions…"*		
1	MOE (reviewer #2)	Nov 2015 report version			Aside from a few comments in introductory statements, issues like water depth and configuration of wetlands are largely ignored.	We have added a paragraph of discussion on the wetland monitoring program to be conducted, which addresses additional data collection as part of Federal condition 11.4.1, and its part in informing the wetland function assessment (see Step 5).		
2	MOE (reviewer	Nov 2015 report			Where are the sections on water quality, quantity and vegetation cover?	We have added a paragraph of discussion on the wetland monitoring program to be conducted, which addresses additional data collection as part of Federal condition 11.4.1, and its part in informing the wetland function assessment (see Step 5).		
3	MOE (reviewer #2)	Nov 2015 report version			This document is required to present "abundance, density, diversity and use" for species at risk (from federal condition 4.1). I don't see the abundance, or density portions addressed in this assessment.	These data are provided in the Vegetation and Wildlife Mitigation and Monitoring Plan (June 5, 2015). The document can be accessed at the link below: https://www.sitecproject.com/sites/default/files/Veg_and_Wildlife_Mit_and_Mon_Plan.pdf.		
4	MOE (reviewer #2)	Nov 2015 report version			What is the process for gathering feedback on the parts of the wetland assessment that deals with the First Nation requirements?	We have added references to where information from the EIS was gathered for the selection of Species Important to Aboriginal Land Use. BC Hydro continues to engage with First Nations groups and additional information obtained through this process relevant to wetland use is provided to the environment team for use in development and implementation of mitigation and monitoring plans.		
5	MOE (reviewer #2)	Nov 2015 report version			The word delisted should be changed to downlisted throughout the document.	This correction has been made.		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
6	MOE (reviewer #2)	Nov 2015 report version	6		I can't tell how the selection index was derived. I remember having more comfort with this when we were walked through it, but the document is missing that context (or I am not understanding it).	We can provide clarification, but will need additional input on where such clarification is required. This will be discussed further at the January 20, 2017 meeting and additional clarity will be provided in the document as needed.		A flow chart has been added to clarify this process (Section 5, Figure 4).
7	MOE (reviewer #2)	Nov 2015 report version	9	3	Step 1 3rd para – "Baseline info on the….was inferred based on descriptions of the habitat types in the EIS". – Will this be checked in the field to ensure that these are correct?	BC Hydro conducted wetland field verification of wetlands within the transmission line right-of-way in 2016 to verify the inferences being made and further characterize the wetland types. 58 of 60 areas identified as wetlands on the transmission line right-of-way were visited and their classification confirmed. In addition to confirming each wetland's classification the following data were recorded: elevation, slope aspect, terrain, exposure, site disturbance, site attributes, soil texture, surficial material, vegetation present and percent cover. Additional site specific data on wetland characteristics will be recorded as part of the wetland monitoring program (see Step 5 on Page 47 of the function assessment).		
8	MOE (reviewer #2)	Nov 2015 report version	9	4	Monitoring data collected: Which attributes will be assessed/monitored?	BC Hydro conducted wetland field verification of wetlands within the transmission line right-of-way in 2016 to verify the inferences being made and further characterize the wetland types. 58 of 60 areas identified as wetlands on the transmission line right-of-way were visited and their classification confirmed. In addition to confirming each wetland's classification the following data were recorded: elevation, slope aspect, terrain, exposure, site disturbance, site attributes, soil texture, surficial material, vegetation present and percent cover.		
9	MOE (reviewer #2)	Nov 2015 report version	10	1	"Information from peer-reviewed literature –is this information backed up by observations gathered by Hydro? You have more specific information from the area at your disposal rather than relying on generalities from the literature. For example, the habitat used by Yellow Rail in BC are more restricted than those outlined in the literature	We have added, throughout the revised document, information on how the baseline data collected by BC Hydro was used in the ranking process, as compared to information gathered from literature.		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
10	MOE (reviewer #2)	Nov 2015 report version	10-11		It would be useful to provide a list or description of the wetland types typically used by each of the migratory bird assemblages. There needs to be a more detailed understanding presented in seasonal changes in wetlands (vernal, draw down areas etc.) and how that changed bird use…in fact this applies throughout for other species as well (flora, amphibians fish).	A sentence directing the reader as to where this information can be found in the associated Excel files has been added to the document. This information can be found in the 'Species Habitat Use' tab of the associated wetland function model spreadsheets (i.e., flora, fauna and species important to Aboriginal land use). Because a fair amount of explanation is required with each species-habitat-function association made, we feel this information is better suited in the Excel files where more detail can be provided. Seasonal changes are captured in the WFA approach by distinguishing the functional importance of various wetlands types during different times of the year (i.e., breeding versus migratory use of wetlands for birds, hibernation versus breeding for amphibians, etc.). Not enough is known about rare plant species to be able to distinguish more than "presence/absence" at this time.		
11	MOE (reviewer #2)	Nov 2015 report version	14-17		Table 2. It would be helpful to include the wetland types by species.	This information can be found in the 'Species Habitat Use' tab of the associated wetland function model spreadsheets (i.e., flora, fauna and species important to Aboriginal land use). We have added a sentence to indicate where this information can be found. Because a fair amount of explanation is required with each species-habitat-function association made, we feel this information is better suited in the Excel files where more detail can be provided.		
12	MOE (reviewer #2)	Nov 2015 report version	18		This plan needs to assess vegetation as well as rare plants in order to serve as a Function assessment (in order to meet 11.4.1 of the federal conditions). Need to pick important species in each wetland type that provide the key ecosystem features that you need to meet your function needs…	Characteristic vegetation cover, as outlined in Federal condition 11.4.1, has been noted in wetlands surveyed during baseline surveys and will be noted for each wetland type sampled as part of the wetland monitoring program (see Step 5). A paragraph has been added to the document (page 47) that outlines this activity. Federal condition 11.4.4 requests the plan include "*compensation measures to address the unavoidable loss of wetland areas and functions supporting migratory birds, species at risk, and the current use of lands and resources by Aboriginal people…"*; Including plant species in the wetland function assessment, that are not at risk or important for current use of lands and resources by aboriginal people is not required.		
13	MOE (reviewer #2)	Nov 2015 report version	19		Table 3. It would be useful to include the wetland types expected to be associated with each spp.	This information can be found in the 'Species Habitat Use' tab of the associated wetland function model spreadsheets (i.e., flora, fauna and species important to Aboriginal land use). We have added a sentence to indicate this. Because a fair amount of explanation is required with each species-habitat-function association made, we feel this information is better suited in the Excel files where more detail can be provided.		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
14	MOE (reviewer #2)	Nov 2015 report version	22		The statement "these inventories were never intended to evaluate habitat" - but that seems to be what they ARE being used for in this document in the absence of better data.	Scientific literature was used as the primary source of information and support for the wetland function assessment model, rather than the existing Site C field inventories, due to the shortage of baseline data linked directly to specific wetland habitat types in the project footprint. Wetland habitat preference, in addition to the timing of wetland use, was assessed for each species based on scientific studies within this region of Canada. Appendix B lists the literature supporting the species presented in the WFA report. This paragraph has been reworded to clarify. Additional language has been added outlining how the raw baseline data was used in the wetland function assessment.		
15	MOE (reviewer	Nov 2015 report	26		Function 8 –There needs to be some consideration of structure and variation in water levels.	Information on water depth will be collected as part of the wetland monitoring program (see revised document page 47).		
16	MOE (reviewer #2)	Nov 2015 report version	32		f) Area, number, configuration and adjacent habitat of wetlands would change the value? Is there a commitment to do this evaluation before wetland creation? Options and principles that would be used to determine configuration should be outlines.	BC Hydro conducted wetland field verification of wetlands within the transmission line right-of-way in 2016 to verify the inferences being made and further characterize the wetland types. 58 of 60 areas identified as wetlands on the transmission line right-of-way were visited and their classification confirmed. BC Hydro has committed to conduct additional sampling of wetlands along the transmission line right-of-way, where the majority of wetland loss is expected to occur, to gather characteristics such as wetland area, number, adjacent habitat per wetland type, in order to better understand and inform replacing wetland function on the landscape by wetland type (see Step 5). This information will be used to record wetland characteristics of each type to be lost, in order to ensure that wetland characteristics are being replaced through the mitigation plan. The effect of number, configuration and adjacent habitat value on function will not be incorporated into the model itself. This is a huge undertaking, and the functional value of these characteristics at a species level, across the 60+ species included in this assessment does not exist in the literature.		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
17	MOE (reviewer #2)	Nov 2015 report version	33		Assumptions – Bullets 3 &4 – see above comment.	At this time, insufficient data is available from the baseline studies to evaluate Bullet #3. The collection of monitoring data could be used to evaluate this assumption in the future. In terms of bullet #4, the wetland monitoring program will record landscape condition and complexity (as well as a number of other variables) for the various wetland types. This will assist in determining key wetland characteristics to restore on the landscape. In terms of habitat quality, compensation ratios and other methods to assess and compensate for wetland function on the landscape, typically do not consider existing wetland quality; therefore, we feel the benefits of this assumption are outweighed by the risks.		
18	MOE (reviewer #2)	Nov 2015 report version	All Assumptions		These assumptions range from questionable to problematic Setting some clear goals would help in making some choices about the wetlands that will be managed in this project.	We have added a sensitivity analysis, in order to test the uncertainty associated with one of the assumptions. BC Hydro will work with the VWTC to outline goals of the wetland mitigation program and how wetlands within the program will be managed.		
19	MOE (reviewer	Nov 2015 report	38		Assumptions – Bullet 3. Likely not a correct assumption.	As baseline rare plant sampling was not directed at recording wetland habitat types, and instances where wetlands were sampled but no rare plants were found was not recorded, this estimate cannot be determined.		
1	MOE (reviewer	Nov 2015 report	9	1	"The area of wetland lost/affected by the project…" – what does affected mean? How will this be determined? What are the metrics?	We have reworded this sentence to more closely match the presentation of the affected area in the EIS, and referenced the appropriate sections.		
2	MOE (reviewer #3)	Nov 2015 report version	9	3	Baseline info on the….was inferred based on descriptions of the habitat types in the EIS". – will this baseline info be surveyed or monitored to verify the inferences being made?	Yes, BC Hydro will be conducting wetland monitoring to collect additional baseline data to verify the inferences being made and further characterize the wetland types. A paragraph on the planned wetland monitoring has been added to the document (see Step 5.).		
3	MOE (reviewer	Nov 2015 report	9	4	What does the monitoring data collected during operations look like? What sort of attributes will be assessed/monitored?	A paragraph on the planned wetland monitoring has been added to the document (see Step 5). At this time there is no difference between monitoring during construction and operations.		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
4	MOE (reviewer #3)	Nov 2015 report version	10	Table 1	It would be useful to know how many polygons or sites exist within the LAA for each wetland type (ie. how many times were each type of wetland mapped?). And, how many of these individual occurrences were verified in the field?	This information has been added to Table 1. A paragraph on the planned wetland ground-truthing has been added, to provide this information (see Step 5). BC Hydro conducted wetland field verification of wetlands within the transmission line right-of-way in 2016 to verify the inferences being made and further characterize the wetland types. 58 of 60 areas identified as wetlands on the transmission line right-of-way were visited and their classification confirmed.		
5	MOE (reviewer #3)	Nov 2015 report version	10	2	"Information from peer-reviewed literature,…..wetland habitat use by indicator species. Baseline wildlife….literature review" - will any of this be field verified for habitat use in the LAA? How was the baseline wildlife data used if there was habitat/species occurrence links made in the original EIS data?	Further detail on how the baseline data was used as part of the wetland function assessment has been added to the document. Species-specific habitat suitability models, which associate species with habitat type for a particular function, were produced using available information from the literature and confirmed via baseline data, as was this assessment process. For some species, such as the dragonflies, broad habitat associations were made (i.e., dragonflies would use all wetland habitat) based on the understanding of habitat use from the literature.		
6	MOE (reviewer #3)	Nov 2015 report version	10-11		It would be useful to provide a list or description of the wetland types typically used by each of the migratory bird assemblages.	This information can be found in the 'Species Habitat Use' tab of the associated wetland function model Excel spreadsheets (i.e., flora, fauna and species important to Aboriginal land use). We have added a sentence to the document directing readers to this spreadsheet. Because a fair amount of explanation is required with each species-habitat-function association made, we feel this information is better suited in the Excel files where more detail can be provided.		
7	MOE (reviewer #3)	Nov 2015 report version	13		Figure 2 is titled "Detailed and TEM wetland mapping for the Site C project" – this map shows both the LAA and RAA doesn't it? Is this fxn assessment for the LAA or both?	We have added to the legend for Figure 2 to identify the LAA. The function assessment is for areas in the LAA affected by the Project.		
8	MOE (reviewer #3)	Nov 2015 report version	14-17		Table 2. it would be useful to include the wetland types expected to be associated with each spp.	This information can be found in the 'Species Habitat Use' tab of the associated wetland function model spreadsheets (i.e., flora, fauna and species important to Aboriginal land use). We have added a sentence to the document directing readers to this spreadsheet. Because a fair amount of explanation is required with each species-habitat-function association made, we feel this information is better suited in the Excel files where more detail can be provided.		
9	MOE (reviewer #3)	Nov 2015 report version	18		Selection of flora indicator species – what % of wetland occurrences/polygons were sampled to generate the list of wetland-associated rare plants for the LAA?	The baseline rare plant survey data was not conducted to determine wetland habitat associations (i.e., wetlands were not purposefully sampled). The list of wetland-associated rare plants was generated from baseline survey data for rare plants, and not from targeted wetland sampling for rare plants.		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
10	MOE (reviewer #3)	Nov 2015 report version	19	Table 3	It would be useful to include the wetland types expected to be associated with each spp.	This information can be found in the 'Species Habitat Use' tab of the associated wetland function model spreadsheets (i.e., flora, fauna and species important to Aboriginal land use). We have added a sentence to the document directing readers to this spreadsheet. Because a fair amount of explanation is required with each species-habitat-function association made, we feel this information is better suited in the Excel files where more detail can be provided.		
11	MOE (reviewer #3)	Nov 2015 report version	21	Table 5	It would be useful to include the wetland types expected to be associated with each spp.	This information can be found in the 'Species Habitat Use' tab of the associated wetland function model spreadsheets (i.e., flora, fauna and species important to Aboriginal land use). We have added a sentence to the document directing readers to this spreadsheet. Because a fair amount of explanation is required with each species-habitat-function association made, we feel this information is better suited in the Excel files where more detail can be provided.		
12	MOE (reviewer #3)	Nov 2015 report version	22	1	"A detailed review of the baseline…..these Wetland Habitat Functions" – will this initial estimate of habitat function be validated through further sampling/monitoring efforts? Not looking for a repeat of the EIS but rather some sort of validation of the linkages made between habitat type, use and overall function.	Wetlands will be monitored for use by key species and if the data allow linkages will be made between habitat type, use and function.		
13	MOE (reviewer #3)	Nov 2015 report version	26		"Suitable foraging habitat must contain concentrations of swarming insects and the appropriate vertical vegetation structure required by each individual species" how is the variability between the different types of wetlands in terms of insect production being accounted for? Is there any preference of one wetland over another? Also, how is the variability in the vertical structure accounted for? There is considerable variability of structure within individual wetland types? For example, the TS – Tamarack-Sedge community found on one site could predominately forested with little sedge while on another site it could be all sedge with a few tamarack?	The invertebrate communities of wetland types are poorly understood. Canadian studies focused on this type of research is greatly lacking, particularly of the magnitude that would allow us to predict or model invertebrate community assemblages between wetlands of the same type, let alone compare wetlands of differing types. As a result, it is not practical to use this as an indicator of vertebrate use as we would only be guessing as to a wetland's importance in this regard. The same holds true for vegetation structure and many other unique "within wetland" characteristics. Studies of this type are often not rigorous enough to apply the data across many vertebrate communities or to wetlands in other regions.		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
14	MOE (reviewer #3)	Nov 2015 report version	31		Step 4, pg 31 – b) what about preference of wetlands/sites? Also, for this example – what would happen if 100 individuals use one type of wetland and only 2 use the others; would the indicator value for each still be .2?	At this time, insufficient data is available from the baseline studies to indicate preference of one wetland type over another beyond our ability to predict presence/absence for a particular function (i.e., migration, nesting, hibernation, etc). In addition, although wetland type preference data may be available from the literature for certain species, it is not available for all, therefore including it for a few species would create an unbalanced bias. At this time, indicator values cannot be adjusted for anticipated species densities. A sensitivity analysis has been conducted to estimate the uncertainty associated with the assumption of habitat preference and the prediction of presence/absence. The WFA model can be used to assess, on a hectare by hectare wetland basis, the functions being replaced for each guild or species through restoration, preservation or replacement. It allows the user to assess which wetland types support the broadest variety of species' functions and which wetland types may be important to only a few species (i.e., amphibians and rare plants). While density cannot be directly addressed in the WFA model, wetland preference can be. BC Hydro's ongoing wetland field monitoring activities will help to identify wetland features that are characteristic, and unique, to the wetland types present on Site C. This data will help to identify common and unique wetland specific features that can then be incorporated into mitigation planning.		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
15	MOE (reviewer #3)	Nov 2015 report version	32		Pg 32 – f) what about issues related to the size and number of individual wetlands? For example, numerous tiny wetlands totally 100ha have a much different value than 2 50ha wetlands. And, the same can be said for wetlands that are adjacent to extensive grasslands compared to forested sites. What about large wetland complexes? How does quality factor into the analysis? What about Connectivity?	BC Hydro conducted wetland field verification of wetlands within the transmission line right-of-way in 2016 to verify the inferences being made and further characterize the wetland types. 58 of 60 areas identified as wetlands on the transmission line right-of-way were visited and their classification confirmed. This information will then be used to replace wetland function on the landscape. A paragraph has been added to the document outlining this process (Page 47). The size and configuration of mitigation wetlands on the landscape will be determined on a site-by-site basis.	the response did not address the questions being asked. The questions are with respect to the logic/assumptions of the wetland function assessment model? The shortcomings of the model in terms of the calculated functional loss values will not be addressed through field data collection/classification confirmation and mitigation site selection?	Due to limitations on the inferences that can be drawn from available ecological data, the calculation of wetland functions in the WFA does not take into consideration factors such as the size and number of wetlands beyond the effect of total area for each wetland type. For the same reason, the wetland function assessment also does not include landscape scale considerations such as adjacency or connectivity. However, these considerations can be dealt with qualitatively or semi-quantitatively by attempting to direct wetland mitigation and compensation efforts towards protecting, enhancing or restoring wetlands with similar characteristics to those that will be lost. Mitigation site selection to compensate for area and function lost will be selected, in part, based on the characteristics of impacted wetlands(e.g., size, adjacent habitat types, etc.), as observed during the field verification process.

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
16	MOE (reviewer #3)	Nov 2015 report version	33		Pg 33 – assumptions – third bullet – the usage of wetland habitats is much than area dependant? As stated earlier, numerous tiny wetlands have a much different value and most likely different level of usage, than two large wetlands of the same type (eg 100, 1ha wetlands vs 2, 50ha wetlands). And, there is simply too much variability within wetland types (as mapped without field verification) to assume usage is proportional to area.	BC Hydro conducted wetland field verification of wetlands within the transmission line right-of-way in 2016 to verify the inferences being made and further characterize the wetland types. 58 of 60 areas identified as wetlands on the transmission line right-of-way were visited and their classification confirmed. This information will then be used to replace wetland function on the landscape. A paragraph has been added to the document outlining this process (Page 47). The size and configuration of mitigation wetlands on the landscape will be determined on a site-by-site basis.	See above	Mitigation site selection to compensate for area and function lost will be selected, in part, based on the characteristics of impacted wetlands (e.g., size, adjacent habitat types, etc.), as observed during the field verification process.

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
17	MOE (reviewer #3)	Nov 2015 report version			Fourth bullet - ??? Habitat quality and fragmentation, especially when considering the surrounding landscape, would significantly impact usage rates? For example, a wetland situated beside an active log sort would not have the same usage rate as the same wetland situated in a large wetland/riparian complex. Landscape condition and complexity are critical components to be considered.	The wetland monitoring program will record landscape condition and complexity, as well as a number of other variables, for the various wetland types. This will assist in determining if wetlands near developed areas receive the same usage as wetlands in non-developed areas. In terms of habitat quality, compensation ratios and other methods to assess and compensate for wetland function on the landscape, typically do not consider existing wetland quality; therefore, we feel the benefits of this assumption are outweighed by the risks.	the question that was asked is with respect to the model assumptions so how will collection of landscape condition and complexity during the monitoring phase (after the functional loss values have been calculated) address the shortcomings of the model?	As discussed previously, the determination of wetland function value per wetland type is limited by the inferences that can reasonably be drawn from available ecological data. However, the collection of data relating to landscape condition and complexity during the monitoring phase will help to address model limitations. Mitigation site selection to compensate for area and function lost will then be selected, in part, based on the characteristics of impacted wetlands (e.g., size, adjacent habitat types, etc.), as observed during the field verification process, to the degree feasible.

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
18	MOE (reviewer #3)	Nov 2015 report version	Assumptions		Overall, I find these assumptions problematic but these could be rectified to a degree if all of the individual wetlands could be verified in terms of type, structure and condition. You would need to ensure that all wetland types are in fact created equally, each with similar adjacent habitats and/or complexes associated with them. And, establish stronger, definitive (I.e. field verified) species links to wetland/habitat types. There seem to be too many variables unaccounted for in the overall functional assessment.	The model is to be refined following on-the-ground monitoring to be conducted as part of the wetland monitoring program. Of the wetlands to be affected, 20% of each wetland type are to be ground-truthed, with further field monitoring to be conducted (see Step 5). Sampling of wetlands along the transmission line occurred in August 2016.		
19	MOE (reviewer #3)	Nov 2015 report version	38		Pg 38 – assumptions – third bullet – is this a fair assumption? Were all wetland sites sampled during baseline surveys (ie. not the wetland polygons but the actual wetland types, including those mapped within complex polygons).	See comment above – as baseline rare plant sampling was not directed at wetland habitats, and instances where wetlands were sampled but no rare plants were found was not recorded, this estimate cannot be determined.		
1	ECCC, June 1 2017	December 2016 report version		a.	How does BC Hydro propose to use the 95% confidence intervals and model outputs? CWS recommends a conservative approach be adopted in implementation of the model. Doing so would reflect the uncertainty in the model and the limitations around the extent to which compensation measures that will be implemented on-the-ground can replace the functions lost.	BC Hydro agrees that a conservative approach is warranted to assist in addressing uncertainty with the model. BC Hydro will work with the VWTC to determine how model outputs will be used to quantify wetland mitigation works.		
2	ECCC, June 1 2017	December 2016 report		b.	The model does not address other wetland functions (broadly, hydrological, biochemical, ecological (other than birds and plants))	The model addresses function for migratory birds, rare plants, amphibians, bats, species important to Aboriginal land use and species at risk. Hydrological information is defined by each wetland type and confirmed in the field. As discussed at the June 16, 2017 meeting water quality sampling will begin in 2017.		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
3	ECCC, June 1 2017	December 2016 report version		c.	In relation to (a.) and (b.), two considerations include: Regarding the power analysis (Table G1), the information contained within the table is not captured or linked to the Report or other programs/plans. Given the general direction in which other plans are proceeding, it is important that the anticipated uncertainty in the other programs/plans in relation to this Report are appropriately addressed. Refer to (a.) above.	The information in Appendix G is referenced in Section 4, paragraph 3 of the report. BC Hydro will work with the VWTC to determine how model outputs will be used to quantify wetland mitigation works.		
4	ECCC, June 1 2017	December 2016 report version		Sensitivity analysis	It is important to note that a sensitivity analysis tests the extent to which the model output is influenced by changes in value of specific variables; however, it has no bearing on whether assumptions underlying the model are true or false. The WFA model is clear, explicit, consistent and rigorous. None of these attributes make the model necessarily 'true' i.e. that is, that its derivative necessarily represent the biological reality.	Agreed – none of the attributes make the model necessarily "true". The perturbation analysis is primarily focused on assumption #1 (i.e., habitats where indicator species are found are equally preferred). In regards to assumptions #2, 3 and 4: Although there is a lot of literature on the general impacts of habitat quality, fragmentation and habitat availability on relative usage, data is not available in either the literature or collected in the LAA, on the impacts at a species-level, specific to a particular wetland type and function. While there may be some data to inform on relative usage in the LAA, there isn't enough data available (nor are there enough wetlands in the area, as noted in Appendix G) to inform the WFA in a rigorous, verifiable and accurate way. Therefore, in order to meet federal condition 11.4.4 (i.e., evaluating loss of wetland areas and functions supporting migratory birds, species at risk, and the current use of lands and resources by Aboriginal people), these assumptions were necessary to be made.		
5	ECCC, June 1 2017	December 2016 report version			A summary table of the sensitivity analysis in the main body of the Report (the 'total' column at the end of each analysis) and a discussion/interpretation of the values might be considered.	This has been incorporated in the revised document, including a new Table 8.		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
6	ECCC, June 1 2017	December 2016 report version			It is not entirely clear how sensitive the model is to any of the bird variables other perhaps for amphibians (?). Why does the model appear to be insensitive to any variable? Is it a lack of variance in the data? Additional, specific questions along these lines include: •What cutoff in sensitivity values should considered to determine if a variable has a strong effect? •Which, if any, of the variables need to be flagged as important? •Would undertaking a multivariate analysis, i.e. all variables change at the same time, change results?	For most species-usages, the model appears relatively insensitive to relative preference perturbations of +/- 50% for a focal habitat. Note that relative preferences are only redistributed to the habitats that were identified as "used" by a species through the literature review. This restricts the possibilities for unrealistic usage scenarios. For example, relative preferences of 0.33 were assumed for each of the habitats SE, Wf02, and Wf13 for Open Habitat Songbirds. If we perturb the relative preference of SE by +50%, then relative preference becomes 0.5. The remaining two habitats are assumed equally preferred at levels of 0.25 each. Regarding the question about a lack of variance in the data, these tables are not informed by actual usage data. Hence, characteristics of data (like variance) do not play a role. Habitats identified from the literature review as providing some value to each species group / usage were considered equally used when equally available since limited other information was available. Regarding the question about a cutoff in sensitivity values, there are no specific guidelines. Because relative preferences for different habitats are linked (i.e. if relative preference for one habitat increases, there must be corresponding decreases in preference for other habitats), it is difficult to isolate whether increasing preference for one habitat has an effect. These sensitivity analyses were conducted to understand how much we would expect the results to vary if our underlying assumption of equal habitat preference for difference species group / usages (eg. relative preference of 1/3 for each of SE, Wf02, and Wf13 for Open Habitat Songbirds) was wrong. Regarding the question about which variables need to be flagged as important, because relative preferences for different habitats are linked, it is difficult to isolate whether increasing preference for one habitat has an effect. Regarding the question about undertaking a multivariate analysis, we cannot be certain but wouldn't expect the results to change much. Relative preferences for all habitats change when one is perturbed since they must add to 100%.		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
7	ECCC, June 1 2017	December 2016 report version			In relation to the following statement (page 44), *'the 95% confidence intervals for a 50% perturbation have been included in all model spreadsheets. This addition helps to compensate for the uncertainty in the model associated with assumption #1 for flora and fauna, as well as provide compensation for the estimate of indirect effects on wetland area (e.g., sensory disturbance, downstream effects) to wetland function and time delays related to the mitigation process',* it is not clear to us how the 95% CI for a 50% perturbation informs on indirect effects of other variables. If, for example, the model proves to be very sensitive to a variable not considered here, the 10% or so effect documented here will be misleading as to the true effect of unconsidered variables. In effect, this statement seems to say that any variable not considered so far should fall within the documented 10% range of effect identified in this power analysis.	We cannot be certain that this will provide adequate compensation for indirect effects; however, we feel the 95% CI presents a conservative approach to account for direct and indirect effects. Although information in the literature may exist on the effect of indirect effects to migratory birds or species at risk at a general level, this information is not available at a species-level, for each function and wetland type found in the LAA, as required to inform the wetland function assessment. Appendix G provides an example of required sampling effort in the LAA to inform the model with accurate and reliable information.		
8	ECCC, June 1 2017	December 2016 report version		Sampling Effort and Power Analysis (Appendix G)	What difference (%) from baseline density is BC Hydro trying to document? Will this be applied to each metric of the compensation plan (e.g. abundance, species diversity)?	Appendix G provides a summary of the additional sampling effort that would be needed populate the model with data collected from the study area. Table G1 provides the number of samples needed to detect practical differences on the order of 20, 50, 100, 150, 200 and 250% from baseline with 80% statistical power and an alpha significance level of 0.05.		
9	ECCC, June 1 2017	December 2016 report		General	Are any wetlands missed through the application of different classification systems?	No wetlands are missed. The classification system used is a provincial system and captures the wetlands present in the study area. Marl Fen and Tufa Seeps are not included in the Function Assessment as they are point occurrences on the baseline mapping.		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
10	ECCC, June 1 2017	December 2016 report version		General	In relation to wetlands situated within and along the transmission line right-of-way, CWS advises that a change in wetland morphology is likely to result in a loss of function(s) such that the impacts that arise are subject to wetland compensation pursuant to this Report	BC Hydro will be mitigating, through the wetland mitigation program, for wetland losses, including partial losses of wetlands.		
1	MOE (reviewer #1), June 8 2017	December 2016 report version			As per my comments in the document I would like to see the stated assumptions in the development of the assessment model brought forward to very early on in the document (prior to section 1). There, all assumptions in the process need to be explicitly stated and associated statements of how those assumptions are to be evaluated. The reporting of the results are fine where they are but currently this section is buried way in the back where many will not go and these are key to acceptance of this tool.	We agree, and have moved the model assumptions earlier in the document; however, they have been placed at the head of Section 5 (i.e., the step by step description of the ranking protocol), as we feel that placing the assumptions prior to Section 1 is out of context of the model structure. To draw attention to the assumptions prior to Section 1, we have made reference in the introduction to their location in the document, and have changed the title of Section 5 to 'Determining Total Loss Given Habitat Affected: Wetland Function Assessment Model Structure and Assumptions'.		
2	MOE (reviewer #1), June 8 2017	December 2016 report version			Although I have been involved in the review of this tool all along, I have to say that once I get so Step 4 I do struggle to keep things straight in my head as to what is actually going on. It is much easier when you are in the room and having the tool explained to you but as a reader familiar with it I am challenged to keep up on paper. I would suggest that at the beginning of step 4 a paragraph or 2 be added that outlines the overall approach to this section in straightforward language such that one understands what is being outlined and why in the subsequent text and screen shots.	A flow chart has now been included, in addition to the screenshots and spreadsheets, to clarify this process.		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
3	MOE (reviewer	December 2016 report		Table 1	Is this map polygon area – not clear in this table	"Minimum area (ha)" is the smallest polygon size of that wetland ecosystem type within the TEM dataset (in the LAA). The Min and Max are there to show the range of wetland size in the LAA. This information has been added to the Table 1 caption.		
4	MOE (reviewer	December 2016 report		Table 1	What is the overlap in these two?	This information has been taken directly from the "Terrestrial Wildlife and Vegetation Effects Assessment: Part 1: Vegetation and Ecological Communities" (Hilton et al. 2013a) and the methodology as to how these areas have been obtained can be found there. This information has been added to the Table 1 caption.		
5	MOE (reviewer #1), June 8 2017	December 2016 report version	13	2	I always come to this paragraph and think – really. Is the level of reference that would best inform this. Presumably someone else has done a thorough treatment of this – especially within the HEP process in the US.	Noted. A review of approaches to evaluate wetland function, and comparison to the WFA approach selected, is presented in the Introductory section of the document.		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
6	MOE (reviewer #1), June 8 2017	December 2016 report version	37	d)	Nowhere in this document have you dealt with the issue of the challenges associated with very small (<5%) or very large (>95) expected values. The latter is rarely an issue but the former has been identified in the literature as having significant implications for preference analyses. Low expected values can result in unreasonably high or low metrics of preference due to the small size of the denominator in the calculation. Chesson published on this effect (I think in the early 1980's).	We were unable to find in the literature the issue the reviewer is describing (both by an author and general issues search). Please provide a specific reference that can be reviewed. Note that for habitat usage, the smallest value that a species can have is 0.13 (i.e., 1/8, as there are eight wetland habitat types. See, for example, boreal chorus frog habitat usage for breeding) and the largest value that a species can have is 1 (i.e., 1/1. See, for example, Columbia spotted frog habitat usage for hibernation).	July 21, 2017 [Reviewer #1 provided Strauss 1979 Trans Am Fish Soc 108; Vanderploeg and Scavia 1979 J Fish Res Board Can] Discusses the issues of non-normal and skewed availability data when doing this type of selection analyses. July 25, 2017 [Reviewer #1 provided Neu et al. 1974 JWM 38] notes that: 1. At least one expected observation should be in each category 2. Nor more than 20% of all categories contain less than 5 expected observations Jelinski 1991 also notes that if small expected frequencies are part of the modelling process then very small differences in actual and expected use could be significant but not biologically real	In regards to the Manly-Chesson Index, Boitani and Fuller (page 126; Research Techniques in Animal Ecology: Controversies and Consequences) cite that "*The Manly-Chesson index of habitat selection does not fluctuate with inclusion or exclusion of seldom-used habitats*". In addition, Manly et al. (2002; page 55; Resource Selection by Animals: Statistical Design and Analysis for Field Studies. 2nd edition) discuss that "*One of the advantages of working with selection ratios is that this effect is largely avoided when decisions must be made on whether or not to include rarely used categories in the analysis*". The concerns raised in the Neu and Jelinski papers are not relevant to the wetland function assessment model. In the Neu paper, chi-squared statistical significance testing is used to assess evidence of habitat preference. We are not assessing habitat preference. At a species or species-group level, we have assumed equal preference for the habitats identified as "used" by the species in the literature. We do not conduct any statistical significance tests in the report.

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
7	MOE (reviewer #1), June 8 2017	December 2016 report version	38	f)	Why is this true. Why would a habitat with low functional value have high usage just because it is abundant. That same argument would suggest that lawns in cities would have high habitat useage just because there are lots of them. I think this assumption is unreasonable and needs to be explicitly dealt with in the assumptions section.	This portion of the model has now been removed.		
8	MOE (reviewer	December 2016 report	38	g)	See my comments for (d) above	This portion of the model has now been removed.		
9	MOE (reviewer #1), June 8 2017	December 2016 report version	39	i)	This section needs a much stronger treatment regarding the metrics for restoration. Nowhere does it reflect on the baseline condition values for a particular wetland. If you are creating a wetland from 0 then obviously the gain is the full value of that wetland. If, however you are restoring or enhancing an existing wetland you most likely do not have a baseline wetland function value of 0. How do you plan on calculating that – it has a very important and real bearing on the accounting process for mitigation and its absence in this process is troubling.	The WFA was developed to quantify the functions of different wetland types for different species. The accounting associated for mitigating for wetland losses in terms of area and function will need to be discussed by the VWTC. As discussed at the June 16, 2017 meeting, another meeting focused on wetland mitigation is needed. The VWTC has scheduled this meeting for mid to late autumn 2017.		
10	MOE (reviewer #1), June 8 2017	December 2016 report version	40	a), first bullet	How rich is this plot data. My question relates to how many plots actually inform these calculations; how many observations are we talking about. Are these based on a reasonable sample size – they may be but I can't tell from this.	This information is included in the document, in the 'Function 10: Rare plant use' section. Data used to create these species-wetland habitat associations comes from approximately 2600 survey plots conducted throughout British Columbia, collected as part of classification programs, mapping projects and theses (MacKenzie and Moran 2004). We have added a reference to this section at the head of the flora ranking process description.		
11	MOE (reviewer	December 2016 report	42	e)	See my previous comments re: preference analyses	See response above.		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
12	MOE (reviewer #1), June 8 2017	December 2016 report version	44	Model assumptions, general	Thank you for including these. I believe that these need to be very explicitly stated up front in the document (prior to section 1 – this analysis process is based on a number of assumptions a, b, c. This is how we have evaluated the implications of those assumptions being violated. I don't actually think you have examined the effect of assumption violation here – just the sensitivity of your models to some perturbation. See my comments below on this.	We have explicitly evaluated assumption 1 – "habitats where indicator species are found are equally preferred". We agree, and have moved the model assumptions earlier in the document; however, they have been placed at the head of Section 5 (i.e., the step by step description of the ranking protocol), as we feel that placing the assumptions prior to Section 1 is out of context of the model structure. To draw attention to the assumptions prior to Section 1, we have made reference in the introduction to their location in the document, and have changed the title of Section 5 to 'Determining Total Loss Given Habitat Affected: Wetland Function Assessment Model Structure and Assumptions'.		
13	MOE (reviewer	December 2016 report	44	Model assumptions	It is likely that all of these are violated, some more egregiously than others. There are some that are inherently just wrong.	These assumptions have been discussed at length at each wetland function assessment meeting. We have added text outlining why these assumptions have been made and conducted a sensitivity analysis to assist in implementing the program using a conservative approach.		
14	MOE (reviewer #1), June 8 2017	December 2016 report version	44	Model assumptions	No this is only the case if you desire to roll the values up in this analyses beyond the functional groups. We have consistently stated that is probably neither advisable nor valuable and that the analyses and reporting needs to remain at a more detailed level.	Values are only 'rolled up' for migratory birds, where a selection of indicator species was used to represent each assemblage. Detail on the decision-making process for this approach is given in the report. The detail at a per-species level remains for all other functional groups (i.e., bats, amphibians, species important to Aboriginal land use, rare plants).		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
15	MOE (reviewer #1), June 8 2017	December 2016 report version	45	Step 1	This process assumes that only 1 habitat is different than the rest and the remainder are equivalent – which does not really test the assumption. You could much more robustly test the assumptions by perturbing 1 habitat and then assigning the remaining relative values randomly to the others. The assumption and the sensitivity would likely be much different if there were a 50% perturbation and the remaining 4 habitats have a very uneven values. That is the real test of this assumption. Could be done with some bootstrapping approaches. In addition the more habitat that a functional group uses, given the process you have used to test sensitivity, the less the sensitivity by definition. The approach above may help resolve that.	Note that relative preferences are only redistributed to the habitats that were identified as "used" by a species through the literature review. This restricts the possibilities for unrealistic usage scenarios by assigning remaining relative values randomly to the other habitats. For each of the 1000 model runs of the perturbation analysis, a randomly selected focal habitat is perturbed for each species group. So – for Migratory Birds Nesting, we could choose to perturb the habitat preference for SE for Marsh-Nesting shorebirds, perturb the preference for WS for coniferous songbirds, and say TS for aerial insectivores. In response to this comment, we investigated how much the aggregated relative preference for habitats varied across perturbation runs. In this investigation, we noted that: 1. Habitats that were not supported in the literature as being used by a species group were never selected by our protocol; 2. As expected and designed, the averages across the perturbation runs matched "Proportional wetland type preference" from the Excel workbook NPS_bchydro_siteC_faunaspp_wetlandfunction_Dec2016.xlsx; 3. When aggregated across the species, the preferences vary less than you might expect for a +/- 50% perturbation. This is because the perturbations are done at a species level and then these differences are moderated by combining across species. A different focal habitat is perturbed for each species (e.g., in a single run, preference for focal habitat OW may be perturbed for dabbling ducks, but preference for WH perturbed for coniferous songbirds). We provide an example below of aggregated relative preference for migratory birds for brood rearing, including the average relative preference and the (5th percentile, 95th percentile) that resulted across the 1000 perturbation runs. Note that the perturbation is done at the species or assemblage level, and then aggregated into functional groups (i.e., migratory birds). Migratory birds, brood rearing: OW relative usage: 0.561 (0.531, 0.594) WS relative usage: 0 WH relative usage: 0 SE relative usage: 0.190 (0.125, 0.250) TS relative usage: 0 Wf02 relative usage: 0.124 (0.083, 0.167) Wf13 relative usage: 0.126 (0.083, 0.167) BT relative usage: 0		
1	MOE (reviewer #2),	December 2016 report	6	11.4.1	Are these in another document?	This information is in the June 5, 2015 Vegetation and Widlife Mitigation and Monitoring Plan available at: https://www.sitecproject.com/sites/default/files/Veg_and_Wildlife_Mit_and_Mon_Plan.pdf.		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
2	MOE (reviewer	December 2016 report		Table 1	I am confused as to why the minimum area is so much smaller that the total area affected by construction and operations.	"Minimum area (ha)" is the smallest polygon size of that wetland ecosystem type within the TEM dataset (in the LAA). This information has now been added to the Table 1 caption.		
3	MOE (reviewer	December 2016 report	13		Odd choice of references	Noted. To clarify, these references were used to describe the 13 species assemblages defined on page 13-14.		
4	MOE (reviewer	December 2016 report	14	1	Refer to table 2 here?	Reference to Table 2 has been added to the document.		
5	MOE (reviewer	December 2016 report	14	2	Earlier it states you couldn't use this classification system	Yes, you are correct. We have removed this sentence, as it does not add to the description of migratory bird indicator species selection.		
6	MOE (reviewer	December 2016 report	14	2	Except for SAR?	This paragraph pertains to the selection of migratory indicator bird species, not species at risk indicator species, so the statement is correct.		
7	MOE (reviewer	December 2016 report	15	1	Is this still true with listing of Barn Swallow?	This paragraph pertains to the selection of migratory indicator bird species, not species at risk indicator species, so the statement is correct. Note that Barn Swallow, as of December 2016, was a blue-listed species in BC, so was already included as a species at risk indicator species.		
8	MOE (reviewer #2), June 8 2017	December 2016 report version	23	Table 3	Has this list been updated since 2015?	This list was updated in 2016. Updates to the Provincial and Federal lists will be tracked through the end of reservoir clearing (the time when impacts to wetlands will occur) and as needed (e.g. if the species is not adequately covered by the current indicator species in the assessment) additional species will be added to this document. A note has been added to indicate this for all indicator species lists in the report.		
9	MOE (reviewer	December 2016 report	25	Table 6	Needs updating	This list was updated in 2016. Updates to the Provincial and Federal lists will be tracked through the end of reservoir clearing (the time when impacts to wetlands will occur) and as needed (e.g. if the species is not adequately covered by the current indicator species in the assessment) additional species will be added to this document.		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
10	MOE (reviewer	December 2016 report	26	3	This can be updated with better observations over time.	Yes the data can be updated over time with data collected during wetland monitoring, but this is outside the scope of the function assessment.		
11	MOE (reviewer	December 2016 report	27	Function 1	This sentence needs some help…..	This sentence has been reworded for clarity.		
12	MOE (reviewer	December 2016 report	29	2	Common Goldeneyes up to 1.3 km, Wood Duck 2 km, Buffleheads less than 500 m…ie varies	We have broadened this statement, and added the distance travelled for brood-rearing by mallards as an example only.		
13	MOE (reviewer	December 2016 report	30	Function 5	All true, but what is being lost and recreated? If you don't know how will it be measured?	The Function Assessment quantifies the amphibian breeding habitat lost. Monitoring of wetlands will assess use before the Project and use after the Project.		
14	MOE (reviewer #2),	December 2016 report	32	Function 10	?? not a sentence	This sentence has been reworded.		
15	MOE (reviewer	December 2016 report	32		See Table 8	Reference to Tables 8 and 9 added (note: Table numbering has changed in October 2017 version of the report).		
16	MOE (reviewer	December 2016 report	38	f)	Not sure Im following this line of thought either.	This text has been modified to better reflect Assumption #3 of the model.		
17	MOE (reviewer #2), June 8	December 2016 report	39	i)	How will this be calculated…I totally agree with ECL's comment above..this needs to be articulated sooner than later.	The WFA was developed to quantify the functions of different wetland types for different species. The accounting associated for mitigating for wetland losses, in terms of area and function, will needs to be discussed by the VWTC. As discussed at the June 16, 2017 meeting, another meeting focused on wetland mitigation is needed. The VWTC has scheduled this meeting for mid to late autumn 2017.		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
18	MOE (reviewer #2), June 8 2017	December 2016 report version	39	Example	Would depend on restored from what. Restored from a parking lot or farm fieldwould be a full accounting but acquiring a fully functional marl fen is no net gain unless that are improvements to it.	With respect to the marl fen, BC Hydro has protected the fen and restored its function in the following way and will assume full credit for the ha protected: -excluded cattle from the wetland through fencing -stopped withdrawing water for cattle		
19	MOE (reviewer	December 2016 report	40	a), bullet #2	Wasn't the wetland typing done with approximate coverages? Is this being generated post hoc?	Note that the context of this sentence is with respect to calculation of the secondary habitat associations for rare plants, based on what has been reported in MacKenzie and Moran (2004), not with mapping of wetlands in the LAA.		
20	MOE (reviewer #2), June 8	December 2016 report	43	i)	See earlier comments on this accounting system that has yet to be developed	The WFA was developed to quantify the functions of different wetland types for different species. The accounting associated for mitigating for wetland losses, in terms of area and function, will need to be discussed by the VWTC. As discussed at the June 16, 2017 meeting, another meeting focused on wetland mitigation is needed. The VWTC has scheduled this meeting for mid to late autumn 2017.		
21	MOE (reviewer #2), June 8 2017	December 2016 report version	44	general	I agree with Eric, move to front	We agree, and have moved the model assumptions earlier in the document; however, they have been placed at the head of Section 5 (i.e., the step by step description of the ranking protocol), as we feel that placing the assumptions prior to Section 1 is out of context of the model structure. To draw attention to the assumptions prior to Section 1, we have made reference in the introduction to their location in the document, and have changed the title of Section 5 to 'Determining Total Loss Given Habitat Affected: Wetland Function Assessment Model Structure and Assumptions'.		
1	MOE (reviewer #3), June 8	December 2016 report		Table 1	Regardless of whether or not the wetland was 1st, 2nd or 3rd decile (i.e. the count is the number of instances a given wetland was mapped in the LAA)	Unclear as to what is meant by 1st, 2nd or 3rd decile; however, these are all the S1, S2 and S3 portions of each wetland polygon. This information was added to Table 1.		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
2	MOE (reviewer #3), June 8 2017	December 2016 report version	38	f)	This calculation assumes total area of a wetland type determines availability (ie a larger total area equates to greater availability). What about the importance of numerous small wetlands (ie. A wetland type with a high count but relatively small total area)? In such an instance, overall availability may be better determined by count or a combination count & area? Look at the SE unit – 19% of the total LAA wetland area is SE, 30% of the LAA wetland occurrences are SE.	Collection of information on average and range of wetland size for each type during the monitoring phase will address the shortcomings of the model by proving information to ensure mitigation sites properly reflect the on-the-ground characteristics of 'area lost' for each wetland type and function, with 'area restored'. In addition, this text has been modified to better reflect Assumption #3 of the model.		
3	MOE (reviewer #3), June 8 2017	December 2016 report version	44	1.	I am not a bird biologist but this assumption does not make sense. Based on the structural and veg composition differences between all of these wetland habitats (shrub vs herb), preferential select must be considered?	Using the literature, we feel, was the best approach to inform general habitat usage (i.e., if there was any evidence of potential habitat usage, it was included). However, detail on relative preferences (i.e., a species preferring one particular wetland habitat type found in the LAA over another) was insufficient from the literature.		
4	MOE (reviewer #3), June 8 2017	December 2016 report version	44	3.	As noted earlier, this assumes that area alone determines availability. I think the SE is a good example where total area may not be the only determining factor of availability and usage? The number of occurrences is a factor as well, as is landscape context (the importance of adjacent habitat types).	Collection of information on average and range of wetland size for each type during the monitoring phase will address the shortcomings of the model by proving information to ensure mitigation sites properly reflect the on-the-ground characteristics of 'area lost' for each wetland type and function, with 'area restored'.		
5	MOE (reviewer #3), June 8 2017	December 2016 report version	44	4.	As stated above, I am not a bird biologist but I simply cannot understand how landscape context and quality/condition of habitat do not influence usage? Is there research available to support this assumption?	Although there is a lot of literature on the general impacts of habitat quality, fragmentation and habitat availability on relative usage, data is not available in either the literature or collected in the LAA, on the impacts at a species-level, specific to a particular wetland type and function. While there may be some data to inform on relative usage in the LAA, there isn't enough data available (nor are there enough wetlands in the area, as noted in Appendix G) to inform the WFA in a rigorous, verifiable and accurate way. Therefore, in order to meet federal condition 11.4.4 (i.e., evaluating loss of wetland areas and functions supporting migratory birds, species at risk, and the current use of lands and resources by Aboriginal people), these assumptions were necessary to be made.		

No.	Commentator	Source	Page Number	Paragraph	Comment	BCH Response	Reply, June 2017	BCH response to June 2017 Reply
6	MOE (reviewer	December 2016 report	47	1	What does “noted” mean? Was a 100% visitation achieved?	This sentence has been reworded for clarification.		
7	MOE (reviewer #3), June 8 2017	December 2016 report version	47	2	is this being completed by map polygon or by true wetland type (Ie in the case of a complex map polygon, are you field verify each of the two or three wetland types found in the polygon)?	These data are being collected by polygon and as needed at different wetland types within the polygon.		
7	MOE (reviewer	December 2016 report	47	3	As above, is 58 of 60 wetland polygons or actual wetland types?	This sentence has been reworded for clarification.		

Appendix I: Functional Loss Ranking Tables

In the absence of access to the Excel files NPS_bchydro_siteC_faunaspp_wetlandfunction_Oct2017.xlsx, NPS_bchydro_siteC_floraspp_wetlandfunction_Oct2017.xlsx and NPS_bchydro_siteC_Aboriginalspp_wetlandfunction_Oct2017.xlsx used to calculate total functional loss given habitat affected, the functional loss data tables for each group of indicator species is provided below. Note that not provided below, due to the complexity of the information included, is the 'Species habitat use' and 'Functional loss per habitat' worksheets from NPS_bchydro_siteC_faunaspp_wetlandfunction_Oct2017.xlsx and the 'Species associated habitats' worksheet from NPS_bchydro_siteC_floraspp_wetlandfunction_Oct2017.xlsx. The 'Species habitat use' and 'Functional loss per habitat' worksheets contain the information from Section 4.0 used to populate Tables I1 – I10, and the 'Species associated habitats' contains the data used to populate Tables I11 and I12. Screenshots of these tables are presented in Appendix D and E, as examples provided in conjunction with Section 5.2 and 5.3.

Table I1. Migratory birds nesting functional loss ranking table.

Wetland Type by Species Group	OW:	WS:	WH:	SE:	TS:	Wf02:	Wf13:	BT: sb		
Dabbling Ducks	0	0.20	0.20	0.20	0	0.20	0.20	0		1
Diving Ducks	0	0	0	1	0	0	0	0		1
Cavity-nesting Ducks	0	0	0	0	0	0	0	0		0
Swans & Geese	0	0	0	1	0	0	0	0		1
Waterbirds	0	0	0	1	0	0	0	0		1
Terns & Gulls	0	0	0	0.33	0.33	0	0	0.33		1
Forest-nesting Shorebirds	0	0.20	0.20	0	0.20	0.20	0	0.20		1
Marsh-nesting Shorebirds	0	0	0	0.33	0	0.33	0.33	0		1
Rails	0	0	0	0.33	0	0.33	0.33	0		1
Open Habitat Songbirds	0	0	0	0.33	0	0.33	0.33	0		1
Deciduous Songbirds	0	0.50	0.50	0	0	0	0	0		1
Coniferous Songbirds	0	0.20	0.20	0	0.20	0.20	0	0.20		1
Aerial Insectivores	0	0.20	0.20	0.20	0.20	0	0.20	0		1
Total relative preference	0.00	1.30	1.30	4.73	0.93	1.60	1.40	0.73		12
Proportional wetland type preference	0.00	0.11	0.11	0.39	0.08	0.13	0.12	0.06		1
Affected Wetland Area (ha) - Construction	17	50	392	142	68	0	1	93		763
Total Loss Given Habitat Affected - Construction	0.00	5.42	42.47	56.01	5.29	0.00	0.12	5.68		114.98
(2.5, 97.5) percentiles for +/- 50% Perturbation	--	(3.70, 7.19)	(28.58, 56.35)	(50.19, 61.93)	(3.78, 6.80)	--	(0.083, 0.15)	(3.81, 7.56)		(101.48, 127.88)
Restored Wetland Area	0	100	0	100	0	0	0	100		300
Total Gain Given Habitat Restored	0.00	10.83	0.00	39.44	0.00	0.00	0.00	6.11		56.39

Table I2. Migratory birds feeding functional loss ranking table.

Wetland Type by Species Group	OW:	WS:	WH:	SE:	TS:	Wf02:	Wf13:	BT: sb		
Dabbling Ducks	0.50	0	0	0.50	0	0	0	0		1
Diving Ducks	1	0	0	0	0	0	0	0		1
Cavity-nesting Ducks	1	0	0	0	0	0	0	0		1
Geese & Swans	0.50	0	0	0.50	0	0	0	0		1
Waterbirds	1	0	0	0	0	0	0	0		1
Terns & Gulls	0.50	0	0	0.50	0	0	0	0		1
Forest-nesting Shorebirds	0.50	0	0	0.50	0	0	0	0		1
Marsh-nesting Shorebirds	0	0.20	0.20	0.20	0	0.20	0.20	0		1
Rails	0	0	0	0.33	0	0.33	0.33	0		1
Open Habitat Songbirds	0	0	0	0.33	0	0.33	0.33	0		1
Deciduous Songbirds	0	0.33	0.33	0	0	0.33	0	0		1
Coniferous Songbirds	0	0.17	0.17	0.17	0.17	0.17	0	0.17		1
Aerial Insectivores	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13		1
Total relative preference	5.13	0.83	0.83	3.16	0.29	1.49	0.99	0.29		13
Proportional wetland type preference	0.39	0.06	0.06	0.24	0.02	0.11	0.08	0.02		1
Affected Wetland Area (ha) - Construction	17	50	392	142	68	0	1	93		763
Total Loss Given Habitat Affected - Construction	6.70	3.17	24.88	34.50	1.53	0.00	0.08	2.09		72.94
(2.5, 97.5) percentiles for +/- 50% Perturbation	(5.38, 8.02)	(2.25, 4.10)	(17.46, 32.40)	(23.33, 45.58)	(1.04, 2.01)	--	(0.052, 0.10)	(1.43, 2.75)		(59.89, 85.34)
Restored Wetland Area	0	0	0	0	0	0	0	0		0
Total Gain Given Habitat Restored	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0

Table I3. Migratory birds brood-rearing functional loss ranking table.

Wetland Type by Species Group	OW:	WS:	WH:	SE:	TS:	Wf02:	Wf13:	BT: sb		
Dabbling Ducks	0.50	0	0	0.50	0	0	0	0		1
Diving Ducks	1	0	0	0	0	0	0	0		1
Cavity-nesting Ducks	1	0	0	0	0	0	0	0		1
Geese & Swans	1	0	0	0	0	0	0	0		1
Waterbirds	1	0	0	0	0	0	0	0		1
Terns & Gulls	0	0	0	0	0	0	0	0		0
Forest-nesting Shorebirds	0	0	0	0.33	0	0.33	0.33	0		1
Marsh-nesting Shorebirds	0	0	0	0.33	0	0.33	0.33	0		1
Rails	0	0	0	0.33	0	0.33	0.33	0		1
Open Habitat Songbirds	0	0	0	0	0	0	0	0		0
Deciduous Songbirds	0	0	0	0	0	0	0	0		0
Coniferous Songbirds	0	0	0	0	0	0	0	0		0
Aerial Insectivores	0	0	0	0	0	0	0	0		0
Total relative preference	4.50	0	0	1.50	0	1	1	0		8
Proportional wetland type preference	0.56	0	0	0.19	0	0.13	0.13	0		1
Affected Wetland Area (ha) - Construction	17	50	392	142	68	0	1	93		763
Total Loss Given Habitat Affected - Construction	9.56	0.00	0.00	26.63	0.00	0.00	0.13	0.00		36.31
(2.5, 97.5) percentiles for +/- 50% Perturbation	(9.03, 10.09)	--	--	(16.27, 36.98)	--	--	(0.083, 0.17)	--		(26.48, 46.11)
Restored Wetland Area	0	0	0	0	0	0	0	0		0
Total Gain Given Habitat Restored	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00

Table I4. Migratory birds migration functional loss ranking table.

Wetland Type by Species Group	OW:	WS:	WH:	SE:	TS:	Wf02:	Wf13:	BT: sb		
Dabbling Ducks	1	0	0	0	0	0	0	0		1
Diving Ducks	1	0	0	0	0	0	0	0		1
Cavity-nesting Ducks	1	0	0	0	0	0	0	0		1
Geese & Swans	1	0	0	0	0	0	0	0		1
Waterbirds	1	0	0	0	0	0	0	0		1
Terns & Gulls	1	0	0	0	0	0	0	0		1
Forest-nesting Shorebirds	0.50	0	0	0.50	0	0	0	0		1
Marsh-nesting Shorebirds	0	0.20	0.20	0.20	0	0.20	0.20	0		1
Rails	0	0	0	0.33	0	0.33	0.33	0		1
Open Habitat Songbirds	0	0	0	0.33	0	0.33	0.33	0		1
Deciduous Songbirds	0	0.33	0.33	0	0	0.33	0	0		1
Coniferous Songbirds	0	0.25	0.25	0	0.25	0	0	0.25		1
Aerial Insectivores	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13		1
Total relative preference	6.63	0.91	0.91	1.49	0.38	1.33	0.99	0.38		13
Proportional wetland type preference	0.51	0.07	0.07	0.11	0.03	0.10	0.08	0.03		1
Affected Wetland Area (ha) - Construction	17	50	392	142	68	0	1	93		763
Total Loss Given Habitat Affected - Construction	8.66	3.49	27.39	16.29	1.96	0.00	0.08	2.68		60.56
(2.5, 97.5) percentiles for +/- 50% Perturbation	(8.25, 9.00)	(2.34, 4.55)	(19.62, 35.16)	(10.46, 22.29)	(1.26, 2.66)	--	(0.052, 0.10)	(1.72, 3.64)		(50.99, 69.84)
Restored Wetland Area	0	0	0	0	0	0	0	0		0
Total Gain Given Habitat Restored	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0

Table I5. Amphibian breeding functional loss ranking table.

Species	OW:	WS:	WH:	SE:	TS:	Wf02:	Wf13:	BT: sb		
Boreal Chorus Frog	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13		1
Columbia Spotted Frog	0.50	0	0	0.50	0	0	0	0		1
Western Toad	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13		1
Total relative preference	0.75	0.25	0.25	0.75	0.25	0.25	0.25	0.25		3
Proportional wetland type preference	0.25	0.08	0.08	0.25	0.08	0.08	0.08	0.08		1
Affected Wetland Area (ha) - Construction	17	50	392	142	68	0	1	93		763
Total Loss Given Habitat Affected - Construction	4.25	4.17	32.67	35.50	5.67	0.00	0.08	7.75		90.08
(2.5, 97.5) percentiles for +/- 50% Perturbation	(2.53, 6.02)	(2.98, 5.36)	(23.33, 42.0)	(20.29, 50.71)	(4.05, 7.29)	--	(0.0007, 0.0015)	(5.54, 9.96)		(72.66, 107.56)
Restored Wetland Area	0	0	0	0	0	0	0	0		0
Total Gain Given Habitat Restored	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00

Table I6. Amphibian feeding functional loss ranking table.

Species	OW:	WS:	WH:	SE:	TS:	Wf02:	Wf13:	BT: sb		
Boreal Chorus Frog	0	0.14	0.14	0.14	0.14	0.14	0.14	0.14		1
Columbia Spotted Frog	0	0.14	0.14	0.14	0.14	0.14	0.14	0.14		1
Western Toad	0	0.14	0.14	0.14	0.14	0.14	0.14	0.14		1
Total relative preference	0	0.43	0.43	0.43	0.43	0.43	0.43	0.43		3
Proportional wetland type preference	0	0.14	0.14	0.14	0.14	0.14	0.14	0.14		1
Affected Wetland Area (ha) - Construction	17	50	392	142	68	0	1	93		763
Total Loss Given Habitat Affected - Construction	0.00	7.14	56.00	20.29	9.71	0.00	0.14	13.29		106.5714
(2.5, 97.5) percentiles for +/- 50% Perturbation	--	(5.56, 8.73)	(43.56, 68.44)	(15.78, 24.79)	(7.56, 11.87)	--	(0.11, 0.17)	(10.33, 16.24)		(95.31, 118.42)
Restored Wetland Area	0	0	0	0	0	0	0	0		0
Total Gain Given Habitat Restored	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0

Table I7. Amphibian hibernation functional loss ranking table.

Species	OW:	WS:	WH:	SE:	TS:	Wf02:	Wf13:	BT: sb		
Boreal Chorus Frog	0	0.50	0.50	0	0	0	0	0		1
Columbia Spotted Frog	1	0	0	0	0	0	0	0		1
Western Toad	0	0.50	0.50	0	0	0	0	0		1
Total relative preference	1	1	1	0	0	0	0	0		3
Proportional wetland type preference	0.33	0.33	0.33	0	0	0	0	0		1
Affected Wetland Area (ha) - Construction	17	50	392	142	68	0	1	93		763
Total Loss Given Habitat Affected - Construction	5.67	16.67	130.67	0.00	0.00	0.00	0.00	0.00		153
(2.5, 97.5) percentiles for +/- 50% Perturbation	(5.67, 5.67)	(8.33, 25.00)	(65.33, 196)	--	--	--	--	--		(96, 210)
Restored Wetland Area	0	0	0	0	0	0	0	0		0
Total Gain Given Habitat Restored	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0

Table I8. Bats feeding functional loss ranking table.

Species	OW:	WS:	WH:	SE:	TS:	Wf02:	Wf13:	BT: sb		
Little Brown Myotis	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13		1
Northern Myotis	0	0	0	0	0.50	0	0	0.50		1
Long-eared Myotis	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13		1
Silver-haired Bat	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13		1
Eastern Red Bat	0	0.25	0.25	0	0.25	0	0	0.25		1
Hoary Bat	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13		1
Long-legged Myotis	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13		1
Big Brown Bat	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13		1
Total relative preference	0.75	1	1	0.75	1.50	0.75	0.75	1.50		8
Proportional wetland type preference	0.09	0.13	0.13	0.09	0.19	0.09	0.09	0.19		1
Affected Wetland Area (ha) - Construction	17	50	392	142	68	0	1	93		763
Total Loss Given Habitat Affected - Construction	1.59	6.25	49.00	13.31	12.75	0.00	0.09	17.44		100.44
(2.5, 97.5) percentiles for +/- 50% Perturbation	(1.37, 1.86)	(5.13, 7.46)	(40.25, 56.88)	(11.09, 15.21)	(9.41, 16.09)	--	(0.078, 0.11)	(12.63, 22.21)		(92.73, 107.52)
Restored Wetland Area	0	0	0	0	0	0	0	0		0
Total Gain Given Habitat Restored	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0

Table I9. Bats roosting functional loss ranking table.

Species	OW:	WS:	WH:	SE:	TS:	Wf02:	Wf13:	BT: sb		
Little Brown Myotis	0	0	0	0	0	0	0	0		0
Northern Myotis	0	0	0	0	0	0	0	0		0
Long-eared Myotis	0	0	0	0	0	0	0	0		0
Silver-haired Bat	0	0	0	0	0	0	0	0		0
Eastern Red Bat	0	0.50	0.50	0	0	0	0	0		1
Hoary Bat	0	0.25	0.25	0	0.25	0	0	0.25		1
Long-legged Myotis	0	0	0	0	0	0	0	0		0
Big Brown Bat	0	0	0	0	0	0	0	0		0
Total relative preference	0	0.75	0.75	0	0.25	0	0	0.25		2
Proportional wetland type preference	0	0.38	0.38	0	0.13	0	0	0.13		1
Affected Wetland Area (ha) - Construction	17	50	392	142	68	0	1	93		763
Total Loss Given Habitat Affected - Construction	0.00	18.75	147.00	0.00	8.50	0.00	0.00	11.63		185.88
(2.5, 97.5) percentiles for +/- 50% Perturbation	--	(9.38, 28.13)	(73.50, 220.50)	--	(4.25, 12.75)	--	--	(5.81, 17.44)		(123.02, 248.73)
Restored Wetland Area	0	0	0	0	0	0	0	0		0
Total Gain Given Habitat Restored	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0

Table I10. Fauna species at risk functional loss ranking table. For species at risk that were also considered as indicator species for other groups (highlighted yellow), an average functional use was considered across all functions evaluated (e.g., for western toad, an average was taken across the indicator values for amphibian breeding, feeding and hibernation habitat). Rows used to make calculations for the averages described are hidden.

Species	OW:	WS:	WH:	SE:	TS:	Wf02:	Wf13:	BT: sb		
Aphrodite fritillary, *manitoba* subspecies	0	0	0.50	0.50	0	0	0	0		1
Assiniboine skipper	0	0	0.50	0.50	0	0	0	0		1
Bronze copper	0	0	0	1	0	0	0	0		1
Common ringlet, *benjamini* subspecies	0	0	0.50	0	0	0	0	0.50		1
Common woodnymph, *nephele* subspecies	0	0	0.50	0.50	0	0	0	0		1
Great spangled fritillary, *pseudocarpenteri* subspe	0	0	0.33	0.33	0.33	0	0	0		1
Tawny crescent	0	0	0.50	0	0.50	0	0	0		1
Prairie bluet	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0		1
Western Toad	0.04	0.26	0.26	0.09	0.09	0.09	0.09	0.09		1
Northern Myotis	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.50		1
Little Brown Myotis	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13		1
Surf scoter	1	0	0	0	0	0	0	0		1
Common Nighthawk	0.08	0.15	0.15	0.15	0.15	0.08	0.15	0.08		1
Barn swallow	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13		1
Rusty Blackbird	0	0.13	0.13	0	0.30	0.13	0	0.30		1
Olive-sided Flycatcher	0	0	0	0	0.50	0	0	0.50		1
Nelson's Sparrow	0	0	0	0.33	0	0.33	0.33	0		1
Yellow Rail	0	0	0	0.33	0	0.33	0.33	0		1
Short-eared Owl	0	0.20	0.20	0.20	0.20	0	0	0.20		1
Total relative preference	1.52	1.13	3.97	4.33	2.97	1.37	1.30	2.42		19.00
Proportional wetland type preference	0.08	0.06	0.21	0.23	0.16	0.07	0.07	0.13		1.00
Affected Wetland Area (ha) - Construction	17	50	392	142	68	0	1	93		763
Total Loss Given Habitat Affected - Construction	1.36	2.98	81.81	32.38	10.61	0.00	0.07	11.86		141.07
(2.5, 97.5) percentiles for +/- 50% Perturbation	(1.35, 1.54)	(2.26, 3.57)	(57.27, 104.73)	(25.21, 39.29)	(7.19, 13.52)	--	(0.051, 0.087)	(7.65, 15.87)		(121.94, 157.06)
Restored Wetland Area	0	0	0	0	0	0	0	0		0
Total Gain Given Habitat Restored	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0

Table I11. Flora species at risk functional loss primary habitat ranking table. Red indicates that species does not have a primary habitat associated with it in the EIS, or in the raw Site C datasets. These three species were either not linked to wetland habitat types found in the LAA (i.e., Meadow Willow), or were found as part of earlier studies in the Peace River Region (i.e., Slender Mannagrass, Rocky Mountain Willowherb).

Species	**Primary habitat use**											
	OW	**WS**	**WH**	**SE**	**TS**	**Wf02**	**Wf13**	**BT**	**Marl Fen**	**Tufa Seep**		
Hudson Bay Sedge	0	0	0	0	1	0	0	0	0	0		1
Iowa Golden-saxifrage	0	0	0	0	0	0	0	0	0	1		1
Hall's Willowherb	0	0	0	0	1	0	0	0	0	0		1
Slender Mannagass	0	0	0	0	0	0	0	0	0	0		0
White Adder's-mouth Orchid	0	0	0	0	0	0	0	1	0	0		1
Small-flowered Lousewort	0	0	0	0	0.5	0	0	0.5	0	0		1
Meadow Willow	0	0	0	0	0	0	0	0	0	0		0
Slender Wedgegrass	0	0	1	0	0	0	0	0	0	0		1
Ochroleucous bladderwort	0	0	0	1	0	0	0	0	0	0		1
Herzogiella turfacea	0	0	0	0	1	0	0	0	0	0		1
Rocky Mountain Willowherb	0	0	0	0	0	0	0	0	0	0		0
Total Relative Preference	0	0	1	1	3.5	0	0	1.5	0	1		7
Proportional wetland type preference	0	0	0.143	0.143	0.500	0.000	0.000	0.214	0.000	0.143		1

Table I12. Flora species at risk functional loss secondary habitat ranking table. Orange indicates that the rare species did not have associated species during the site surveys that were not invasives, classified to the species level, or not described in Mackenzie and Moran (2004). Therefore, they have no ranking as park of the secondary habitat use ranking.

Species	Secondary habitat use ranking											
	OW	WS	WH	SE	TS	Wf02	Wf13	BT	Marl Fen	Tufa Seep		
Hudson Bay Sedge	0	0	0	0	0.407	0	0.052	0.542	0	0		1
Iowa Golden-saxifrage	0	0	0	0	0	0	0	0	0	0		0
Hall's Willowherb	0	0.017	0.118	0.011	0.270	0.137	0.034	0.411	0	0		1
Slender Mannagass	0	0	0	0	0	0	0	0	0	0		0
White Adder's-mouth Orchid	0	0.016	0.021	0.021	0.262	0.223	0.127	0.329	0	0		1
Small-flowered Lousewort	0	0	0	0	0.296	0	0	0.704	0	0		1
Meadow Willow	0	0.191	0.809	0	0	0	0	0	0	0		1
Slender Wedgegrass	0	0.193	0.081	0.147	0.117	0.184	0.147	0.131	0	0		1
Ochroleucous bladderwort	0	0.256	0.191	0.123	0.123	0.184	0.123	0	0	0		1
Herzogiella turfacea	0	0	0	0	0.35	0.06	0	0.59	0	0		1
Rocky Mountain Willowherb	0	0	0	0	0	0	0	0	0	0		0
Total Relative Preference	0	0.67	1.22	0.30	1.82	0.79	0.48	2.70				8
Proportional wetland type preference	0	0.08	0.15	0.04	0.23	0.10	0.06	0.34				1

Table I13. Flora species at risk functional loss summary habitat ranking table.

	OW:	WS:	WH:	SE:	TS:	Wf02:	Wf13:	BT: sb		
Primary Proportional wetland type preference	0.00	0.00	0.14	0.14	0.50	0.00	0.00	0.21		1
Secondary Proportional wetland type preference	0.00	0.08	0.15	0.04	0.23	0.10	0.06	0.34		1
Average Proportional wetland type preference	0.00	0.04	0.15	0.09	0.36	0.05	0.03	0.28		1
Affected Wetland Area (ha) - Construction	17	50	392	142	68	0	1	93		763
Total Loss Given Habitat Affected - Construction	0.00	2.10	57.89	12.83	24.75	0.00	0.03	25.68		123.28
(2.5, 97.5) percentiles for +/- 50% Perturbation	--	(1.62, 2.81)	(53.04, 61.07)	(12.17, 13.46)	(20.90, 29.02)	--	(0.025, 0.036)	(19.58, 30.86)		(118.43, 126.60)
Restored Wetland Area	0	0	0	100	100	0	0	50		250
Total Gain Given Habitat Restored	0.00	0.00	0.00	9.04	36.40	0.00	0.00	13.81		59.24

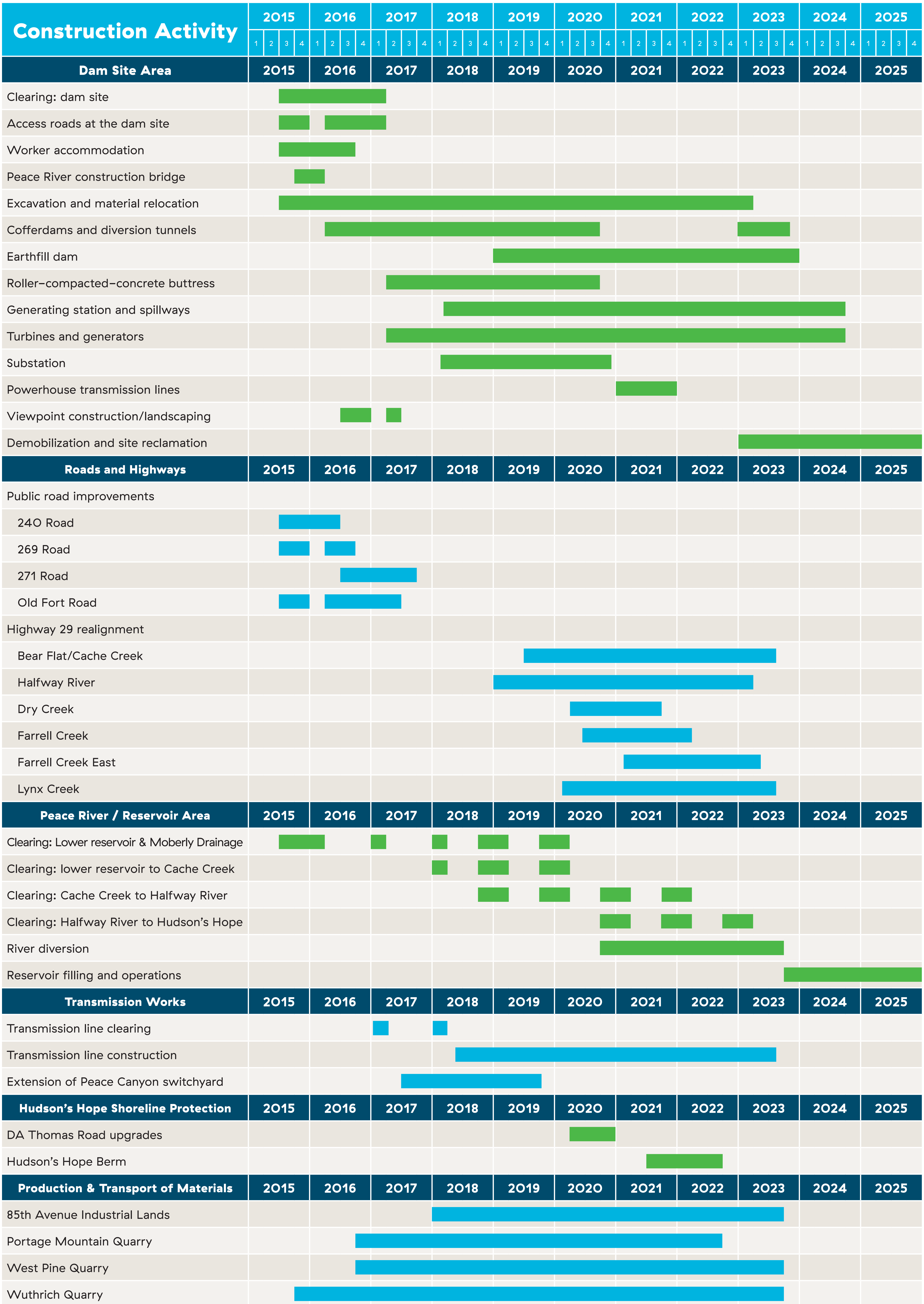
Table I14. Species important to Aboriginal land use functional loss ranking table.

	Habitat Type									
Species	OW:	WS:	WH:	SE:	TS:	Wf02:	Wf13:	BT: sb		
Labrador Tea	0	0	0	0	0.5	0	0	0.5		1
Highbush Cranberry	0	0.33	0.33	0	0	0	0	0.33		1
Moose	0	0.20	0.20	0.20	0.00	0.20	0.20	0		1
Total relative preference	0.00	0.53	0.53	0.20	0.50	0.20	0.20	0.83		3
Proportional wetland type preference	0.00	0.18	0.18	0.07	0.17	0.07	0.07	0.28		1
Affected Wetland Area (ha) - Construction	17	50	392	142	68	0	1	93		763
Total Loss Given Habitat Affected - Constructio	0.00	8.89	69.69	9.47	11.33	0.00	0.07	25.83		125.28
(2.5, 97.5) percentiles for +/- 50% Perturbation	--	(5.69, 12.08)	(44.64, 94.73)	(4.73, 14.20)	(5.67, 17.0)	--	(0.033, 0.10)	(12.92, 38.75)		(100.56, 149.76)
Restored Wetland Area	0	0	0	0	0	0	0	0		0
Total Gain Given Habitat Resored	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0

Appendix 2. Site C Clean Energy Project Construction Schedule

Site C Construction Schedule

BC Hydro
Power smart



The construction schedule is indicative only and subject to change. The purpose of the schedule is to illustrate the general sequence of construction activities, but the dates and schedule may change.

January 2018

BCH16-591

Appendix 3. Breeding Bird Follow-up Monitoring 2017 Annual Report

Site C Clean Energy Project
Breeding Bird Follow-up Monitoring
2017 Annual Report

PRESENTED TO

BC Hydro and Power Authority

DECEMBER 22, 2017
ISSUED FOR REVIEW
FILE: 704-ENV.VENV03095-01.SONG-2017

This "Issued for Review" document is provided solely for the purpose of client review and presents our interim findings and recommendations to date. Our usable findings and recommendations are provided only through an "Issued for Use" document, which will be issued subsequent to this review. Final design should not be undertaken based on the interim recommendations made herein. Once our report is issued for use, the "Issued for Review" document should be either returned to Saulteau EBA Environmental Services Joint Venture or destroyed.

Saulteau EBA Environmental Services Joint Venture.
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Edmonton, AB T5V 1B4 CANADA
Tel 780.451.2121 Fax 780.454.5688

Site C Clean Energy Project Breeding Bird Follow-Up Monitoring 2017 Annual Report

FILE: 704-ENV.VENV03095-01.SONG-2017
December 22, 2017

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EXECUTIVE SUMMARY

Saulteau EBA Environmental Services Joint Venture (SEES JV) completed breeding bird point count surveys in the area of BC Hydro and Power Authority's (BC Hydro) Site C Clean Energy Project ("Site C") in spring and summer 2017. The surveys were part of BC Hydro's Breeding Bird Follow-up Monitoring Program. The breeding birds monitoring program is focussed on passerines (songbird perching birds), hummingbirds, swifts, doves, kingfisher, and pigeons (all members of the orders *Passeriformes*, *Apodiformes*, *Columbiformes*, and *Coraciiformes*), which are collectively referred to as songbirds. Songbird baseline surveys were conducted in 2006, 2008, 2011 and 2012. Surveys were again conducted in 2016 and 2017 as part of the monitoring program. This report describes the methods used to conduct the 2017 surveys and provides a summary of the results.

Surveys were conducted May 28 to July 10, 2017 at 179 stations within the project footprint, in habitats adjacent to the footprint and in the BC Hydro mitigation properties. Each station was surveyed two times in order to maximize the detection of early and late breeders. Birds were surveyed using unlimited radius point counts. The geographic focus of surveys in 2017 was on the east half of the Peace River valley footprint (from the Halfway River to the dam site) and the Transmission Line.

A total of 2,403 songbirds of 71 songbird species were recorded during the point count surveys in 2017. Eight species listed under the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), the Species at Risk Act (SARA) and/or British Columbia's Red and Blue lists were observed during the surveys. Surveys in Marl Fen, Rutledge and Wilder Creek mitigation properties recorded 18, 36 and 26 songbird species, respectively.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

1.0 INTRODUCTION

Saulteau EBA Environmental Services Joint Venture (SEES JV) completed breeding bird point count surveys in the area of BC Hydro and Power Authority's (BC Hydro) Site C Clean Energy Project ("Site C") in spring and summer 2017. The surveys were part of BC Hydro's Breeding Bird Follow-up Monitoring Program (Volume 2, Section 14 in BC Hydro 2013). This report describes the methods used to conduct the 2017 surveys and provides a summary of the results.

The breeding birds monitoring program is focussed on passerines (songbird perching birds), hummingbirds, swifts, doves, kingfisher, and pigeons (all members of the orders *Passeriformes*, *Apodiformes*, *Columbiformes*, and *Coraciiformes*), which are collectively referred to as songbirds. Songbird baseline surveys were conducted in 2006, 2008, 2011 and 2012. Surveys were again conducted in 2016 and 2017 as part of the monitoring program.

2.0 METHODS

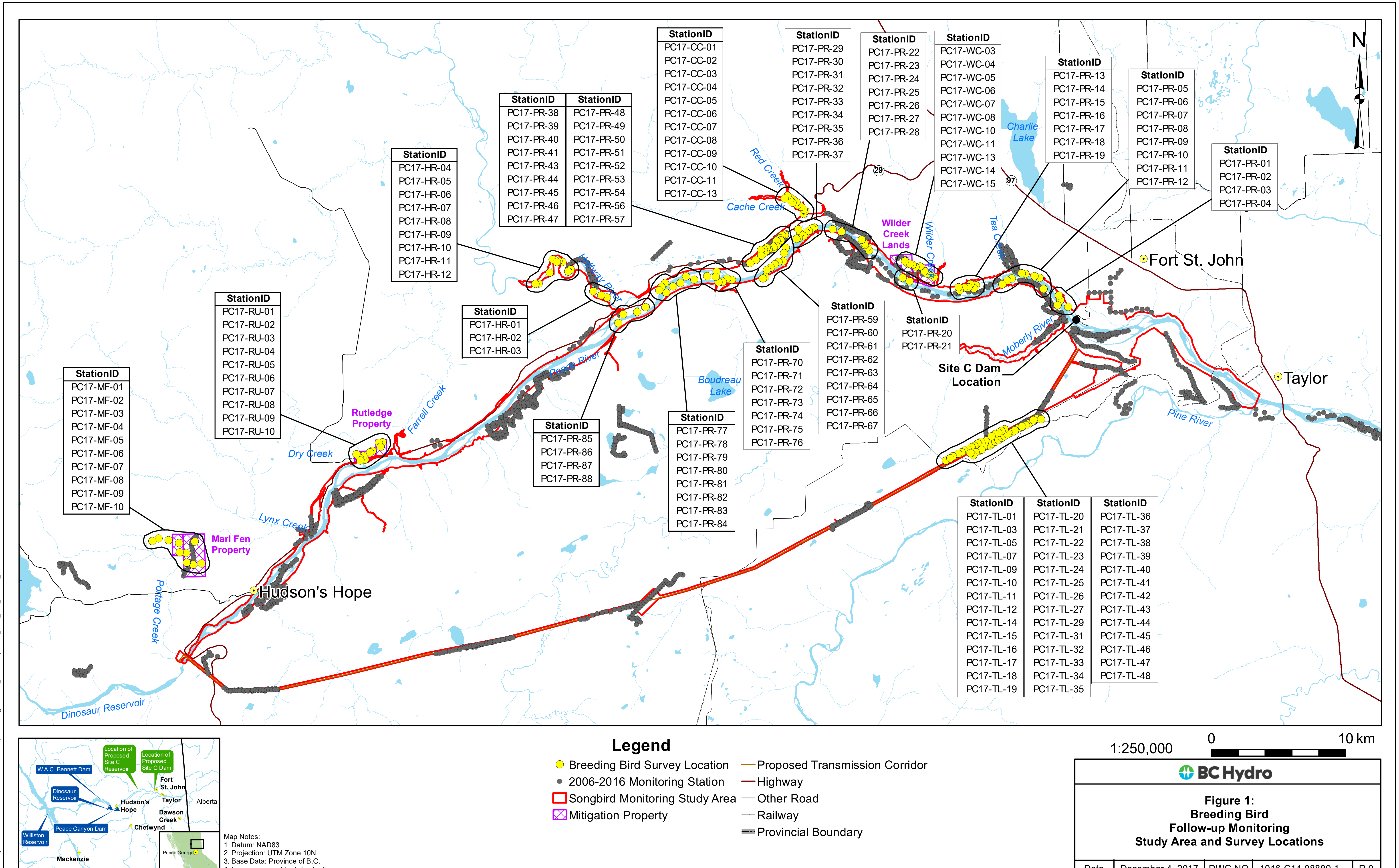
2.1 Survey Area

Songbird surveys were conducted in and around the project footprint and in the BC Hydro proposed mitigation properties (Figure 1). The footprint is primarily composed of the dam, generating station and spillways, reservoir, transmission line and construction access roads.

2.2 Survey Station Locations

Station locations were selected based on areas and habitats in and around the footprint that had not received sampling in the past, habitat for rare species, and habitats of high bird abundance and species richness. Terrestrial Ecosystem Mapping (TEM) developed for the EIS (Hilton et al., 2013) was used as the habitat base. To identify habitats for priority sampling, the number of past surveys were tallied by ecosystem unit (combination of site series and structural stage) to determine those units with few or no past surveys.

The geographic focus of surveys in 2017 was in and around the east half of the Peace River valley footprint (from the Halfway River to the dam site) and the Transmission Line. This included areas that were scheduled to be cleared later in 2017 and 2018. All other portions of the footprint not already cleared are scheduled to be cleared in late 2018 to 2022. Station locations are shown in Figure 1 and the number of stations by general location are listed in Table 1.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PC17-TL-46
PC17-TL-47
PC17-TL-48
Red Creek
Cache Creek
Wilder Creek Lands
Wilder Creek
Tea Creek
Charlie Lake
Fort St. John
Moberly River
Site C Dam Location
Taylor
Pine River
Boudreau Lake
Peace River
Farrell Creek
Rutledge Property
Dry Creek
Lynx Creek
Marl Fen Property
Hudson's Hope
Portage Creek
Dinosaur Reservoir
29
97
Location of Proposed Site C Reservoir
Location of Proposed Site C Dam
W.A.C. Bennett Dam
Dinosaur Reservoir
Fort St. John
Hudson's Hope
Taylor
Alberta
Dawson Creek
Peace Canyon Dam
Chetwynd
Williston Reservoir
Mackenzie
Prince George
Vancouver
Legend
Breeding Bird Survey Location
2006-2016 Monitoring Station
Songbird Monitoring Study Area
Mitigation Property
Proposed Transmission Corridor
Highway
Other Road
Railway
Provincial Boundary
Map Notes:
1. Datum: NAD83
2. Projection: UTM Zone 10N
3. Base Data: Province of B.C.
4. Figure prepared by Tetra Tech.
1:250,000
0
10 km
BC Hydro
Figure 1:
Breeding Bird
Follow-up Monitoring
Study Area and Survey Locations
Date
December 4, 2017
DWG NO
1016-C14-08889-1
R 0
Path: W:\Projects\VAN\149420\VENV03095-01\GIS\Maps\BreedingBird\2017_AnnualReport\BB_1016_C14_08889-1_R0.mxd
Construction of the Site C Clean Energy Project is subject to required regulatory and permitting approvals.

Table 1. Number of stations surveyed in 2017 by general location

General Location	Number of Stations Surveyed
Dam to Wilder Creek	19
Transmission Line East	41
Watson Slough	18
Wilder to Bear Flats	18
Cache Creek	12
Watson Slough to Halfway River	28
Halfway River	12
Wilder Creek Mitigation Property	11
Marl Fen Mitigation Property	10
Rutledge Mitigation Property	10
Total	**179**

2.3 Bird Surveys

Birds were surveyed using point count methods consistent with past surveys and with those recommended by the Resources Information Standards Committee (RISC 1999). However, beginning in 2017 the precise survey protocol was modified in two ways. The 2017 point count surveys were conducted as unlimited radius point counts (instead of the 100m fixed-radius conducted previously) with distance-to-detection intervals set at 0-50 m, 51-100 m and >100 m. The unlimited radius distance allows for greater potential for species detection during surveys. The detection distance intervals have two benefits: 1) allow for comparison to the baseline 100 m fixed-radius point count data and 2) allow for distance-based estimates of absolute abundance if that analytical approach is utilized in the future. Second, each point-count survey was conducted over 10 minutes (instead of the 5 minute survey period conducted previously) and bird detections were recorded in three intervals: 0-3 minutes, 3-5 minutes and 5-10 minutes. The longer survey period provides for potential for greater bird detections. The three time intervals will allow for comparison to the 5-minute point count baseline data and allows for time-of-detection estimates of absolute abundance, if that analytical approach is utilized in the future.

Point counts were conducted May 28 to July 10. Point counts took place from sunrise to approximately four hours after sunrise. At each station, the surveyor waited one minute upon arriving, then commenced the 10 minute survey period and recorded all birds seen and/or heard. Data were recorded on a standardized data form.

Each station was surveyed (visited) two times in order to maximize the detection of early and late breeders. The results of the visits at each station were pooled using maximum detection (the largest number of each species found over both surveys at the station). This approach assumes that repeat observations of a species after the first visit are the same individuals, plus new individuals if a greater number is detected.

Incidental observations of any species group were recorded when non-songbird species were observed during surveys, or when species were observed outside of survey stations (e.g. when surveyors were traveling between stations) or survey periods (e.g. before or after daily observations have started/finished). For each incidental observation of a rare species, date, time, GPS location, gender, behavior and habitat was recorded. Observations of birds other than songbirds will be collected in a database to contribute to other mitigation and monitoring plans, such as the ground-nesting raptor, woodpecker, Common Nighthawk, waterbird and cavity-nesting species plans.

2.4 Collection of Habitat Data

Habitat data were collected at 162 of the 179 stations. Seventeen of the stations could not be revisited to collect habitat data due to access (changing water levels that prohibited boat access) and safety (presence of bears and livestock). Habitat data for these stations will be collected in 2018, if accessible. Data were recorded using the Ministry of Forests' Ground Inspection Form (GIF) and included all site fields and a partial vegetation list. Soil attributes were not collected. In addition to the GIF form fields, the number of dead standing trees (snags) greater than 15 cm diameter at breast height was recorded within a 50 m radius of the plot centre. Classification of each station was completed according to the Terrestrial Ecosystem Mapping units defined in the EIS (Hilton *et al.*, 2013a).

3.0 RESULTS AND DISCUSSION

The number of stations surveyed in each ecosystem unit (Map Code/Site Series and Structural Stage) is provided below (Table 2).

Table 2. Number of point count stations in each ecosystem unit.

Map Code	Site Series	Name	Structural Stage	Number of Stations Surveyed
AM	01	White spruce/Trembling aspen - Step moss	Mature forest	1
SW	03	White spruce - Wildrye – Peavine	Pole/sapling	1
SW	03	White spruce - Wildrye – Peavine	Young forest	1
SW	03	White spruce - Wildrye – Peavine	Mature forest	1
BL	04	Black spruce - Lingonberry - Coltsfoot	Young forest	1
BL	04	Black spruce - Lingonberry - Coltsfoot	Mature forest	2
SO	05	White spruce - Currant - Oak fern	Mature forest	1
SH	07	White spruce - Currant – Horsetail	Shrub	1
SH	07	White spruce - Currant – Horsetail	Young forest	1
SH	07	White spruce - Currant – Horsetail	Mature forest	2
Fm02	09	Balsam poplar/White spruce - Red-osier dogwood	Herbaceous	2
Fm02	09	Balsam poplar/White spruce - Red-osier dogwood	Shrub	8
Fm02	09	Balsam poplar/White spruce - Red-osier dogwood	Pole/sapling	2
Fm02	09	Balsam poplar/White spruce - Red-osier dogwood	Young forest	11
Fm02	09	Balsam poplar/White spruce - Red-osier dogwood	Mature forest	7

Map Code	Site Series	Name	Structural Stage	Number of Stations Surveyed
Fm02	09	Balsam poplar/White spruce - Red-osier dogwood	Old forest	1
AM:ap	$01	Trembling aspen - Creamy peavine	Herbaceous	1
AM:ap	$01	Trembling aspen - Creamy peavine	Shrub	4
AM:ap	$01	Trembling aspen - Creamy peavine	Pole/sapling	6
AM:ap	$01	Trembling aspen - Creamy peavine	Young forest	18
AM:ap	$01	Trembling aspen - Creamy peavine	Mature forest	21
LL:ak	$02	Trembling aspen - Kinnikinnick	Mature forest	1
SW:as	$03	Trembling aspen - Soopolallie	Young forest	1
SW:as	$03	Trembling aspen - Soopolallie	Mature forest	1
SC:ab	$05	Trembling aspen – Black Twinberry	Mature forest	1
SH:ac	$07	Balsam poplar – Cow parsnip	Shrub	12
SH:ac	$07	Balsam poplar – Cow parsnip	Pole/sapling	6
SH:ac	$07	Balsam poplar – Cow parsnip	Young forest	10
SH:ac	$07	Balsam poplar – Cow parsnip	Mature forest	9
SH:ac	$07	Balsam poplar – Cow parsnip	Old forest	1
BT	08	Black spruce - Labrador tea – Sphagnum	Shrub	3
BT	08	Black spruce - Labrador tea – Sphagnum	Young forest	2
BT	08	Black spruce - Labrador tea – Sphagnum	Mature forest	2
SE	00	Sedge Wetland	Herbaceous	7
WS	00	Willow – Sedge – Wetland	Herbaceous	1
WS	00	Willow – Sedge – Wetland	Shrub	3
WS	00	Willow – Sedge – Wetland	Mature forest	1
WH	00	Willow – Horsetail – Sedge – Riparian Wetland	Herbaceous	1
WH	00	Willow – Horsetail – Sedge – Riparian Wetland	Shrub	7
WH	00	Willow – Horsetail – Sedge – Riparian Wetland	Pole/sapling	1
AS	00	White spruce/Trembling aspen – Soopolallie	Shrub	5
WW	00	Fuzzy-spiked Wildrye – Wolf-willow	Herbaceous	4
WW	00	Fuzzy-spiked Wildrye – Wolf-willow	Shrub	2
CF	-	Cultivated field (including pastures)	Herbaceous	5

A total of 2,403 birds of 71 species were recorded during the point count surveys in 2017 (Table 3). Eight species listed under the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), the Species at Risk Act (SARA) and/or British Columbia's Red and Blue lists were observed during the surveys. The songbird species observed are provided in Table 4. Other bird species were recorded as incidental observations and are provided in Appendix B.

Table 3. Point count survey summary for 2017

Metric	Count
Number of survey stations	179
Number of point counts	358
Number of bird species detected	109
Number of songbird species detected	71
Number of rare songbird species detected	8
Number of songbirds detected (based on maximum count over the two surveys at each station)	2,403
Mean songbird species per station (standard deviation in parentheses)	11.8 (3.0)
Mean songbird count per station (standard deviation in parentheses)	13.4 (4.4)

Table 4. Songbird species observed during the 2017 point count surveys

Common Name	BC List	COSEWIC	SARA	Total Count[1]	Incidence[2]
Belted Kingfisher	Yellow	-	-	4	4
Olive-sided Flycatcher	Blue	Threatened	Schedule 1 - Threatened	12	12
Western Wood-Pewee	Yellow	-	-	24	23
Alder Flycatcher	Yellow	-	-	28	28
Pacific-slope Flycatcher	Yellow	-	-	3	3
Least Flycatcher	Yellow	-	-	78	69
Eastern Kingbird	Yellow	-	-	2	2
Warbling Vireo	Yellow	-	-	38	36
Red-eyed Vireo	Yellow	-	-	163	139
Philadelphia Vireo	Yellow	-	-	5	5
Blue-headed Vireo	Yellow	-	-	9	9
American Crow	Yellow	-	-	21	16

Common Name	BC List	COSEWIC	SARA	Total Count[1]	Incidence[2]
Common Raven	Yellow	-	-	107	92
Blue Jay	Yellow	-	-	18	17
Gray Jay	Yellow	-	-	18	17
Black-billed Magpie	Yellow	-	-	35	25
Cedar Waxwing	Yellow	-	-	34	32
Black-capped Chickadee	Yellow	-	-	12	10
Boreal Chickadee	Yellow	-	-	3	3
Bank Swallow	Yellow	Threatened	Schedule 1 - Threatened	26	3
Northern Rough-winged Swallow	Yellow	-	-	2	1
Tree Swallow	Yellow	-	-	8	4
Ruby-crowned Kinglet	Yellow	-	-	20	18
Marsh Wren	Yellow	-	-	3	3
Red-breasted Nuthatch	Yellow	-	-	22	20
House Wren	Yellow	-	-	14	14
Gray Catbird	Yellow	-	-	10	10
Hermit Thrush	Yellow	-	-	85	84
Swainson's Thrush	Yellow	-	-	137	128
Townsend's Solitaire	Yellow	-	-	2	2
American Robin	Yellow	-	-	136	117
Purple Finch	Yellow	-	-	9	8
Pine Siskin	Yellow	-	-	8	4
Canada Warbler	Blue	Threatened	Schedule 1 - Threatened	2	2
Wilson's Warbler	Yellow	-	-	22	21
MacGillivray's Warbler	Yellow	-	-	6	6
Common Yellowthroat	Yellow	-	-	64	56
Black-and-white Warbler	Yellow	-	-	33	33
Connecticut Warbler	Blue	-	-	1	1
Orange-crowned Warbler	Yellow	-	-	27	26
Tennessee Warbler	Yellow	-	-	33	32

Common Name	BC List	COSEWIC	SARA	Total Count[1]	Incidence[2]
Nashville Warbler	Yellow	-	-	1	1
Northern Waterthrush	Yellow	-	-	52	45
Ovenbird	Yellow	-	-	79	67
Bay-breasted Warbler	Red	-	-	2	2
Yellow-rumped Warbler	Yellow	-	-	66	64
Magnolia Warbler	Yellow	-	-	16	13
Black-throated Gray Warbler	Yellow	-	-	1	1
Yellow Warbler	Yellow	-	-	133	116
American Redstart	Yellow	-	-	81	69
Cape May Warbler	Blue	-	-	7	7
Townsend's Warbler	Yellow	-	-	3	1
Black-throated Green Warbler	Blue	-	-	7	7
Red-winged Blackbird	Yellow	-	-	64	15
Brewer's Blackbird	Yellow	-	-	16	5
Baltimore Oriole	Blue	-	-	6	6
Brown-headed Cowbird	Yellow	-	-	22	22
Western Meadowlark	Yellow	-	-	2	2
Dark-eyed Junco	Yellow	-	-	40	39
Swamp Sparrow	Yellow	-	-	33	27
Lincoln's Sparrow	Yellow	-	-	81	74
Song Sparrow	Yellow	-	-	57	57
Savannah Sparrow	Yellow	-	-	4	4
Vesper Sparrow	Yellow	-	-	14	12
Clay-colored Sparrow	Yellow	-	-	40	37
Chipping Sparrow	Yellow	-	-	18	17
White-throated Sparrow	Yellow	-	-	167	141
White-crowned Sparrow	Yellow	-	-	2	1
Rose-breasted Grosbeak	Yellow	-	-	41	39
Western Tanager	Yellow	-	-	64	60

[1] Total count is the sum of the maximum count at all stations. Maximum count is the largest number of each species found over both surveys at the survey station.

[2] Incidence is the number of stations the species was observed at.

Songbirds observed in the three BC Hydro mitigation properties are listed in Table 5. The number of songbird species observed was 18, 36 and 26 in the Marl Fen, Rutledge and Wilder Creek properties, respectively.

Table 5. Songbirds observed at the BC Hydro mitigation properties during the 2017 point count surveys.

Common Name	BC List	COSEWIC	SARA	Total Count[1]		
				Marl Fen	Rutledge	Wilder Creek
Western Wood-Pewee	Yellow	-	-	-	1	-
Alder Flycatcher	Yellow	-	-	-	2	5
Pacific-slope Flycatcher	Yellow	-	-	-	1	-
Least Flycatcher	Yellow	-	-	2	3	4
Warbling Vireo	Yellow	-	-	1	1	1
Red-eyed Vireo	Yellow	-	-	3	12	16
Blue-headed Vireo	Yellow	-	-	2	-	1
American Crow	Yellow	-	-	1	-	3
Common Raven	Yellow	-	-	6	6	16
Blue Jay	Yellow	-	-	-	2	-
Gray Jay	Yellow	-	-	4	-	-
Black-billed Magpie	Yellow	-	-	3	9	2
Cedar Waxwing	Yellow	-	-	-	4	3
Ruby-crowned Kinglet	Yellow	-	-	6	-	-
Red-breasted Nuthatch	Yellow	-	-	2	-	-
House Wren	Yellow	-	-	-	4	3
Gray Catbird	Yellow	-	-	-	-	8
Hermit Thrush	Yellow	-	-	8	5	3
Swainson's Thrush	Yellow	-	-	3	7	5
Townsend's Solitaire	Yellow	-	-	-	2	-
American Robin	Yellow	-	-	9	7	4
Purple Finch	Yellow	-	-	-	-	2
Wilson's Warbler	Yellow	-	-	1	1	1
Common Yellowthroat	Yellow	-	-	2	-	-
Black-and-white Warbler	Yellow	-	-	1	-	-
Orange-crowned Warbler	Yellow	-	-	-	1	3

Common Name	BC List	COSEWIC	SARA	Total Count[1]		
				Marl Fen	Rutledge	Wilder Creek
Tennessee Warbler	Yellow	-	-	-	1	-
Northern Waterthrush	Yellow	-	-	5	-	-
Ovenbird	Yellow	-	-	5	5	-
Yellow-rumped Warbler	Yellow	-	-	6	2	-
Yellow Warbler	Yellow	-	-	-	9	13
American Redstart	Yellow	-	-	2	11	-
Cape May Warbler	Blue	-	-	1	-	-
Brewer's Blackbird	Yellow	-	-	-	6	-
Baltimore Oriole	Blue	-	-	-	1	-
Brown-headed Cowbird	Yellow	-	-	-	1	1
Western Meadowlark	Yellow	-	-	-	1	-
Dark-eyed Junco	Yellow	-	-	-	5	-
Swamp Sparrow	Yellow	-	-	2	-	-
Lincoln's Sparrow	Yellow	-	-	6	5	2
Song Sparrow	Yellow	-	-	1	-	1
Savannah Sparrow	Yellow	-	-	2	2	-
Vesper Sparrow	Yellow	-	-	-	3	10
Clay-colored Sparrow	Yellow	-	-	1	7	9
Chipping Sparrow	Yellow	-	-	2	1	-
White-throated Sparrow	Yellow	-	-	3	15	12
Rose-breasted Grosbeak	Yellow	-	-	-	5	1
Western Tanager	Yellow	-	-	-	3	1

[1] Total Count is the sum of the maximum count at all stations. Maximum count is the largest number of each species found over both surveys at the survey station.

4.0 REFERENCES

BC Hydro. 2013. Site C Clean Energy Project Environmental Impact Assessment. Volume 2 - Assessment Methodology and Environmental Effects Assessment.

Hilton, S., L. Andrusiak, R. Krichbaum, L. Simpson, and C. Bjork. 2013a. Part 1 Vegetation and Ecological Communities. Terrestrial Vegetation and Wildlife Report. Site C Clean Energy Project. Report to BC Hydro, Vancouver, BC.

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Resources Inventory Committee. 1999. Inventory Methods for Forest and Grassland Songbirds. Version 2.0. Standards for Components of British Columbia's Biodiversity No. 15. BC Ministry of Environment, Lands and Parks, Resources Inventory Branch, Victoria, BC.

APPENDIX A
2017 POINT COUNT STATIONS

Table A.1: Point count stations surveyed in 2017

Station	Location Reference	Geographic Coordinates (UTM)	First Visit	Second Visit	Map Code	Site Series	Ecosystem (Site Series / Structural Stage)
PC17-CC-01	Cache Creek	10V, 609010, 6238122	2017-06-04	2017-07-08	SH:ac	$07	Balsam poplar – Cow parsnip (Shrub)
PC17-CC-02	Cache Creek	10V, 609126, 6238352	2017-06-04	2017-07-08	SH:ac	$07	Balsam poplar – Cow parsnip (Shrub)
PC17-CC-03	Cache Creek	10V, 608999, 6238451	2017-06-04	2017-07-08	SH:ac	$07	Balsam poplar – Cow parsnip (Pole/sapling)
PC17-CC-04	Cache Creek	10V, 608839, 6238669	2017-06-04	2017-07-08	AM:ap	$01	Trembling aspen - Creamy peavine (Young forest)
PC17-CC-05	Cache Creek	10V, 608543, 6238783	2017-06-04	2017-07-08	Fm02	09	Balsam poplar/white spruce - Red-osier dogwood (Young forest)
PC17-CC-06	Cache Creek	10V, 608477, 6239003	2017-06-04	2017-07-08	Fm02	09	Balsam poplar/white spruce - Red-osier dogwood (Young forest)
PC17-CC-07	Cache Creek	10V, 608238, 6239161	2017-06-04	2017-07-08	AM:ap	$01	Trembling aspen - Creamy peavine (Mature forest)
PC17-CC-08	Cache Creek	10V, 608185, 6238950	2017-06-04	2017-07-08	Fm02	09	Balsam poplar/white spruce - Red-osier dogwood (Young forest)
PC17-CC-09	Cache Creek	10V, 608009, 6239326	2017-06-04	2017-07-08	Fm02	09	Balsam poplar/white spruce - Red-osier dogwood (Young forest)
PC17-CC-10	Cache Creek	10V, 607985, 6239157	2017-06-04	2017-07-08	Fm02	09	Balsam poplar/white spruce - Red-osier dogwood (Pole/sapling)
PC17-CC-11	Cache Creek	10V, 607794, 6239472	2017-06-04	2017-07-08	Fm02	09	Balsam poplar/white spruce - Red-osier dogwood (Mature forest)
PC17-CC-13	Cache Creek	10V, 607588, 6239268	2017-06-04	2017-07-08	Fm02	09	Balsam poplar/white spruce - Red-osier dogwood (Mature forest)
PC17-HR-01	Halfway River	10V, 594381, 6231899	2017-06-13	2017-07-02	Fm02	09	Balsam poplar/white spruce - Red-osier dogwood (Shrub)
PC17-HR-02	Halfway River	10V, 593958, 6232067	2017-06-13	2017-07-02	SH	07	White spruce - Currant – Horsetail

Station	Location Reference	Geographic Coordinates (UTM)	First Visit	Second Visit	Map Code	Site Series	Ecosystem (Site Series / Structural Stage)
							(Mature forest)
PC17-HR-03	Halfway River	10V, 593366, 6232369	2017-06-13	2017-07-06	AM:ap	$01	Trembling aspen - Creamy peavine (Young forest)
PC17-HR-04	Halfway River	10V, 591684, 6234008	2017-06-13	2017-07-06	SH:ac	$07	Balsam poplar – Cow parsnip (Mature forest)
PC17-HR-05	Halfway River	10V, 591506, 6233832	2017-06-13	2017-07-06	SH:ac	$07	Balsam poplar – Cow parsnip (Shrub)
PC17-HR-06	Halfway River	10V, 591060, 6234553	2017-06-13	2017-07-06	WH	00	Willow – Horsetail – Sedge – Riparian Wetland (Shrub)
PC17-HR-07	Halfway River	10V, 590781, 6234624	2017-06-13	2017-07-06	WH	00	Willow – Horsetail – Sedge – Riparian Wetland (Pole/sapling)
PC17-HR-08	Halfway River	10V, 590342, 6234736	2017-06-13	2017-07-06	Fm02	09	Balsam poplar/white spruce - Red-osier dogwood (Mature forest)
PC17-HR-09	Halfway River	10V, 590135, 6233750	2017-06-13	2017-07-06	Fm02	09	Balsam poplar/white spruce - Red-osier dogwood (Mature forest)
PC17-HR-10	Halfway River	10V, 589303, 6232950	2017-06-13	2017-07-06	Fm02	09	Balsam poplar/white spruce - Red-osier dogwood (Mature forest)
PC17-HR-11	Halfway River	10V, 589071, 6232924	2017-06-13	2017-07-06	Fm02	09	Balsam poplar/white spruce - Red-osier dogwood (Mature forest)
PC17-HR-12	Halfway River	10V, 590648, 6234564	2017-06-13	2017-07-06	SH:ac	$07	Balsam poplar – Cow parsnip (Young forest)
PC17-MF-01	Marl Fen	10V, 564238, 6212108	2017-06-03	2017-07-03	BL	04	Black spruce - Lingonberry - Coltsfoot (Mature forest)
PC17-MF-02	Marl Fen	10V, 563624, 6212035	2017-06-03	2017-07-03	CF	-	Cultivated field (including pastures) (Herbaceous)
PC17-MF-03	Marl Fen	10V, 563149, 6212182	2017-06-03	2017-07-03	WS	00	Willow – Sedge – Wetland (Herbaceous)
PC17-MF-04	Marl Fen	10V, 563089, 6212907	2017-06-03	2017-07-03	BL	04	Black spruce - Lingonberry - Coltsfoot (Mature forest)

Station	Location Reference	Geographic Coordinates (UTM)	First Visit	Second Visit	Map Code	Site Series	Ecosystem (Site Series / Structural Stage)
PC17-MF-05	Marl Fen	10V, 563733, 6213758	2017-06-03	2017-07-03	AM:ap	$01	Trembling aspen - Creamy peavine (Pole/sapling)
PC17-MF-06	Marl Fen	10V, 562602, 6212939	2017-06-03	2017-07-03	BL	04	Black spruce - Lingonberry - Coltsfoot (Young forest)
PC17-MF-07	Marl Fen	10V, 562578, 6213647	2017-06-03	2017-07-03	CF	-	Cultivated field (including pastures) (Herbaceous)
PC17-MF-08	Marl Fen	10V, 561777, 6213854	2017-06-03	2017-07-03	AM:ap	$01	Trembling aspen - Creamy peavine (Pole/sapling)
PC17-MF-09	Marl Fen	10V, 561036, 6213971	2017-06-03	2017-07-03	AM:ap	$01	Trembling aspen - Creamy peavine (Mature forest)
PC17-MF-10	Marl Fen	10V, 560586, 6213785	2017-06-03	2017-07-03	AM:ap	$01	Trembling aspen - Creamy peavine (Young forest)
PC17-PR-01	Dam to Wilder Creek	10V, 628673, 6231205	2017-05-30	2017-06-28	AS	00	White spruce/trembling aspen – Soopolallie (Shrub)
PC17-PR-02	Dam to Wilder Creek	10V, 628090, 6231725	2017-05-30	2017-06-29	WH	00	Willow – Horsetail – Sedge – Riparian Wetland (Shrub)
PC17-PR-03	Dam to Wilder Creek	10V, 627967, 6232066	2017-05-30	2017-06-29	AM:ap	$01	Trembling aspen - Creamy peavine (Herbaceous)
PC17-PR-04	Dam to Wilder Creek	10V, 627898, 6231347	2017-05-30	2017-06-29	WH	00	Willow – Horsetail – Sedge – Riparian Wetland (Shrub)
PC17-PR-05	Dam to Wilder Creek	10V, 626843, 6232553	2017-05-30	2017-06-29	Fm02	09	Balsam poplar/white spruce - Red-osier dogwood (Shrub)
PC17-PR-06	Dam to Wilder Creek	10V, 626544, 6233377	2017-05-30	2017-06-29	SW:as	$03	Trembling aspen - Soopolallie (Young forest)
PC17-PR-07	Dam to Wilder Creek	10V, 626184, 6233496	2017-05-30	2017-06-29	AM:ap	$01	Trembling aspen - Creamy peavine (Shrub)
PC17-PR-08	Dam to Wilder Creek	10V, 625493, 6233671	2017-05-30	2017-06-29	AM:ap	$01	Trembling aspen - Creamy peavine (Young forest)

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PC17-PR-09	Dam to Wilder Creek	10V, 625218, 6233704	2017-05-30	2017-06-29	AM:ap	$01	Trembling aspen - Creamy peavine (Young forest)
PC17-PR-10	Dam to Wilder Creek	10V, 624474, 6233331	2017-05-30	2017-06-29	Fm02	09	Balsam poplar/white spruce - Red-osier dogwood (Herbaceous)
PC17-PR-11	Dam to Wilder Creek	10V, 624133, 6233160	2017-05-30	2017-06-29	Fm02	09	Balsam poplar/white spruce - Red-osier dogwood (Shrub)
PC17-PR-12	Dam to Wilder Creek	10V, 623772, 6232889	2017-05-30	2017-06-28	Fm02	09	Balsam poplar/white spruce - Red-osier dogwood (Pole/sapling)
PC17-PR-13	Dam to Wilder Creek	10V, 621821, 6232824	2017-05-30	2017-06-29	SH:ac	$07	Balsam poplar – Cow parsnip (Mature forest)
PC17-PR-14	Dam to Wilder Creek	10V, 621689, 6232576	2017-05-30	2017-06-29	SH:ac	$07	Balsam poplar – Cow parsnip (Mature forest)
PC17-PR-15	Dam to Wilder Creek	10V, 621414, 6232904	2017-05-30	2017-06-29	Fm02	09	Balsam poplar/white spruce - Red-osier dogwood (Mature forest)
PC17-PR-16	Dam to Wilder Creek	10V, 621267, 6232677	2017-05-30	2017-06-29	SH:ac	$07	Balsam poplar – Cow parsnip (Young forest)
PC17-PR-17	Dam to Wilder Creek	10V, 620939, 6232637	2017-05-30	2017-06-29	SH:ac	$07	Balsam poplar – Cow parsnip (Mature forest)
PC17-PR-18	Dam to Wilder Creek	10V, 620615, 6232428	2017-05-30	2017-06-28	SH:ac	$07	Balsam poplar – Cow parsnip (Shrub)
PC17-PR-19	Dam to Wilder Creek	10V, 620523, 6232665	2017-05-30	2017-06-29	SH:ac	$07	Balsam poplar – Cow parsnip (Young forest)
PC17-PR-20	Wilder to Bear Flats	10V, 616882, 6233119	2017-05-31	2017-06-30	Fm02	09	Balsam poplar/white spruce - Red-osier dogwood (Shrub)
PC17-PR-21	Wilder to Bear Flats	10V, 616366, 6233373	2017-05-31	2017-06-30	Fm02	09	Balsam poplar/white spruce - Red-osier dogwood (Shrub)
PC17-PR-22	Wilder to Bear Flats	10V, 613881, 6235427	2017-05-31	2017-06-30	Fm02	09	Balsam poplar/white spruce - Red-osier dogwood (Shrub)

Station	Location Reference	Geographic Coordinates (UTM)	First Visit	Second Visit	Map Code	Site Series	Ecosystem (Site Series / Structural Stage)
PC17-PR-23	Wilder to Bear Flats	10V, 613742, 6235639	2017-05-31	2017-06-30	Fm02	09	Balsam poplar/white spruce - Red-osier dogwood (Young forest)
PC17-PR-24	Wilder to Bear Flats	10V, 613558, 6235826	2017-05-31	2017-06-30	Fm02	09	Balsam poplar/white spruce - Red-osier dogwood (Shrub)
PC17-PR-25	Wilder to Bear Flats	10V, 613533, 6235924	2017-05-31	2017-06-30	Fm02	09	Balsam poplar/white spruce - Red-osier dogwood (Young forest)
PC17-PR-26	Wilder to Bear Flats	10V, 613325, 6236198	2017-05-31	2017-06-30	Fm02	09	Balsam poplar/white spruce - Red-osier dogwood (Herbaceous)
PC17-PR-27	Wilder to Bear Flats	10V, 611824, 6236789	2017-05-31	2017-06-30	WH	00	Willow – Horsetail – Sedge – Riparian Wetland (Shrub)
PC17-PR-28	Wilder to Bear Flats	10V, 611166, 6236981	2017-05-31	2017-06-30	SO	05	White spruce - Currant - Oak fern (Mature forest)
PC17-PR-29	Wilder to Bear Flats	10V, 609790, 6237117	2017-05-31	2017-06-30	WH	00	Willow – Horsetail – Sedge – Riparian Wetland (Shrub)
PC17-PR-30	Wilder to Bear Flats	10V, 609634, 6237061	2017-05-31	2017-06-30	WH	00	Willow – Horsetail – Sedge – Riparian Wetland (Shrub)
PC17-PR-31	Wilder to Bear Flats	10V, 609393, 6236856	2017-05-31	2017-06-30	SH:ac	$07	Balsam poplar – Cow parsnip (Pole/sapling)
PC17-PR-32	Wilder to Bear Flats	10V, 609188, 6236727	2017-05-31	2017-06-30	SH:ac	$07	Balsam poplar – Cow parsnip (Shrub)
PC17-PR-33	Wilder to Bear Flats	10V, 609029, 6236489	2017-05-31	2017-06-30	WH	00	Willow – Horsetail – Sedge – Riparian Wetland (Herbaceous)
PC17-PR-34	Wilder to Bear Flats	10V, 608751, 6236678	2017-05-31	2017-06-30	SH:ac	$07	Balsam poplar – Cow parsnip (Pole/sapling)
PC17-PR-35	Wilder to Bear Flats	10V, 608598, 6236983	2017-05-31	2017-06-30	SH:ac	$07	Balsam poplar – Cow parsnip (Shrub)
PC17-PR-36	Wilder to Bear Flats	10V, 608622, 6236314	2017-05-31	2017-06-30	SH:ac	$07	Balsam poplar – Cow parsnip (Pole/sapling)

Station	Location Reference	Geographic Coordinates (UTM)	First Visit	Second Visit	Map Code	Site Series	Ecosystem (Site Series / Structural Stage)
PC17-PR-37	Wilder to Bear Flats	10V, 608476, 6236258	2017-05-31	2017-06-30	SH:ac	$07	Balsam poplar – Cow parsnip (Shrub)
PC17-PR-38	Watson Slough	10V, 607605, 6236561	2017-05-29	2017-06-27	SE	00	Sedge Wetland (Herbaceous)
PC17-PR-39	Watson Slough	10V, 607396, 6236515	2017-05-29	2017-06-27	WS	00	Willow – Sedge – Wetland (Shrub)
PC17-PR-40	Watson Slough	10V, 607273, 6236303	2017-05-29	2017-06-27	WS	00	Willow – Sedge – Wetland (Mature forest)
PC17-PR-41	Watson Slough	10V, 607314, 6236171	2017-05-29	2017-07-05	SW:as	$03	Trembling aspen - Soopolallie (Mature forest)
PC17-PR-43	Watson Slough	10V, 607111, 6235979	2017-05-29	2017-07-05	AM:ap	$01	Trembling aspen - Creamy peavine (Mature forest)
PC17-PR-44	Watson Slough	10V, 606990, 6236110	2017-05-29	2017-07-05	WS	00	Willow – Sedge – Wetland (Shrub)
PC17-PR-45	Watson Slough	10V, 606970, 6235744	2017-05-29	2017-07-05	SE	00	Sedge Wetland (Herbaceous)
PC17-PR-46	Watson Slough	10V, 606770, 6235559	2017-05-29	2017-07-05	SE	00	Sedge Wetland (Herbaceous)
PC17-PR-47	Watson Slough	10V, 606759, 6235685	2017-05-29	2017-07-05	SE	00	Sedge Wetland (Herbaceous)
PC17-PR-48	Watson Slough	10V, 606406, 6235515	2017-05-28	2017-07-05	BT	08	Black spruce - Labrador tea – Sphagnum (Shrub)
PC17-PR-49	Watson Slough	10V, 606266, 6235622	2017-05-28	2017-07-05	AM:ap	$01	Trembling aspen - Creamy peavine (Young forest)
PC17-PR-50	Watson Slough	10V, 606203, 6235322	2017-05-28	2017-07-05	BT	08	Black spruce - Labrador tea – Sphagnum (Mature forest)
PC17-PR-51	Watson Slough	10V, 606055, 6235491	2017-05-28	2017-07-05	AM:ap	$01	Trembling aspen - Creamy peavine (Young forest)
PC17-PR-52	Watson Slough	10V, 606065, 6235222	2017-05-28	2017-07-05	BT	08	Black spruce - Labrador tea – Sphagnum (Mature forest)
PC17-PR-53	Watson Slough	10V, 605840, 6235450	2017-05-28	2017-07-05	AM:ap	$01	Trembling aspen - Creamy peavine (Young forest)

Station	Location Reference	Geographic Coordinates (UTM)	First Visit	Second Visit	Map Code	Site Series	Ecosystem (Site Series / Structural Stage)
PC17-PR-54	Watson Slough	10V, 605844, 6235010	2017-05-28	2017-06-27	BT	08	Black spruce - Labrador tea – Sphagnum (Shrub)
PC17-PR-56	Watson Slough	10V, 605447, 6234696	2017-05-28	2017-06-27	SH	07	White spruce - Currant – Horsetail (Mature forest)
PC17-PR-57	Watson Slough	10V, 605027, 6234478	2017-05-28	2017-06-27	SH	07	White spruce - Currant – Horsetail (Shrub)
PC17-PR-59	Watson Slough to Halfway River	10V, 607681, 6235617	2017-06-01	2017-06-30	SH:ac	$07	Balsam poplar – Cow parsnip (Shrub)
PC17-PR-60	Watson Slough to Halfway River	10V, 607548, 6235217	2017-06-01	2017-06-30	WH	00	Willow – Horsetail – Sedge – Riparian Wetland (Shrub)
PC17-PR-61	Watson Slough to Halfway River	10V, 607479, 6234615	2017-06-01	2017-07-01	SH:ac	$07	Balsam poplar – Cow parsnip (Old forest)
PC17-PR-62	Watson Slough to Halfway River	10V, 607137, 6234555	2017-06-01	2017-07-01	SH:ac	$07	Balsam poplar – Cow parsnip (Mature forest)
PC17-PR-63	Watson Slough to Halfway River	10V, 606868, 6234389	2017-06-01	2017-07-01	Fm02	09	Balsam poplar/white spruce - Red-osier dogwood (Old forest)
PC17-PR-64	Watson Slough to Halfway River	10V, 606566, 6234135	2017-06-01	2017-07-01	Fm02	09	Balsam poplar/white spruce - Red-osier dogwood (Shrub)
PC17-PR-65	Watson Slough to Halfway River	10V, 606281, 6233960	2017-06-01	2017-07-01	Fm02	09	Balsam poplar/white spruce - Red-osier dogwood (Young forest)
PC17-PR-66	Watson Slough to Halfway River	10V, 606148, 6233430	2017-06-01	2017-07-01	AM	01	White spruce/trembling aspen - Step moss (Mature forest)
PC17-PR-67	Watson Slough to Halfway River	10V, 605987, 6233328	2017-06-01	2017-07-01	AM:ap	$01	Trembling aspen - Creamy peavine (Mature forest)
PC17-PR-70	Watson Slough to Halfway River	10V, 603674, 6233222	2017-06-01	2017-07-01	SH:ac	$07	Balsam poplar – Cow parsnip (Mature forest)
PC17-PR-71	Watson Slough to Halfway River	10V, 603308, 6233296	2017-06-01	2017-07-01	SH:ac	$07	Balsam poplar – Cow parsnip (Pole/sapling)

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PC17-PR-72	Watson Slough to Halfway River	10V, 603001, 6233074	2017-06-01	2017-07-01	AM:ap	$01	Trembling aspen - Creamy peavine (Mature forest)
PC17-PR-73	Watson Slough to Halfway River	10V, 602678, 6233042	2017-06-01	2017-07-01	AM:ap	$01	Trembling aspen - Creamy peavine (Mature forest)
PC17-PR-74	Watson Slough to Halfway River	10V, 602521, 6233832	2017-06-01	2017-07-01	SH:ac	$07	Balsam poplar – Cow parsnip (Shrub)
PC17-PR-75	Watson Slough to Halfway River	10V, 602457, 6233450	2017-06-01	2017-07-01	Fm02	09	Balsam poplar/white spruce - Red-osier dogwood (Young forest)
PC17-PR-76	Watson Slough to Halfway River	10V, 601836, 6233487	2017-06-02	2017-07-01	SH:ac	$07	Balsam poplar – Cow parsnip (Mature forest)
PC17-PR-77	Watson Slough to Halfway River	10V, 600879, 6233238	2017-06-02	2017-07-02	SH:ac	$07	Balsam poplar – Cow parsnip (Mature forest)
PC17-PR-78	Watson Slough to Halfway River	10V, 600261, 6233483	2017-06-02	2017-07-02	Fm02	09	Balsam poplar/white spruce - Red-osier dogwood (Young forest)
PC17-PR-79	Watson Slough to Halfway River	10V, 599837, 6232979	2017-06-02	2017-07-02	Fm02	09	Balsam poplar/white spruce - Red-osier dogwood (Young forest)
PC17-PR-80	Watson Slough to Halfway River	10V, 599292, 6232725	2017-06-02	2017-07-02	SH:ac	$07	Balsam poplar – Cow parsnip (Young forest)
PC17-PR-81	Watson Slough to Halfway River	10V, 598699, 6232989	2017-06-02	2017-07-02	SH:ac	$07	Balsam poplar – Cow parsnip (Shrub)
PC17-PR-82	Watson Slough to Halfway River	10V, 598787, 6232277	2017-06-02	2017-07-02	Fm02	09	Balsam poplar/white spruce - Red-osier dogwood (Young forest)
PC17-PR-83	Watson Slough to Halfway River	10V, 598450, 6232698	2017-06-02	2017-07-02	SH:ac	$07	Balsam poplar – Cow parsnip (Shrub)
PC17-PR-84	Watson Slough to Halfway River	10V, 598271, 6232434	2017-06-02	2017-07-02	SH:ac	$07	Balsam poplar – Cow parsnip (Shrub)
PC17-PR-85	Watson Slough to Halfway River	10V, 597265, 6231180	2017-06-02	2017-07-02	SH:ac	$07	Balsam poplar – Cow parsnip (Mature forest)

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PC17-PR-86	Watson Slough to Halfway River	10V, 596635, 6230836	2017-06-02	2017-07-02	SH:ac	$07	Balsam poplar – Cow parsnip (Pole/sapling)
PC17-PR-87	Watson Slough to Halfway River	10V, 595583, 6230650	2017-06-02	2017-07-02	SH:ac	$07	Balsam poplar – Cow parsnip (Young forest)
PC17-PR-88	Watson Slough to Halfway River	10V, 595231, 6230011	2017-06-02	2017-07-02	SH	07	White spruce - Currant – Horsetail (Young forest)
PC17-RU-01	Rutledge Property	10V, 577700, 6221125	2017-06-03	2017-07-03	AS	00	White spruce/trembling aspen – Soopolallie (Shrub)
PC17-RU-02	Rutledge Property	10V, 577422, 6221101	2017-06-03	2017-07-03	AS	00	White spruce/trembling aspen – Soopolallie (Shrub)
PC17-RU-03	Rutledge Property	10V, 577549, 6220791	2017-06-03	2017-07-03	SH:ac	$07	Balsam poplar – Cow parsnip (Young forest)
PC17-RU-04	Rutledge Property	10V, 576962, 6220495	2017-06-03	2017-07-03	SH:ac	$07	Balsam poplar – Cow parsnip (Young forest)
PC17-RU-05	Rutledge Property	10V, 576763, 6220403	2017-06-03	2017-07-03	AM:ap	$01	Trembling aspen - Creamy peavine (Shrub)
PC17-RU-06	Rutledge Property	10V, 576398, 6219847	2017-06-03	2017-07-03	AM:ap	$01	Trembling aspen - Creamy peavine (Shrub)
PC17-RU-07	Rutledge Property	10V, 576263, 6220109	2017-06-03	2017-07-03	SH:ac	$07	Balsam poplar – Cow parsnip (Young forest)
PC17-RU-08	Rutledge Property	10V, 576009, 6219974	2017-06-03	2017-07-03	CF	-	Cultivated field (including pastures) (Herbaceous)
PC17-RU-09	Rutledge Property	10V, 575764, 6220252	2017-06-03	2017-07-03	CF	-	Cultivated field (including pastures) (Herbaceous)
PC17-RU-10	Rutledge Property	10V, 576056, 6219782	2017-06-03	2017-07-03	CF	-	Cultivated field (including pastures) (Herbaceous)
PC17-TL-01	Transmission Line East	10V, 626326, 6222900	2017-06-06	2017-07-09	SC:ab	$05	Trembling aspen – Black Twinberry (Mature forest)

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PC17-TL-03	Transmission Line East	10V, 625794, 6222547	2017-06-06	2017-07-09	SW	03	White spruce - Wildrye – Peavine (Mature forest)
PC17-TL-05	Transmission Line East	10V, 624919, 6222146	2017-06-06	2017-07-09	BT	08	Black spruce - Labrador tea – Sphagnum (Young forest)
PC17-TL-07	Transmission Line East	10V, 624520, 6221888	2017-06-06	2017-07-09	AM:ap	$01	Trembling aspen - Creamy peavine (Young forest)
PC17-TL-09	Transmission Line East	10V, 622898, 6220901	2017-06-07	2017-07-09	AM:ap	$01	Trembling aspen - Creamy peavine (Young forest)
PC17-TL-10	Transmission Line East	10V, 622638, 6221285	2017-06-07	2017-07-10	SE	00	Sedge Wetland (Herbaceous)
PC17-TL-11	Transmission Line East	10V, 622188, 6221182	2017-06-05	2017-06-26	AM:ap	$01	Trembling aspen - Creamy peavine (Mature forest)
PC17-TL-12	Transmission Line East	10V, 622034, 6220504	2017-06-05	2017-07-10	AM:ap	$01	Trembling aspen - Creamy peavine (Mature forest)
PC17-TL-14	Transmission Line East	10V, 619588, 6219784	2017-06-05	2017-06-26	AM:ap	$01	Trembling aspen - Creamy peavine (Mature forest)
PC17-TL-15	Transmission Line East	10V, 621967, 6221050	2017-06-05	2017-06-26	SE	00	Sedge Wetland (Herbaceous)
PC17-TL-16	Transmission Line East	10V, 622660, 6220888	2017-06-05	2017-07-10	AM:ap	$01	Trembling aspen - Creamy peavine (Mature forest)
PC17-TL-17	Transmission Line East	10V, 621699, 6220866	2017-06-05	2017-06-26	SE	00	Sedge Wetland (Herbaceous)
PC17-TL-18	Transmission Line East	10V, 622414, 6220802	2017-06-05	2017-06-26	AM:ap	$01	Trembling aspen - Creamy peavine (Mature forest)
PC17-TL-19	Transmission Line East	10V, 621497, 6220766	2017-06-05	2017-06-26	AM:ap	$01	Trembling aspen - Creamy peavine (Mature forest)
PC17-TL-20	Transmission Line East	10V, 622234, 6220586	2017-06-05	2017-06-26	AM:ap	$01	Trembling aspen - Creamy peavine (Pole/sapling)

Station	Location Reference	Geographic Coordinates (UTM)	First Visit	Second Visit	Map Code	Site Series	Ecosystem (Site Series / Structural Stage)
PC17-TL-21	Transmission Line East	10V, 621217, 6220593	2017-06-05	2017-06-26	AM:ap	$01	Trembling aspen - Creamy peavine (Pole/sapling)
PC17-TL-22	Transmission Line East	10V, 621784, 6220387	2017-06-05	2017-07-10	AM:ap	$01	Trembling aspen - Creamy peavine (Mature forest)
PC17-TL-23	Transmission Line East	10V, 620963, 6220511	2017-06-05	2017-06-26	AM:ap	$01	Trembling aspen - Creamy peavine (Young forest)
PC17-TL-24	Transmission Line East	10V, 621620, 6220158	2017-06-05	2017-07-10	AM:ap	$01	Trembling aspen - Creamy peavine (Mature forest)
PC17-TL-25	Transmission Line East	10V, 620755, 6220385	2017-06-05	2017-06-26	AM:ap	$01	Trembling aspen - Creamy peavine (Mature forest)
PC17-TL-26	Transmission Line East	10V, 621406, 6220324	2017-06-05	2017-07-10	SH:ac	$07	Balsam poplar – Cow parsnip (Young forest)
PC17-TL-27	Transmission Line East	10V, 620511, 6220282	2017-06-05	2017-06-26	AM:ap	$01	Trembling aspen - Creamy peavine (Mature forest)
PC17-TL-29	Transmission Line East	10V, 620106, 6220103	2017-06-05	2017-06-26	AM:ap	$01	Trembling aspen - Creamy peavine (Young forest)
PC17-TL-31	Transmission Line East	10V, 619907, 6219942	2017-06-05	2017-06-26	AM:ap	$01	Trembling aspen - Creamy peavine (Young forest)
PC17-TL-32	Transmission Line East	10V, 626663, 6222851	2017-06-06	2017-07-10	AM:ap	$01	Trembling aspen - Creamy peavine (Mature forest)
PC17-TL-33	Transmission Line East	10V, 626081, 6222783	2017-06-06	2017-07-09	BT	08	Black spruce - Labrador tea – Sphagnum (Shrub)
PC17-TL-34	Transmission Line East	10V, 625529, 6222406	2017-06-06	2017-07-09	SW	03	White spruce - Wildrye – Peavine (Pole/sapling)
PC17-TL-35	Transmission Line East	10V, 625237, 6222305	2017-06-06	2017-07-09	SW	03	White spruce - Wildrye – Peavine (Young forest)
PC17-TL-36	Transmission Line East	10V, 624705, 6222025	2017-06-06	2017-07-09	BT	08	Black spruce - Labrador tea – Sphagnum (Young forest)

Station	Location Reference	Geographic Coordinates (UTM)	First Visit	Second Visit	Map Code	Site Series	Ecosystem (Site Series / Structural Stage)
PC17-TL-37	Transmission Line East	10V, 624271, 6221790	2017-06-06	2017-07-09	AM:ap	$01	Trembling aspen - Creamy peavine (Mature forest)
PC17-TL-38	Transmission Line East	10V, 623041, 6221045	2017-06-07	2017-07-09	AM:ap	$01	Trembling aspen - Creamy peavine (Young forest)
PC17-TL-39	Transmission Line East	10V, 623262, 6221181	2017-06-07	2017-07-09	AM:ap	$01	Trembling aspen - Creamy peavine (Young forest)
PC17-TL-40	Transmission Line East	10V, 623485, 6221299	2017-06-07	2017-07-09	AM:ap	$01	Trembling aspen - Creamy peavine (Young forest)
PC17-TL-41	Transmission Line East	10V, 623735, 6221477	2017-06-07	2017-07-09	WS	00	Willow – Sedge – Wetland (Shrub)
PC17-TL-42	Transmission Line East	10V, 623926, 6221592	2017-06-07	2017-07-09	SH:ac	$07	Balsam poplar – Cow parsnip (Young forest)
PC17-TL-43	Transmission Line East	10V, 624153, 6221718	2017-06-07	2017-07-09	AM:ap	$01	Trembling aspen - Creamy peavine (Mature forest)
PC17-TL-44	Transmission Line East	10V, 623942, 6222106	2017-06-07	2017-07-09	AM:ap	$01	Trembling aspen - Creamy peavine (Shrub)
PC17-TL-45	Transmission Line East	10V, 623728, 6221980	2017-06-07	2017-07-09	AM:ap	$01	Trembling aspen - Creamy peavine (Young forest)
PC17-TL-46	Transmission Line East	10V, 623495, 6221854	2017-06-07	2017-07-09	AM:ap	$01	Trembling aspen - Creamy peavine (Young forest)
PC17-TL-47	Transmission Line East	10V, 623262, 6221740	2017-06-07	2017-07-09	AM:ap	$01	Trembling aspen - Creamy peavine (Pole/sapling)
PC17-TL-48	Transmission Line East	10V, 622987, 6221581	2017-06-07	2017-07-09	AM:ap	$01	Trembling aspen - Creamy peavine (Pole/sapling)
PC17-WC-03	Wilder Creek	10V, 618694, 6233438	2017-06-08	2017-07-06	WW	00	Fuzzy-spiked Wildrye – Wolf-willow (Herbaceous)
PC17-WC-04	Wilder Creek	10V, 618379, 6233570	2017-06-08	2017-07-06	AM:ap	$01	Trembling aspen - Creamy peavine (Mature forest)

Station	Location Reference	Geographic Coordinates (UTM)	First Visit	Second Visit	Map Code	Site Series	Ecosystem (Site Series / Structural Stage)
PC17-WC-05	Wilder Creek	10V, 618189, 6233696	2017-06-08	2017-07-06	WW	00	Fuzzy-spiked Wildrye – Wolf-willow (Herbaceous)
PC17-WC-06	Wilder Creek	10V, 617859, 6234065	2017-06-08	2017-07-06	WW	00	Fuzzy-spiked Wildrye – Wolf-willow (Shrub)
PC17-WC-07	Wilder Creek	10V, 617990, 6233853	2017-06-08	2017-07-06	WW	00	Fuzzy-spiked Wildrye – Wolf-willow (Herbaceous)
PC17-WC-08	Wilder Creek	10V, 617657, 6234218	2017-06-08	2017-07-06	WW	00	Fuzzy-spiked Wildrye – Wolf-willow (Herbaceous)
PC17-WC-10	Wilder Creek	10V, 617319, 6234168	2017-06-08	2017-07-06	AS	00	White spruce/trembling aspen – Soopolallie (Shrub)
PC17-WC-11	Wilder Creek	10V, 617121, 6234343	2017-06-08	2017-07-06	WW	00	Fuzzy-spiked Wildrye – Wolf-willow (Shrub)
PC17-WC-13	Wilder Creek	10V, 616768, 6234411	2017-06-08	2017-07-06	LL:ak	$02	Trembling aspen - Kinnikinnick (Mature forest)
PC17-WC-14	Wilder Creek	10V, 616927, 6234412	2017-06-08	2017-07-06	AS	00	White spruce/trembling aspen – Soopolallie (Shrub)
PC17-WC-15	Wilder Creek	10V, 616543, 6234622	2017-06-08	2017-07-06	AM:ap	$01	Trembling aspen - Creamy peavine (Mature forest)

APPENDIX B
INCIDENTAL BIRD OBSERVATIONS

Table B.1: Incidental observations of birds recorded outside of point count surveys and birds recorded during point counts that are not songbirds.

Common Name	BC List	COSEWIC	SARA	Number of Detections
Ruffed Grouse	Yellow	-	-	31
Spruce Grouse	Yellow	-	-	1
American Wigeon	Yellow	-	-	1
Northern Shoveler	Yellow	-	-	2
Green-winged Teal	Yellow	-	-	2
Blue-winged Teal	Yellow	-	-	8
Mallard	Yellow	-	-	8
Canada Goose	Yellow	-	-	79
Bufflehead	Yellow	-	-	11
Common Goldeneye	Yellow	-	-	3
Barrow's Goldeneye	Yellow	-	-	2
Trumpeter Swan	Yellow	-	-	4
Common Loon	Yellow	-	-	1
Pied-billed Grebe	Yellow	-	-	4
Northern Goshawk	Yellow	-	-	2
Sharp-shinned Hawk	Yellow	-	-	1
Red-tailed Hawk	Yellow	-	-	12
Northern Harrier	Yellow	-	-	2
Bald Eagle	Yellow	-	-	6
American Coot	Yellow	-	-	10
Sora	Yellow	-	-	42
Sandhill Crane	Yellow	-	-	2
Killdeer	Yellow	-	-	5
Spotted Sandpiper	Yellow	-	-	8
Upland Sandpiper	Red	-	-	1
Wilson's Snipe	Yellow	-	-	71
Solitary Sandpiper	Yellow	-	-	19
Great Horned Owl	Yellow	-	-	4

Common Name	BC List	COSEWIC	SARA	Number of Detections
Common Nighthawk	Yellow	Threatened	Schedule 1 - Threatened	1
Northern Flicker	Yellow	-	-	33
Pileated Woodpecker	Yellow	-	-	8
American Three-toed Woodpecker	Yellow	-	-	1
Downy Woodpecker	Yellow	-	-	3
Hairy Woodpecker	Yellow	-	-	10
Yellow-bellied Sapsucker	Yellow	-	-	59
Merlin	Yellow	-	-	1
American Kestrel	Yellow	-	-	8
Olive-sided flycatcher	Blue	Threatened	Schedule 1 - Threatened	1
Say's Phoebe	Yellow	-	-	1
Gray Jay	Yellow	-	-	1
Black-billed Magpie	Yellow	-	-	2
Bank Swallow	Yellow	Threatened	Schedule 1 - Threatened	1
Gray Catbird	Yellow	-	-	1
Wilson's Warbler	Yellow	-	-	2
Bay-breasted Warbler	Red	-	-	1
Yellow-rumped Warbler	Yellow	-	-	1
Magnolia Warbler	Yellow	-	-	1
Black-throated Green	Blue	-	-	1
Boreal Chorus Frog	Yellow	-	-	5
Black Bear	Yellow	-	-	8
Mule Deer	Yellow	-	-	17
Red Squirrel	Yellow	-	-	22
Western Garter Snake	Yellow	-	-	1

APPENDIX C
PROJECT QUALIFIED ENVIRONMENTAL PROFESSIONALS

Name and Affiliation	Project Role
Jeff Matheson, M.Sc., R.P.Bio. Tetra Tech Canada Inc.	Project manager, report author
Kayla Hatzel, B.Sc., B.I.T. Tetra Tech Canada Inc.	Field data collection, data entry
Claudio Bianchini, R.P.Bio. Bianchini Biological Services	Field data collection

APPENDIX D
GENERAL CONDITIONS

LIMITATIONS ON USE OF THIS DOCUMENT

NATURAL SCIENCES

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The ability to rely upon and generalize from environmental baseline data is dependent on data collection activities occurring within biologically relevant survey windows.

It is incumbent upon the Client and any Authorized Party, to be knowledgeable of the level of risk that has been incorporated into the project design or scope, in consideration of the level of the environmental baseline information that was reasonably acquired to facilitate completion of the scope.

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Appendix 4. Waterbird Follow-up Monitoring 2017 Annual Report

DRAFT REPORT

Site C Vegetation and Wildlife
Waterbird Migration Follow-up Monitoring Program – 2017

Prepared for:
BC Hydro
Site C Clean Energy Project
1055 Dunsmuir Street
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Prepared by:
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File: 398-173.07
February 2018

EXECUTIVE SUMMARY

Waterbird surveys were conducted on the Peace River and transmission line portions of the Site C Clean Energy Project study area in 2017. Unlike previous waterbird surveys, precise location data were collected in association with every observation, and habitat data were also collected. Ground, river boat, unmanned aerial vehicle and autonomous recording unit survey methods were used. The data collected from these surveys will allow for the analysis of waterbird habitat associations for investigating project-related changes in relative abundance and diversity, as per the objectives of this monitoring program. In this, the first year of study using the revised methods, descriptive statistics are used to describe the results relative to monitoring objectives.

The results describe the timing of peak waterbird abundances in spring and fall, diversity metrics and habitat associations. Peak abundance was in the early spring, when mostly dabbling ducks and large dabblers (geese) utilize the Peace River. Diversity was relatively low at this time, reflecting large numbers of a few species. Later in the spring, abundance decreased as waterbirds began to occupy the newly-thawed wetlands on the transmission line. In the fall, waterbird abundance on the Peace River and in transmission line wetlands decreased as the migration progresses. On the Peace River in the fall, gulls were the most abundant waterbirds, while dabbling ducks were the most abundant on wetlands on the transmission line. All habitats on the Peace River were used by waterbirds, but the strongest apparent selection was for vegetated back-channel and island reaches. A substantial number of gulls used gravel substrates in confluence reaches on the Peace River in the fall; accounting for approximately half of all fall waterbird observations. On the transmission line wetlands, the strongest apparent selection by waterbirds was for open water, sedge and willow-sedge wetlands.

Ground and boat-based surveys in 2017 achieved better detectability than previous surveys using aerial methods; 30 species were observed on the transmission line and 38 species on the Peace River. In 2015 and 2016 aerial surveys, eight to ten species were observed. Species richness detected during ground and boat-based surveys in 2017 was similar to that observed during 2006 and 2008 boat and ground-based surveys. Five waterbird species at risk were recorded in 2017, none of which were reported since the 2006 and 2008 ground and boat surveys. Shorebird detectability was also much improved in 2017, which provides better baseline knowledge of this waterbird group for effects monitoring. Some alterations to the program are planned for 2018 to improve detectability: altering unmanned aerial vehicle speed and height in the inaccessible back-channels of the Peace River to improve shorebird detectability, and adding UAV surveys on the transmission line to improve detectability in the less-accessible wetlands. Aerial surveys of the Moberly Plateau (transects 2 -4) were conducted in 2017, and as in earlier years these failed to obtain data that have utility in the monitoring of waterbirds. Detectability is low and identification is challenging except for large and visible swans and geese. There is limited utility in the continuation of these aerial surveys given the availability of better and more useful data from ground and boat-based methods.

TABLE OF CONTENTS

List of Tables

List of Figures

List of Appendices

1.0 INTRODUCTION

This document describes the results of the 2017 Waterbird Migration Follow-up Monitoring Program surveys for shorebirds, marsh birds, waterfowl, and other birds associated with aquatic and wetland habitats (collectively known as 'waterbirds'). This program is conducted to help fulfill the requirements and conditions set forth in the Site C Clean Energy Project's Provincial Environmental Assessment Certificate (EAC) (Condition 21) and the Federal Decision Statement (FDS) (Conditions 10.2 10.3, 11.3 and 11.4) and address the uncertainties reported in the Environmental Impact Statement (EIS).

1.1 BACKGROUND

BC Hydro assessed the potential effects of the Site C Clean Energy Project (the 'Project') on Wildlife Resources in the Site C EIS using key species groups, including shorebirds, marsh birds, and waterfowl (BC Hydro 2013). Effects of the project on these waterbirds were assessed in terms of habitat alteration and fragmentation, disturbance and displacement, and mortality (BC Hydro 2013).

The EIS assessed the residual effect of the project on waterfowl and shorebirds as high magnitude given the anticipated extent of river and back channel habitat loss (i.e., habitat alteration and fragmentation). The duration and geographic extent of the effect is dependent on waterbird use of the reservoir and wetlands created through habitat compensation. There was low confidence in the characterization of this expected use, because use will depend on the success of vegetation establishment along the boundaries of the reservoir, the extent of ice formation in the reservoir, the use of nest boxes, and the use of nesting habitat in artificial and created wetlands (BC Hydro 2013).

BC Hydro coordinated baseline studies of waterbirds in the Peace River and adjacent wetlands in 2006 and 2008 and 2012 through 2014. Baseline waterbird studies employed fixed-wing aircraft and twin-engine helicopter surveys and, to a lesser extent, ground and boat surveys (Simpson and Andrusiak 2009, BC Hydro 2013, Churchland et al. 2015). The Vegetation and Wildlife Technical Committee (VWTC) reviewed the summary of baseline studies for waterbirds and noted that no shorebirds were documented during helicopter and fixed-wing aircraft surveys between 2012 and 2014. The lack of shorebird observations during aerial surveys prompted the VWTC to request that a follow-up monitoring program better suited to detecting small birds be developed to provide a more complete assessment of waterbird use of the Peace River during spring and fall migration periods. Such a program was developed in conjunction with the VWTC, and this report provides the summary results from 2017 waterbird surveys.

1.2 MONITORING OBJECTIVES

The objective of the follow-up monitoring program is to address uncertainties regarding the effects of the project (i.e., change from river valley to reservoir and changes in flow regime) on waterbirds that use habitat along and surrounding the Peace River (including wetland and non-wetland areas). Data collected will be used to satisfy the monitoring requirements of the FDS and EAC, by evaluating the effectiveness of mitigation and compensation measures for waterbirds, and to verify the accuracy of the predictions made in the EIS regarding waterbirds and their habitat. The specific objectives are to:

1. Assess changes in waterbird wetland and non-wetland habitat on the Peace River and the transmission line route from project construction through to the first ten (10) years of project operations to assess project-related impacts relative to those predicted in the EIS (EIS Volume 2; Appendix R- Section 4.1 (BC Hydro 2013)).
2. Document changes in waterbird relative abundance and diversity across habitats (Peace River and wetlands) during the first ten (10) years of project operations relative to pre-reservoir and transmission line (2017-2018) conditions to assess project-related impacts relative to those predicted in the EIS (EIS Volume 2; Appendix R- Section 4.1 (BC Hydro 2013)).
3. Monitor waterbird use of natural and created compensatory wetland features from project construction through to the first ten (10) years of project operations to evaluate the effectiveness of mitigation and compensation measures.

The monitoring program will improve the understanding of baseline conditions for waterbirds, and allow a robust assessment of project-related changes in habitat and habitat use by waterbirds. This report contains data from the first year using the improved methods, and as such analyses of change compared to the data previously collected using aerial survey methods are not possible. Comparisons to 2006 and 2008 boat surveys may be possible in future analyses. There is inconsistency in the historical and 2017 boat survey methods and the timing of surveys, such that comparisons are difficult. Descriptive statistics and mapping of the 2017 data shows the utility of these data for future analyses of change to assess any re-distribution of waterfowl from impacted habitat to adjacent wetlands, both natural and created.

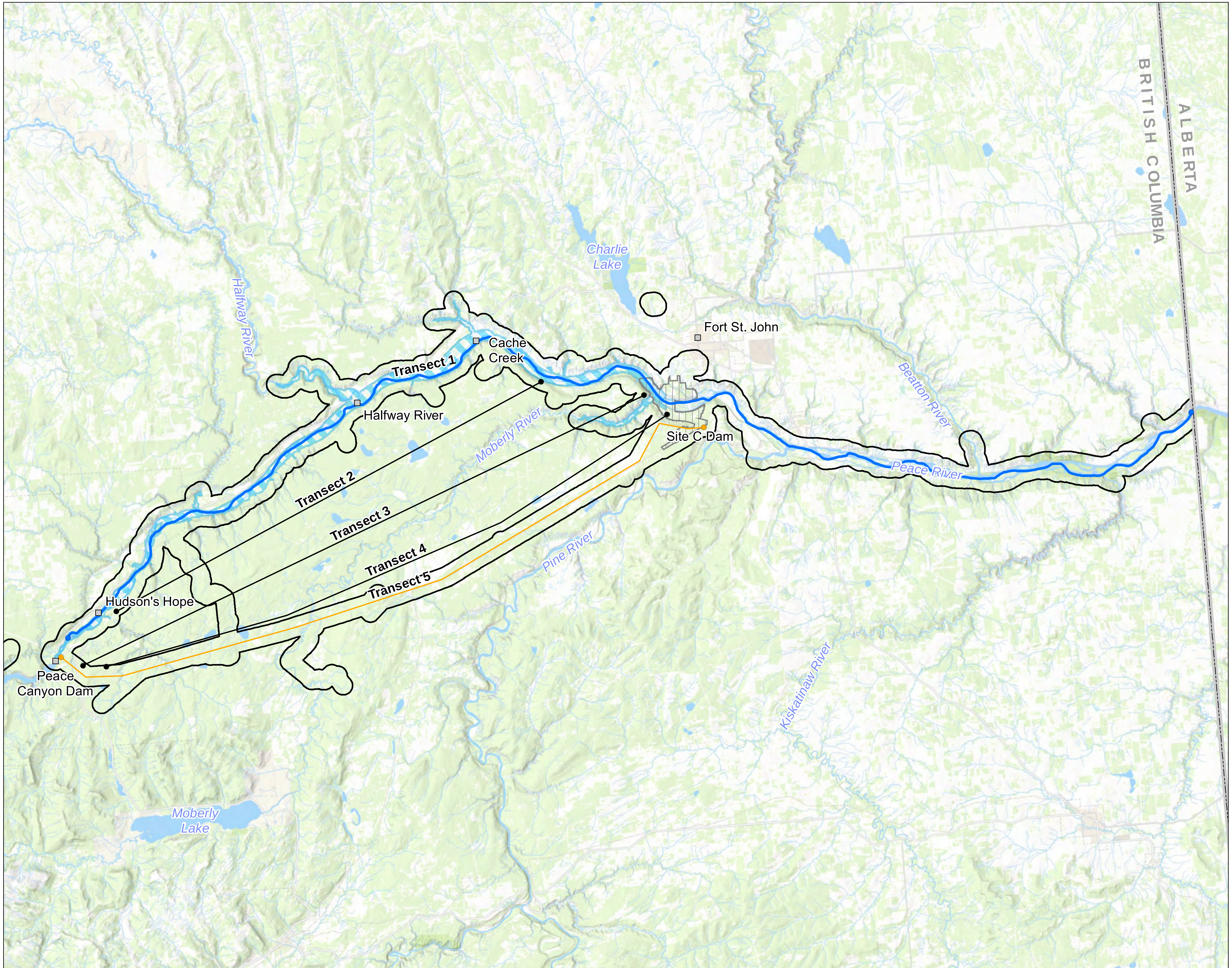
1.3 Study Area and Temporal Scope

The study area is the Peace River between Hudson's Hope and the Alberta border (transect 1), along the transmission line (transect 5) and in wetland habitat on the Moberly Plateau between the transmission line and the Peace River Valley (transects 2 – 4) (**Figure** 1 **1**). Sites with newly enhanced and created compensation wetlands with waterbird habitat will be included in the study area as they are identified.

Waterbird survey data were collected in 2017 and will be collected each year through the project construction period and for the first ten (10) years of project operations, as per EAC Condition 21. The monitoring program is focused on spring and fall migration periods because the greatest numbers and diversity of waterbirds are present in the study area during those periods (Simpson and Andrusiak 2009, Hilton et al. 2013). In 2017, surveys of the Peace River (transect 1), transmission line (transect 5), and wetland habitat between them (transects 2-4) were conducted during three survey periods within each of the spring (April/May) and fall (August/September) migrations to document early, middle, and late migrants in each season. During the spring, Peace River surveys started earlier than transmission line and wetland surveys to document waterbirds using the river before upland wetland habitats thawed and were available for waterbird use. During the fall, river and transmission line surveys were concurrent.

Migratory Waterbird Follow-up Monitoring Program
2017 Report
Site C, Peace River, BC

Waterbird Survey Transects on the Peace River, Wetlands of the Moberly Plateau and Transmission Line Route



Legend

- Site C LAA
- Proposed Dam Site
- Proposed Reservoir
- Wetlands Aerial Survey Transects
- Wetlands Ground and Aerial Survey Transect (Along Transmission Line Right-of-Way)
- Peace River Boat Survey Transect
- Provincial Border

Notes

1. Locations should be considered approximate.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Basemap: ESRI World Topographic Base

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BC hydro

2.0 MONITORING METHODS

To assess project-related changes to waterbirds, habitat information was recorded in association with all waterbird observations. The distribution of broader habitat types across the study area was derived from available terrestrial ecosystem mapping (TEM) data and satellite imagery to categorise river reach types for understanding waterbird distribution changes. Potential impacts to waterbirds will be measured in terms of changes in relative abundance and diversity across habitat and river reach types (BC Hydro 2018).

Differences in site accessibility between the Peace River Valley and wetlands on the Moberly Plateau required distinct survey methods. The Peace River (transect 1) was surveyed by boat and unmanned aerial vehicle (UAV), and the transmission line (transect 5) was surveyed from the ground. Field staff conducted transmission line surveys using an adapted point count method for diurnal species, and autonomous recording units (ARU) for crepuscular/nocturnal species and marsh birds not easily detected with visual surveys. Fixed-wing aircraft surveys were used to monitor the large areas of wetland and non-wetland (e.g. cultivated fields) habitat on transects 2-4 where no roads or established trails provide reliable access. Fixed-wing aircraft surveys were also conducted along the proposed transmission line (transect 5).

Baseline surveys conducted for waterfowl between 2006 and 2014 were designed to assess species within the orders Anseriformes (i.e., ducks, geese, and swans), Procellariiformes (i.e., loons), and Podicipediformes (i.e., grebes). Surveys in 2015 and 2016 (Mushanski et al 2015 and 2016, Hemmera 2016) using the same methods expanded the focus to include all waterbirds including Charadriiformes (e.g., snipe, sandpipers, phalaropes, plovers, gulls, terns, avocets), Gruiformes (e.g., herons, cranes, and rails, and Pelecaniformes (e.g., bitterns). The Waterbird Migration Follow-up Monitoring Program conducted in 2017 uses different survey methods to survey the full range of waterbirds present in the study area.

All waterbirds and all provincially or federally-listed species observed were recorded during waterbird surveys. The time and precise (UTM) location of waterbird observations using time referenced waypoints along with species, number of individuals, and habitat characteristics at observation locations was recorded.

Survey methods to meet the objectives were developed using guidance from Resource Inventory Standards Committee (RISC) protocols, with review from the VWTC. The survey methods employed during the 2017 field program are described in the following sections, and rationale for the methods is presented in the workplan (BC Hydro 2018).

2.1 HABITAT ASSESSMENT

Prior to field surveys, the existing terrestrial ecosystem mapping (TEM) data for habitat within the Peace River Valley and in areas within and between transects 2-5 were summarised, and flow volume data for the spring and fall migration periods were compiled. These data are to be used to account for changes in waterbird abundance and distribution related to variation in water flow and depth within the Peace River (as they vary with release volumes from hydro-electric infrastructure upstream of the study area). The habitat parameters for which data were collected with waterbird observations are described for each survey method in **Sections 2.2 – 2.4**.

The area of wetland habitat types within and between transects 2-5 was summarized from existing TEM data using ARCGIS Desktop (v.10.5.1) software to design surveys and allocate station locations. The most widespread wetland habitat types in the study area are (from largest to smallest in area): Labrador-tea – sedge, tamarack – sedge, and cultivated field (**Table 1**, also shown on **Figure 5**). Sedge and shallow open water were less widespread and willow-sedge was the least common habitat type. Habitat data specific to the transmission line wetland survey stations are presented in **Section 4.3.**

Table 1 Area of wetland habitat types in the Peace River and Moberly Plateau study area

Habitat type	Area (ha)
Labrador-tea – sedge	7,243
Tamarack-sedge	4,749
Cultivated field	3,854
Sedge	1,782
Shallow open water	1,535
Willow-sedge	720

*Unclassified non-forest floodplain wetland types, including willow-horsetail and other non-forested wetland types were 440 ha were not included in the study design due to uncertainty in wetland type classifications.

Hourly waterflow data were obtained from BC Hydro and summarized using SYSTAT (v.13) to present a frequency distribution of flow rates at a representative site within the control and impact treatment areas. Flow rate data were then linked to the waterbird database using Microsoft Access to provide an estimated flow rate for each waterbird record specific to the treatment area in which birds were observed. The flow rate record from the nearest hour was assigned to each waterbird record based on the time of observation in the field. Frequency distributions of flow rates at the time of waterbird observations were generated from the resulting dataset, using SYSTAT to determine if data were recorded during a representative distribution of water flow rates including the full range of water regimes. Following subsequent years of data collection, flow rate data will also be used as a habitat variable in models describing waterbird distribution on the Peace River.

2.2 PEACE RIVER WATERBIRD SURVEYS (TRANSECT 1) – BOAT AND UAV

2.2.1 Study Design

The Peace River surveys assess the relative abundance and diversity of waterbirds using riverine and backchannel habitat in the Peace River valley (transect 1). Two surveys were scheduled in each survey period (i.e., early, middle, and late migration) to provide a total of six surveys in each of the spring and fall season. This allocation of survey effort was designed to provide estimates of relative abundance and diversity and measures of variance within and across survey periods. Surveys will provide measures of inter-annual variance once subsequent years of data collection have been completed.

To assess the relative abundance and diversity of waterbirds along the Peace River (transect 1), a before-after-control-impact (BACI) design is being used to distinguish between background and project-related changes in waterbird relative abundance and diversity. Areas surveyed to assess impacts are: (i) the Site C reservoir (impact from inundation; **Figure 2**), (ii) the Peace River from the Site C dam to the Pine River confluence with the Peace River (impact from change in flow regime; **Figure 3**), and (iii) the Peace River from the Pine River confluence to the Alberta border (control; **Figure 4**). Below the Peace - Pine rivers' confluence, project-related changes in flow regime will be ameliorated by inputs from the Pine River.

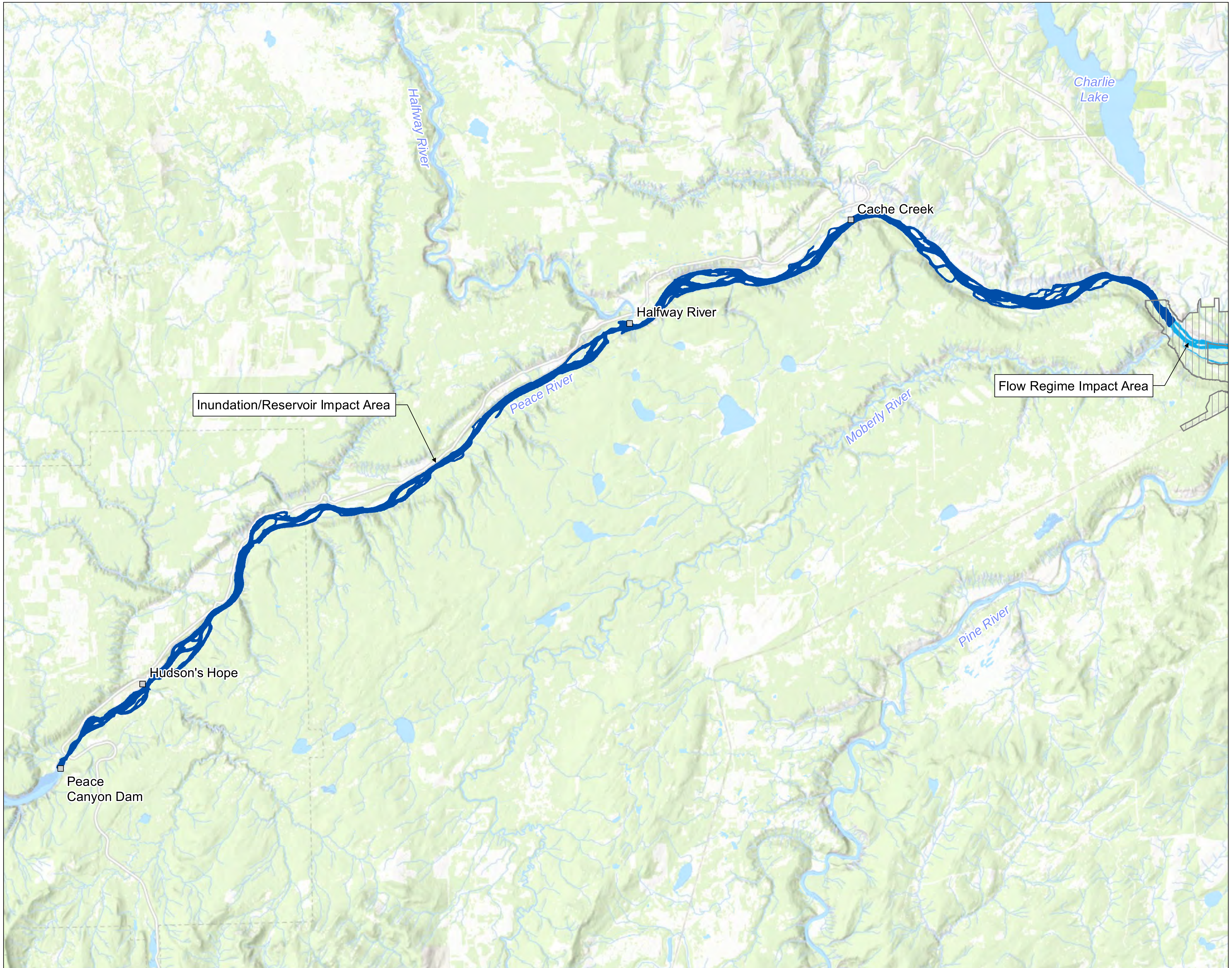
The before condition for the BACI design will be that which exists prior to reservoir filling in fall 2022. Impacts are expected once the reservoir has been filled. The river diversion period (fall 2019 to fall 2022) will be baseline conditions because water volumes and flow rates will be mostly un-changed outside of the immediate construction area and small headpond during this period.

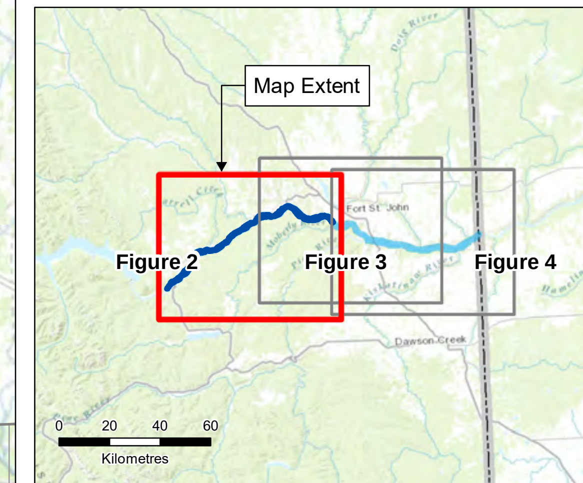
The total length of river within the study area is 146.5 km, 82.1 km in the Inundation Impact area (**Figure 2**), 46.5 km in the Control area (**Figure 4**), and 18.0 km in the Flow Impact area (**Figure 3**). Four reach types were delineated across the Peace River study area (transect 1) using recent aerial photographs to characterize areas dominated by similar habitat as one of: Off-channel, Mainstem, Island and Confluence habitats. All four reach types were present in the Inundation Impact and Control areas; however, Island reaches are absent from the Flow Impact area.

The Peace River is an anthropogenically controlled watercourse, and water volumes released from the upstream Peace Canyon Dam are thought to affect the distribution of waterbirds. To understand the representativeness of survey timing relative to the water regime during spring and fall migration periods, Peace River discharge data for treatment areas were collected from Halfway River (Inundation Impact area), Old Fort (Flow Impact area), and Taylor (Control area). In future analyses these flow volume data may be a confounding influence that will be controlled for.

Migratory Waterbird Follow-up Monitoring Program
2017 Report
Site C, Peace River, BC

Reservoir Inundation Impact Area on the Peace River





Legend

- Inundation/Reservoir Impact Area (3,637 hectares)
- Flow Regime Impact Area
- Proposed Dam Site

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Basemap: ESRI World Topographic Base

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Kilometres

NAD 1983 UTM Zone 10N

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398-173.07	Production Date: Feb 28, 2018	Figure 2

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BC hydro

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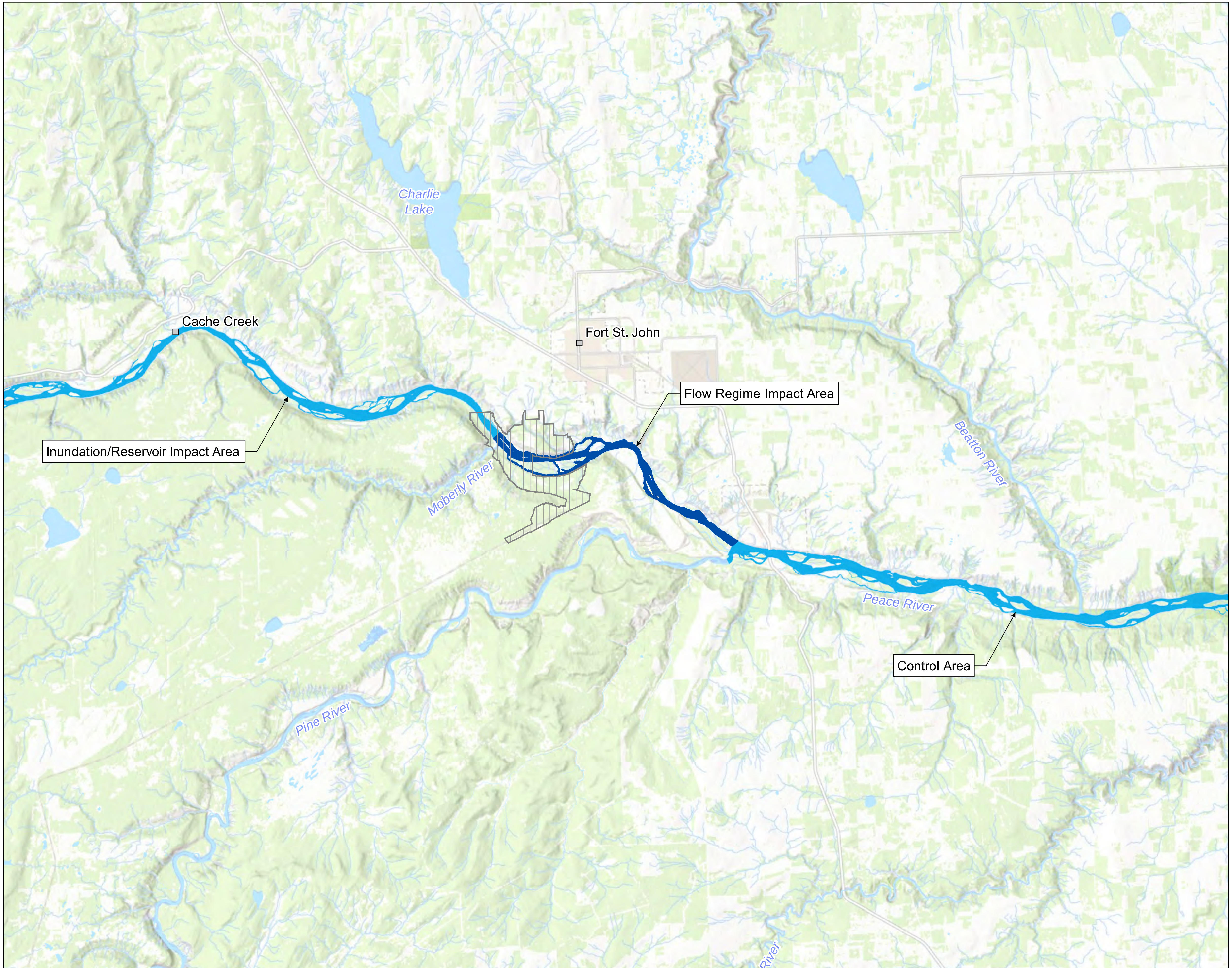
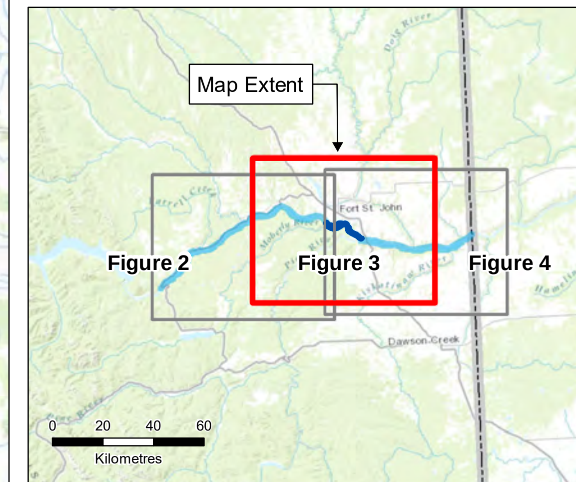
Migratory Waterbird Follow-up Monitoring Program
2017 Report
Site C, Peace River, BC

Flow Regime Change Impact Area on the Peace River





Legend

- Flow Regime Impact Area (703 hectares)
- Inundation/Reservoir Impact Area and Control Area
- Proposed Dam Site

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a “stand-alone” document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

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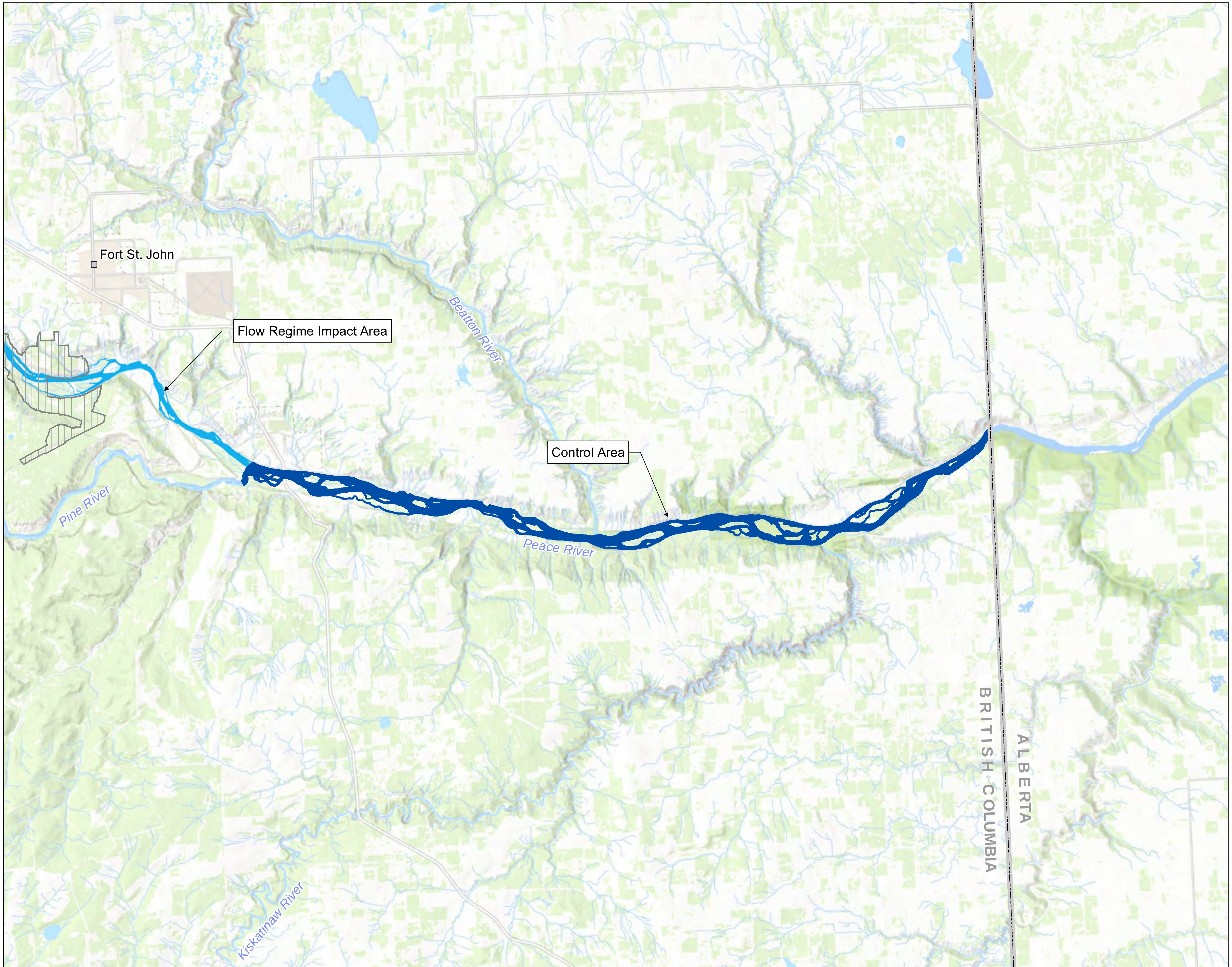
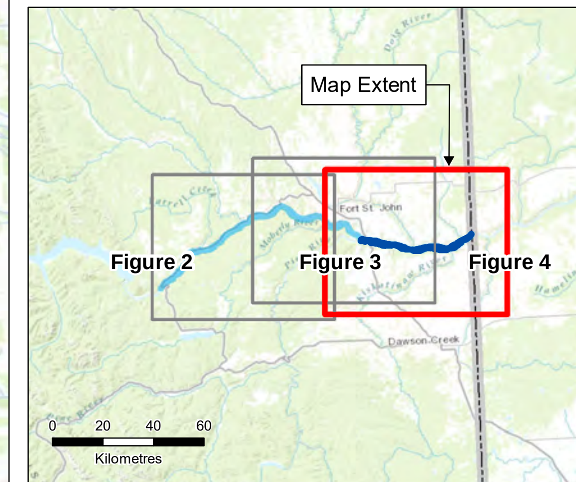
Migratory Waterbird Follow-up Monitoring Program
2017 Report
Site C, Peace River, BC

Control Area on the Peace River





Legend

- Control Area (2,909 hectares)
- Flow Regime Impact Area
- Proposed Dam Site

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Basemap: ESRI World Topographic Base

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398-173.07	Production Date: Feb 28, 2018	Figure 4

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2.2.2 Survey Methods

Boat surveys followed a modified version of the "Floating Rivers in Rafts or Kayaks" methods described in *Inventory Methods for Riverine Birds* (RIC 1998*a*) and *Inventory Methods for Waterfowl and Allied Species* (RIC 1999). Surveys took place in daylight hours between 07:00 and 18:00 over the length of the Peace River, from downstream of the Peace Canyon Dam to the Alberta border using a jet boat (transect 1; **Figure 1**). Surveys required two days to cover this approximately 150 km section of river. For each survey, the upstream portion of the river was surveyed on the first day and the downstream portion of the river was surveyed the next day. Boat surveys allowed visual coverage of the river, shoreline, nearshore areas, exposed sandbanks, gravel bars and mudbanks/flats. Surveys circled around islands to observe backchannels wherever water levels were sufficient for boat access. The boat maintained speeds of 20-40 km/hr depending on river current and bird activity. Boat speed was decreased during waterbird observations to increase the accuracy of species identification and abundance estimates. Two biologists trained in waterbird identification focused survey efforts on opposite shores to the center of the river and communicated bird movements to prevent double counting birds. Surveys were not conducted during sustained inclement weather conditions that would result in a reduced ability to detect waterbirds (i.e., wind speeds greater than 3 on the Beaufort scale [>10 km/h], any rain or fog that resulted in poor visibility [<10 km], <1.5 m waves [no whitecaps]); as per RISC standards (RIC 1999).

UAV surveys recorded birds in areas that could not be accessed by boat (e.g., shallow water), with a camera displaying a live video to surveyors on the ground. To minimize any disturbance to waterfowl, the UAV was deployed at least 100 m from any observed birds, sudden movements were avoided, and any observations requiring close investigation involved approaching individuals at angles not steeper than 20°(Vas et al. 2015). UAV surveys were standardized by flying at a consistent height, whenever possible. The location of observations was determined from UTM coordinates of the UAV flight path and by cross-checking satellite imagery with landscape features (e.g., islands and channels) captured during filming. Species were identified from raw video footage, or with still frames and video at 2 to 4 times magnification when necessary.

Field crews recorded the following information for each individual or flock of waterbirds observed:

- UTM coordinates
- Date and time (hour and minute)
- Species
- Number of Individuals
- Habitat type (gravel bar, beach, open river, back channel, marsh/wetland)
- Current (none, slow, moderate, fast)
- Shoreline sediment characteristics
- Height of observations from UAV footage

2.3 AERIAL WATERBIRD SURVEYS (TRANSECTS 2 – 5) – FIXED-WING AIRCRAFT

2.3.1 Study Design

Fixed wing aircraft surveys assess the abundance and diversity of waterbirds using wetland habitats on the Moberly plateau between the Peace River and the proposed transmission line. Surveys were conducted along the four transects flown by fixed-wing aircraft during previous baseline surveys (transects 2-5; **Figure 1**). The study design treats all four transects as a single survey of the plateau.

Habitat features were recorded in association with each observation to provide information on the relative abundance and diversity of birds in each habitat. Three surveys were scheduled per season to sample waterbird relative abundance and diversity during the early, middle, and late period of the fall and spring migrations. These efforts provide data comparable across seasons (i.e., spring vs. fall) for 2017. Subsequent survey years will provide the data required to assess inter-annual variation under baseline conditions (i.e., background variation) and to assess the significance of changes between baseline and post-construction conditions (data collected after fall 2022).

2.3.2 Survey Methods

Fixed-wing aircraft surveys were conducted once during the early, middle and late periods of the spring and fall migrations in April/May/June and August/September, respectively. Transects were approximately 400 m wide extending 200 m on either side of the fixed wing aircraft. Surveys deviated from the center of the transect to circle around the entirety of any wetland occurring within the transect including portions of the wetland extending beyond the 400 m transect width. Surveys also included any open water bodies observed while flying the transect. Flight height was approximately 500’, and flight speed was approximately 150 km/hr. Data were collected by two observers, with one observer looking out each side of the aircraft.

Field crews recorded the following information for each individual or flock of waterbirds observed:

- UTM coordinates;
- Date and time (hour and minute);
- Species identification (or best possible taxonomic classification);
- Number of individuals; and
- Habitat type (Open water, Wetland, Terrestrial, Other).

The monitoring plan proposed a comparison of aerial survey results to ground-based point counts (see Section 2.4) along transect 5; however, fixed-wing and ground-based surveys often could not be conducted at the same time due to weather and site access constraints.

2.4 TRANSMISSION LINE SURVEYS (TRANSECT 5) – ADAPTED POINT COUNT AND ARU

2.4.1 Study Design

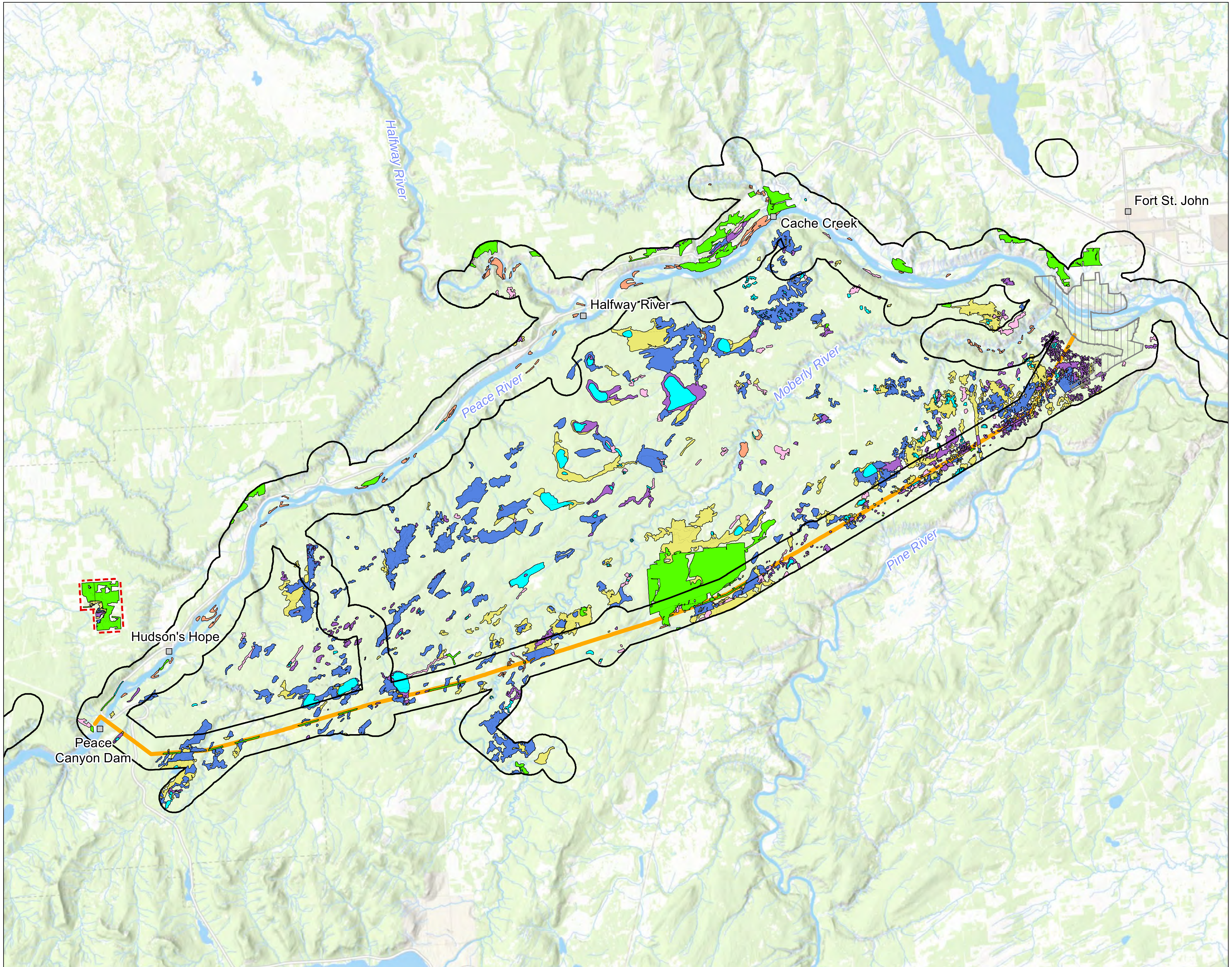
Transmission line surveys assessed the relative abundance and diversity of waterbirds using wetland habitats on transect 5. Prior to field work, wetland habitat types suitable for waterbirds and accessible to field crews were identified and mapped along the transmission line transect; using habitat data collected during baseline studies and satellite imagery (**Figure 5**). The study team allocated survey stations proportionally across wetland types so that more surveys were conducted in the more common habitat types and fewer surveys were conducted in less common habitats (BC Hydro 2018). Surveys were allocated across a minimum of 20 wetland stations to provide sufficient samples for statistical comparisons across seasons, years and the periods before and after project operations. Within each survey period (e.g., early, middle, and late migration), two replicate surveys were conducted at each wetland survey station, for a total of six surveys per season. Wetland surveys were temporally and spatially standardized by surveying within 5-hectare (ha) stations for most habitat types and for 20 minutes at all survey stations. Some survey areas were larger, such as permanent open water (e.g., lakes, ponds) where birds are more easily detected due to clear lines of sight. Access restrictions limited surveys in some wetland types. The transmission line wetland survey portion of the study is not subject to a BACI design (BC Hydro 2018).

Vocalizations of marsh birds (e.g., American bittern (*Botaurus lentiginosus*) and yellow rail (*Coturnicops noveboracensis*) in wetlands with sedge dominance (sedge or willow-sedge) along the proposed transmission line were monitored by ARU for a minimum of three nights during the peak vocalization period (i.e., May and June) at six survey sites.

2.4.2 Survey Methods

Six wetland habitat types in the study area were considered suitable for waterbirds (**Table** 2**2**). Preliminary surveys in each of the wetland types before the 2017 field program, confirmed their use by waterbirds.

Surveys targeting all waterbird species were conducted using similar point count methods to those used in prior years (i.e., five-minute quiet listening period) with the addition of a 15-minute walking transect through the station. Two crews consisting of a crew lead and a technician completed the surveys during daylight hours between 07:00 and 20:00. Crew leads were experienced in visual and vocalization identification of wetland bird species and were trained in wetland vegetation and structural stage identification. Surveys were not conducted during sustained inclement weather such as high winds (i.e., >3 on the Beaufort scale) or moderate to heavy precipitation.



Migratory Waterbird Follow-up Monitoring Program
2017 Report
Site C, Peace River, BC

Wetland Habitat Types in and Adjacent to the Peace River Valley and Transmission Line

Legend

- Site C LAA
- Proposed Dam Site
- Marl Fen Property - BC Hydro Wetland Compensation Site
- Transmission Line Right-of-Way

Wetland Types

- Cultivated field within 100m of wetland (CF)
- Labrador-tea – sedge (BT)
- Non-forested floodplain wetland (WH)
- Sedge (SE)
- Shallow open water (OW)
- Tamarack-sedge (TS)
- Willow sedge (WS)

Notes

1. OW has been used as the idientfier for Shallow Open Water wetland field locations; however, please note that the wetland classification also includes LA and PD habitat codes.
2. Locations should be considered approximate.
3. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Basemap: ESRI World Topographic Base

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398-173.07	Production Date: Feb 28, 2018	Figure 5

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Table 2 Wetland habitat types suitable for waterbirds on the transmission line route, transect 5

Habitat type	Characteristics	Waterbirds expected?
Shallow open water (OW)	Open water with no (or limited) emergent vegetation. Usually the result of beaver activity or other impoundment	Yes, waterbirds are abundant in open water habitat
Tamarack-sedge (TS)	Fen with tamarack dominated overstorey	Yes, provided there is low density overstory vegetation (Twedt et al. 1998) that allows predator detection (Plauny 2000)
Sedge (SE)	Uniform sedge (*Carex* sp) flat low area, typically wetted and often with standing water. Often surrounding or bordering open water habitats.	Yes, provided there is low density overstory vegetation
Labrador-tea – sedge (BT)	Labrador-tea dominated peat bogs	No, waterbirds not anticipated to occur in peat bogs (Eifrig 1911).
Willow-sedge (WS)	Sedge (*Carex* sp.) meadow with scattered willows/scrub birch. Often bordering SE habitat in slightly elevated and areas with less standing water than SE habitat.	Yes, when willows are in low densities
Cultivated Field (CF)	Only considered if wetted and/or water source or wetland occurs within 100 m	Yes, when wetted

The following information was recorded at each survey station:

- UTM coordinates;
- Date;
- Start and end time of survey;
- Proportion of each habitat type within the wetland or survey station; and
- Approximate water depth within each habitat type

The following information was recorded for each survey waterbird or flock observed during surveys:

- UTM coordinates;
- Date and time (Hour and minute);
- Species;
- Number of individuals;
- Habitat type in which the bird was observed;
- Water depth where the bird was observed;
- Behavior; and
- Sex and / or age if discernable

The area of habitat types within each surveyed wetland, as a percentage of the total area, was recorded. These data were used to determine the dominant habitat (i.e., habitat with the greatest area).

Marsh birds were monitored with a Song Meter SM3BAT ARU with omnidirectional SMM-A1 microphones (all Wildlife Acoustics, Inc., Maynard, Massachusetts, USA). ARU provide comparable and potentially greater detection rates for yellow rail as compared to call playback methods (Bayne et al. 2014), and reduce safety hazards associated with accessing and working in remote areas at night. ARU devices were deployed in suitable nesting habitat for yellow rail and American bittern, i.e., open marshes or pond edges with emergent vegetation (Bayne et al. 2014). The following information was recorded for ARU detections of marsh birds:

- UTM coordinates;
- Date and time;
- Species;
- Number of calls; and
- Length of calling period

Following the surveys, acoustic file data were downloaded and analyzed using cluster analysis in Kaleidoscope Pro. Cluster analysis groups calls with similar parameters such as amplitude and frequency. Reference calls for the three target species were obtained from the Cornell Laboratory of Ornithology (Macauley Library), and amplitude and frequency characteristics for several calls from each of the three target species were matched to the groups of calls from the cluster analysis with similar characteristics. Recorded calls suspected to be of the three target species were aurally verified against reference calls of the target species from the Macaulay Library.

2.5 COMPENSATION WETLAND SURVEYS

The 2017 Monitoring Program did not include surveys of wetland compensation sites. Surveys of compensation sites will be conducted in future survey years as they are identified.

3.0 DATA MANAGEMENT AND ANALYSIS

Waterbird records from all surveys were reviewed and compiled in a Microsoft Access database. Data were reviewed to check for anomalous records, and questionable species identification or count data were queried with field staff. Once data were compiled, quality assurance measures were applied to confirm that values were logical and any all outlying records (e.g., high counts, rare species) were verified with field staff.

The total number of waterbirds detected by each survey method is reported for each season and survey period. Totals are described in terms of relative abundance as they represent the number of waterbirds detected across temporal and spatial scales, rather than true abundance, which would require an estimate of the birds not detected during surveys. Relative abundance data are also summarised by species guilds defined by method of foraging: dabbling ducks (small waterfowl that feed primarily on aquatic vegetation); large dabblers (large waterfowl [e.g., geese and swans] that feed primarily on vegetation), piscivorous divers (diving birds that forage on fish), benthic feeding divers (small waterfowl and sea ducks that feed primarily on benthic invertebrates), shorebirds (plovers and sandpipers that feed primarily on or near the shoreline), and unidentified waterbirds. Birds that were not identified to species were recorded to the most specific taxonomic level possible. A full list of species observed and the guilds to which they are assigned is presented in **Appendix A**.

Waterbird diversity is presented as species richness (i.e., number of species), species evenness (i.e., the relative abundance of different species), and the Shannon-Weiner Index (SWI). Species evenness is presented with values ranging from zero to one, where values tending towards one represent more even proportions of species and values tending towards zero represent communities dominated by fewer species. The SWI is a measure of diversity that considers both species richness and evenness. Communities possessing many individuals of a few species receive lower SWI values (minimum 0) than communities with the same number of species but more even abundances across species.

3.1 PEACE RIVER WATERBIRD SURVEYS (TRANSECT 1) – BOAT AND UAV

Waterbird data were summarized to provide mean relative abundance and diversity across sections of the river that will be differentially affected by the project (i.e. treatment areas), seasons, and survey periods. Abundance data were also summarized by river reach categories by calculating summary statistics for all sections of the river with the same contiguous habitat features. Four reach types were identified within the study area based on review of satellite imagery:

- Mainstem (reaches where the river consists of one large channel);
- Island (reaches where the river is split relatively evenly around islands);
- Off-channel (reaches where a small portion of the river runs around islands, or where there are backchannels and/or bodies of water that are only connected to the river during high flows); and
- Confluence (reaches where major tributaries such as the Pine, Beatton, Halfway and Moberly rivers join the Peace River).

To control for variation in abundance due to the size of a reach rather than habitat type, data are summarized in terms of abundance per km of river (i.e., density by river length) as per RISC standards (RIC 1999). Waterbird abundance records were also summarized by foraging guild across substrate and water current.

To assess for potential project-related effects to the relative abundance and diversity of waterbirds, the Peace River study will employ a BACI (before – after – control – impact) model. The BACI model will be used to assess the significance of changes in waterbird abundance and diversity before reservoir filling and project-operations as compared to after, while accounting for background (i.e., natural) variation in the control area. Variables of interest considered in a standard BACI model are Treatment (control/impact) and Period (before/after). The model is defined as follows:

$$Abundance = Treatment\ (control|impact) + Period(before|after) + Treatment * Period$$

This model tests for project-related changes in relative abundance, density or diversity indices depending on which is included as the dependent variable on the left-hand side of the equation. The interaction term (*Treatment * Period*) is known as the BACI effect, and is the term that represents project-related effects. The BACI effect compares changes in means at control and impact sites, occurring between before and after periods (Schwarz 2015). If changes are similar at control and impact sites between the before and after periods, the interaction effect is likely to be statistically not significant. If there is a relatively larger decline or increase in abundance/diversity at the impact site as compared to the control site, then a project-related effect could be statistically significant.

Once additional years of survey data are obtained, the BACI model will be adapted to include additional factors to account for variation in the data unrelated to the project (e.g., season, year) which will increase the power of analyses to assess for project-related effects. The model will also consider habitat characteristics (e.g., substrate, reach, flow) to define their relationship with waterbird abundance and diversity. Inclusion of such additional explanatory variables increases the power of BACI analyses to detect project related effects. The model to be applied following future years of monitoring is expected to be as follows:

$$\begin{aligned}&Abundance\ (or\ Diversity\ or\ Density)\\&\quad = Treatment\ (control|impact) + Period(before|after) + Habitat\ Type\\&\quad + Survey\ Event\ (or\ Survey\ Period) + Season + Year + Treatment * Period\end{aligned}$$

Analyses employing a BACI model statistical framework will be conducted using R statistical software (adapted lme4 package [Schwarz 2015]).

A power analysis based on the BACI model can also be conducted to provide the expected likelihood of detecting project-related effects for a given allocation of survey effort, provided that variance can be defined or estimated for factors in the model. It is possible to calculate statistical power by defining the number of events (n), detected variance across survey events (d), and the significance level (typically $\alpha=0.05$) (Cohen 1988, Champely 2017). It is also possible to find the optimal (n) of events for a desired power and variance level and to expand the power analysis to include additional factors. Studies conducted in 2017 provide variance estimates (d) for survey events within seasons, but data will not be available on inter-annual variability until completion of surveys in 2018. These estimates will be refined in subsequent years and, through the power analysis, will support determination of the number of survey years and events per year required to detect project-related change.

Variance estimates are provided for factors where the data support these statistics; survey event, survey period, and habitat type. These statistics provide preliminary indications of how to optimize survey efforts in future years. Power to detect significant differences between treatment levels and to define relationships of waterbird abundance and diversity with habitat factors will be improved by allocating more effort at temporal and spatial scales where the greatest variation occurs.

3.2 Aerial Waterbird Surveys (Transects 2 – 5) – Fixed-Wing Aircraft

Data from 2017 fixed-wing aircraft surveys are summarized to provide estimates of waterbird abundance and diversity across seasons and wetland habitats of the Moberly Plateau. Species guilds are also reported uniquely for the fixed-wing survey data because observers could not identify small waterfowl to species of duck due at the height and speed of surveys. Additionally, and as documented during baseline studies, shorebirds could not be seen from the height of fixed-wing surveys and are not included in the analysis or summarization of data. Consequently, results are summarized only for ducks, geese, swans, and gulls for fixed-wing surveys. Waterbirds that could not be confidently assigned to one of these groups were summarized as Unidentified Waterbirds. Variance in waterbird abundance was assessed across survey periods.

3.3 Transmission Line Surveys (Transect 5) – Adapted Point Count and ARU

Data from 2017 surveys were summarized to provide estimates of waterbird abundance and diversity across habitats, seasons, and survey periods. All waterbird records from within a survey station were assigned the dominant habitat type at that station. Mean relative abundances within survey stations were used to estimate foraging guild densities for each wetland habitat type. Variance in waterbird abundance was assessed across habitat types and survey periods.

4.0 RESULTS

Results for the monitoring program in 2017 summarize sampling effort and provide an overview of the data collected. The overview summarizes habitat data as well as mean and variance estimates of waterbird abundance and diversity indices within habitat types, seasons, and, where possible, survey period. Data are presented for foraging guilds and for more generalized species groupings for fixed-wing surveys in which species identification was unreliable. Statistical comparisons and modeling planned for subsequent years of data collection are discussed in **Section 3.0**.

4.1 PEACE RIVER WATERBIRD SURVEYS (TRANSECT 1) – BOAT AND UAV

The Peace River study area was surveyed in its entirety during five survey events in the spring and six survey events in the fall over 11 and 12 days respectively (**Table 3**). Due to rain and wind speeds that exceeded survey standards (**Section 2.2.2**), half of the river was not surveyed during the second survey event of the early spring period. All other surveys were completed as scheduled.

Table 3 Peace River survey timing; 2017 migratory waterbird follow-up monitoring program

Season	Survey Period	Survey Event	Survey Dates (2017)
Spring	Early	1	Apr 5, Apr 6
		2	Apr 12
	Middle	3	Apr 26, Apr 27
		4	May 3, May 4
	Late	5	May 10, May 11
		6	May 14, May 15
Fall	Early	1	Aug 8, Aug 9
		2	Aug 14, Aug 15
	Middle	3	Aug 22, Aug 23
		4	Aug 28, Aug 29
	Late	5	Sep 21, Sep 22
		6	Sep 27, Sep 28

The total length of river within the study area was 146.5 km, with 82.1 km in the Inundation Impact area (**Figure 2**), 46.5 km in the Control area (**Figure 4**), and 18.0 km in the Flow Impact area (**Figure 3**). All four reach types are present in the Inundation Impact and Control areas; however, Island reaches are absent from the Flow Impact area (**Table 4**). Off-channel, Mainstem, and Island reaches are present in roughly equivalent lengths across the study area; however, the proportion of these reach types varies across treatment areas. Island reaches comprise the majority of river length in the Inundation Impact (54%) treatment area, whereas Off-channel reaches comprised the majority of river length in the Flow Impact (47%) and Control (42%) treatment areas. Confluence reaches comprise a relatively small proportion of total river length (8.3 km), but occur relatively evenly across treatment areas (**Table 4**).

Table 4 Categories, number, and length of river reaches within the Peace River study area

Treatment Area	Off-channel		Island		Mainstem		Confluence	
	Reaches (no.)	Length (km)	Reaches (no.)	Length (km)	Reaches (no.)	Length (km)	Reaches (no.)	Length (km)
Inundation Impact	5	11.4	8	25.0	5	7.9	2	2.1
Flow Impact	4	8.5	0	0.0	4	6.1	2	3.4
Control	13	34.6	5	15.9	16	28.7	2	2.9
Total	**22**	**54.5**	**13**	**40.9**	**25**	**42.8**	**6**	**8.3**

Peace River discharge data for treatment areas were collected from Halfway River (Inundation Impact area), Old Fort (Flow Impact area), and Taylor (Control area) to assess the representativeness of surveys relative to the water regime during spring and fall migration periods. The distribution of discharge rates during surveys (i.e., when waterbird observations were recorded) were similar to those recorded over the spring and fall migration periods and the surveys encompass the range of discharges that occurred during those periods (**Figure 6, Figure 7, and Figure 8**).

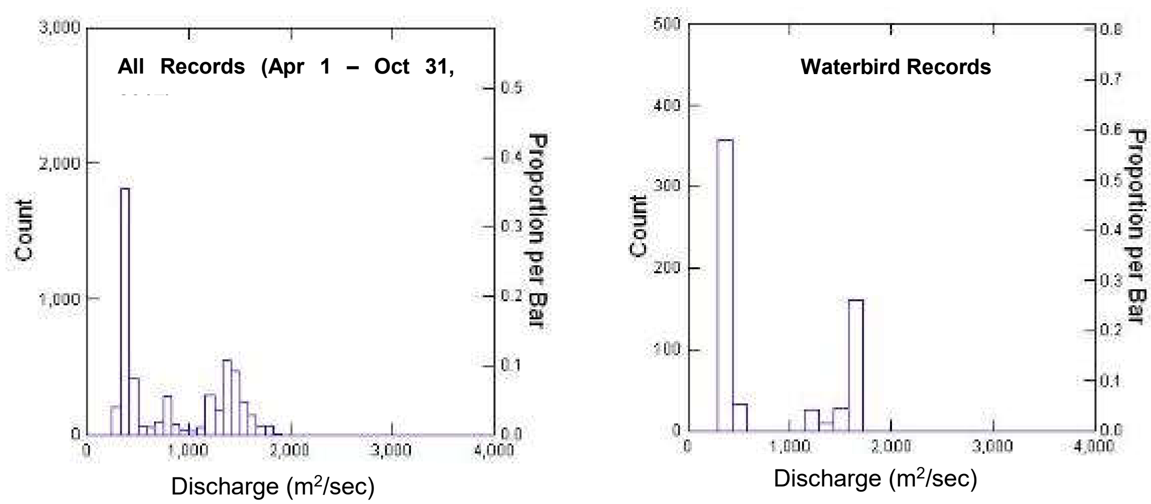


Figure 6 Frequency distribution of hourly Peace River discharge (flow rate) records at Hudson's Hope (Inundation Impact Area) relative to discharge records during waterbird surveys

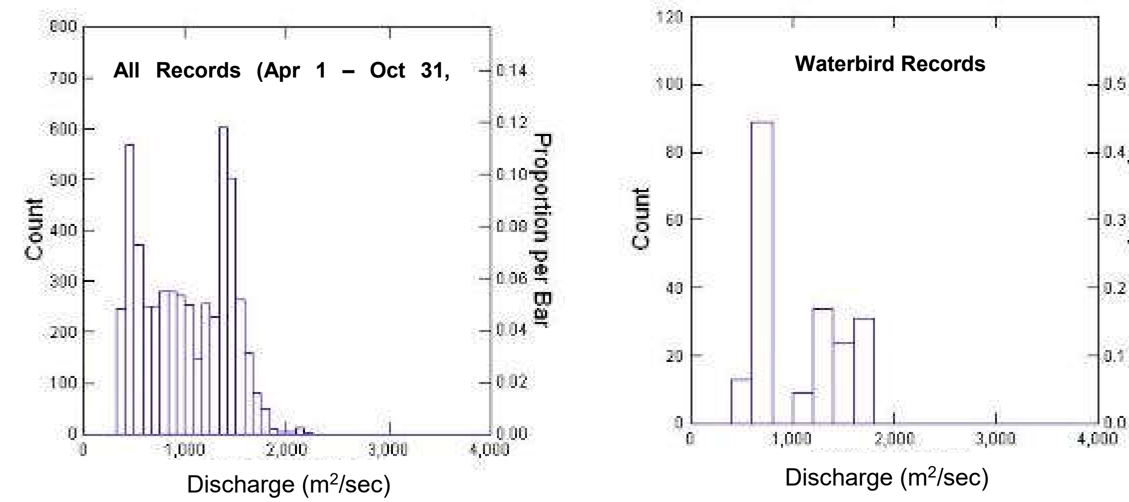


Figure 7 Frequency distribution of hourly Peace River discharge (flow rate) records at Old Fort (Flow Impact Area) relative to discharge records during waterbird surveys

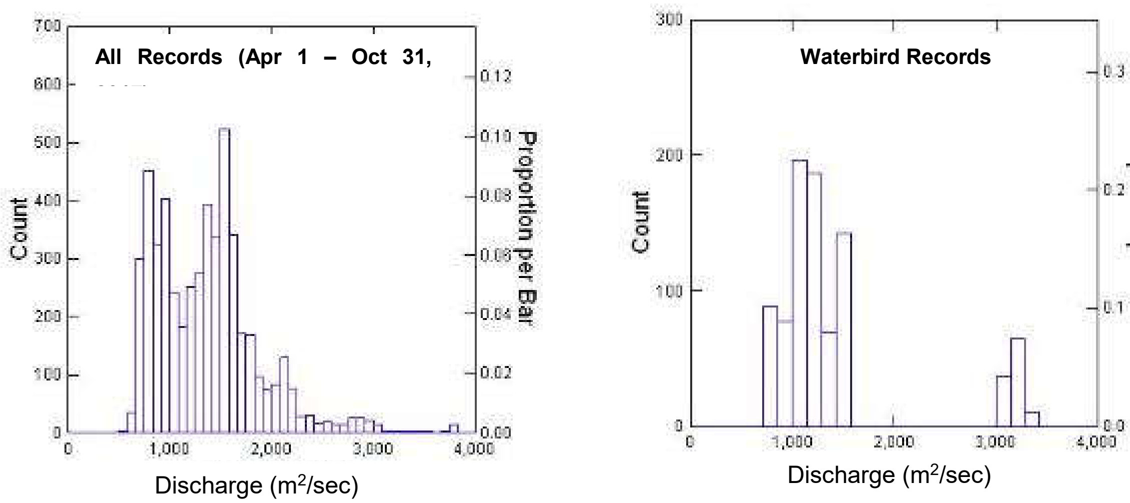


Figure 8 Frequency distribution of hourly Peace River discharge (flow rate) records at Taylor (Control Area) relative to discharge records during waterbird surveys

4.1.1 Relative Abundance and Density

Waterbirds were observed along the entirety of the Peace River study area in spring and fall (see locations figure in **Appendix B – Figures B-1 to B-4**). Total waterbird abundances were highest during the early survey period in both seasons, and were higher in spring as compared to fall (**Table 5**). Abundances of waterfowl (e.g., benthic feeding divers, dabbling ducks, large dabblers, and piscivorous divers) were highest in the early and middle spring periods, but gulls and shorebirds were most abundant in early fall. Large dabblers (primarily Canada goose [*Branta canadensis*]) were the most abundant waterbird overall, but dabbling ducks were more abundant in the middle and late spring survey periods, and gulls more abundant in the early and middle survey periods of the fall (**Table 5**).

Table 5 Mean relative abundance of waterbird foraging guilds, spring and fall 2017

Foraging Guild	Spring Survey Periods			Fall Survey Periods			Total of Means
	Early	Middle	Late	Early	Middle	Late	
Benthic Feeding Divers	62	103	10	7	4	7	193
Dabbling Ducks	822	664	479	117	177	32	2,291
Gulls	0	21	26	722	540	245	1,554
Large Dabblers	1,940	472	385	119	225	408	3,549
Piscivorous Divers	319	112	45	28	39	17	560
Shorebirds	2	1	87	105	51	2	248
Unidentified Waterbirds	173	305	150	12	13	19	672
Total	**3,318**	**1,678**	**1,182**	**1,110**	**1,049**	**730**	**9,067**
Seasonal Total			**6,178**			**2,889**	

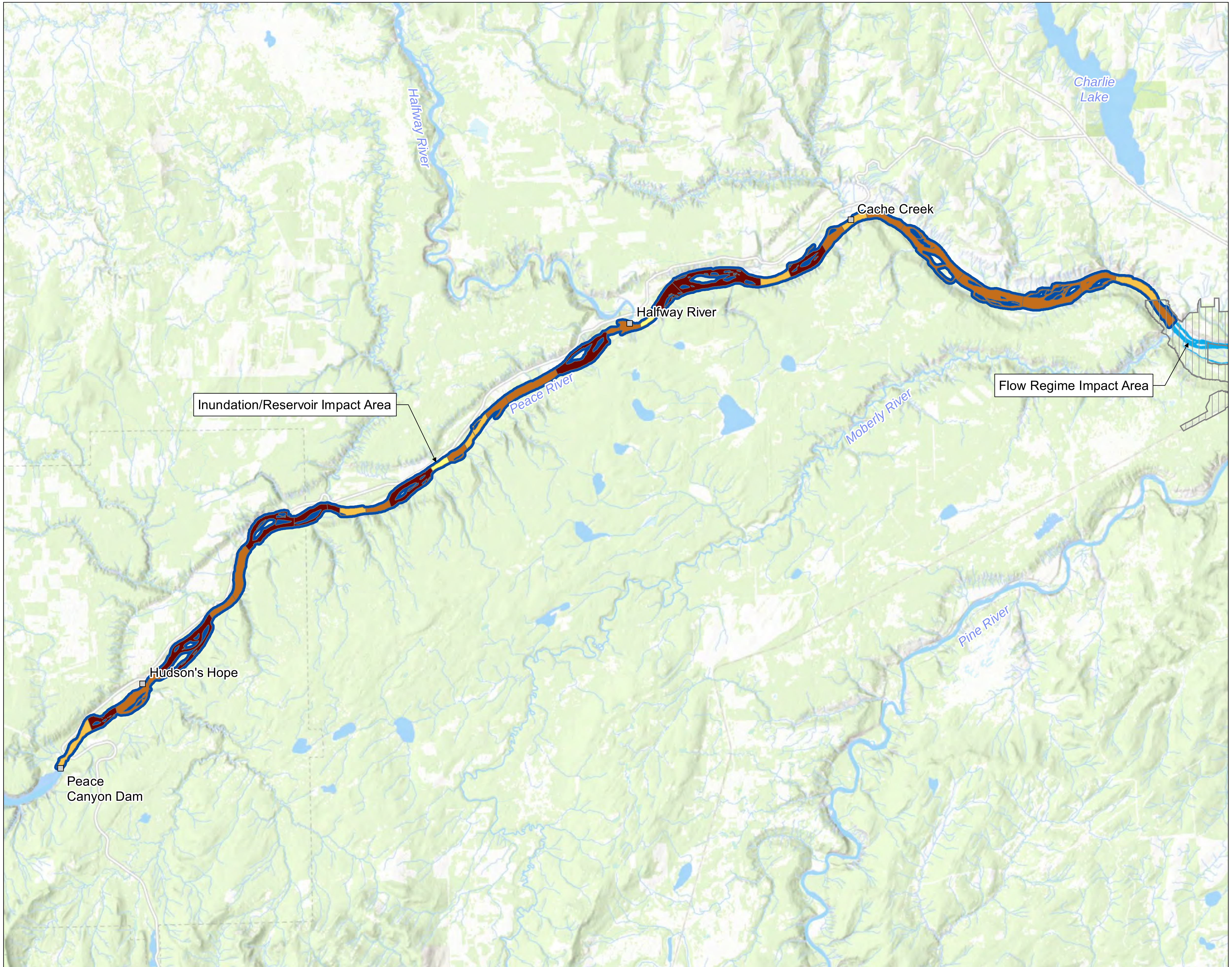
Note: Survey dates are presented in **Table 3**. Mean abundance records for spring and fall are presented in **Table14.**

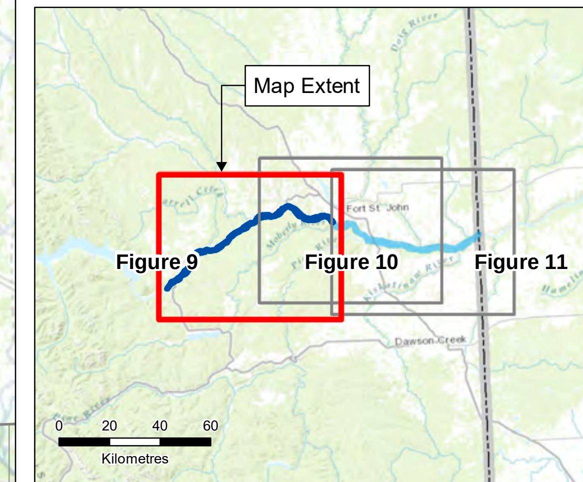
Overall waterbird densities varied substantially across reach types and across seasons. During spring, overall waterbird densities were highest in Island and Off-channel reaches (**Table 6, Figure 9, Figure 10 and Figure 11**). In the fall, waterbird densities in Confluence reaches were at least six-fold higher than those of other reach types (**Table 7, Figure 12, Figure 13 and Figure 14**). Mainstem reaches hosted the lowest waterbird densities in both seasons. Overall waterbird densities were higher during spring as compared to fall in all reach types except Confluence reaches, where densities were approximately six-fold higher during fall. All treatment areas supported similar waterbird densities in spring (**Table 6, Figure 9, Figure 10 and Figure 11**), but the Flow Impact area supported higher densities than the Control or Inundation Impact area during fall, likely due to high numbers of gulls in the Confluence reaches of the Peace River between the dam site and the Pine River (**Table 7, Figure 12, Figure 13 and Figure 14**).

The distribution of overall waterbirds primarily reflects distributions of the most abundant foraging guilds in each season (i.e., large dabblers and dabbling ducks in spring, gulls and large dabblers in fall) as described above (**Table 5**).

Migratory Waterbird Follow-up Monitoring Program
2017 Report
Site C, Peace River, BC

Density (birds/km) of Spring Migrant Waterbirds in Reaches of the Inundation Impact Treatment Area





Legend

- Inundation/Reservoir Impact Area (3,637 hectares)
- Flow Regime Impact Area
- Proposed Dam Site

Count per 1km

- 0
- >0-2
- >2-6
- >6-14
- >14-31

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Basemap: ESRI World Topographic Base

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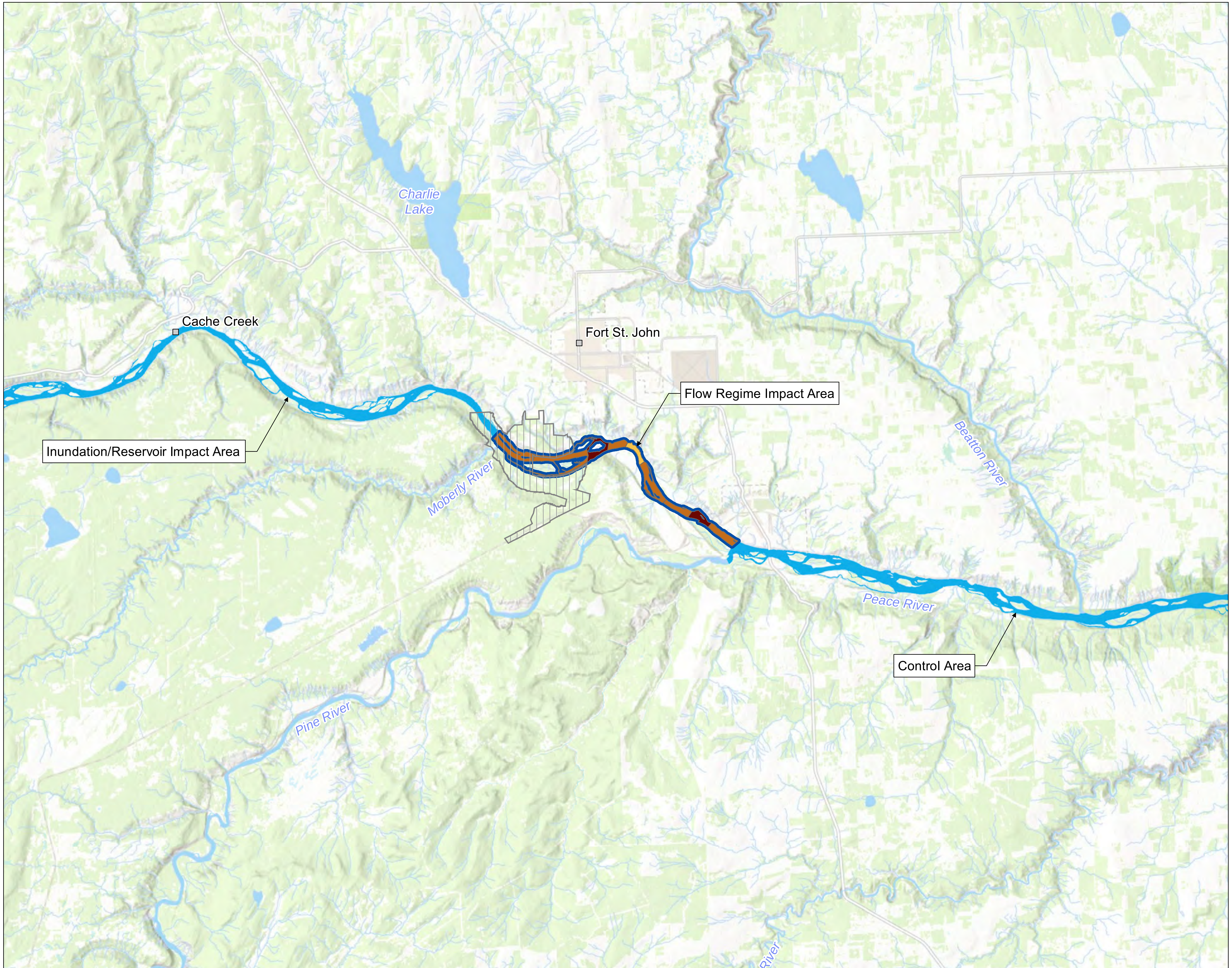
Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

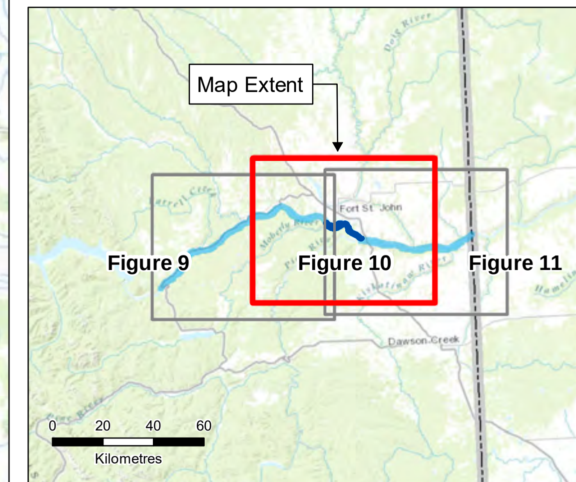
398-173.07	Production Date: Feb 28, 2018	Figure 9

Hemmera An Ausenco Company
BC hydro



Migratory Waterbird Follow-up Monitoring Program
2017 Report
Site C, Peace River, BC

Density (birds/km) of Spring Migrant Waterbirds in Reaches of the Flow Impact Treatment Area



Legend

- Flow Regime Impact Area (703 hectares)
- Inundation/Reservoir Impact Area and Control Area
- Proposed Dam Site

Count per 1km

- 0
- >0-2
- >2-6
- >6-14
- >14-31

Notes

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398-173.07	Production Date: Feb 28, 2018	Figure 10

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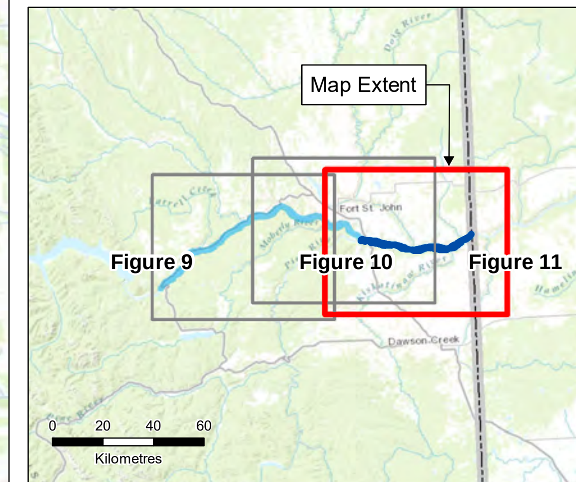
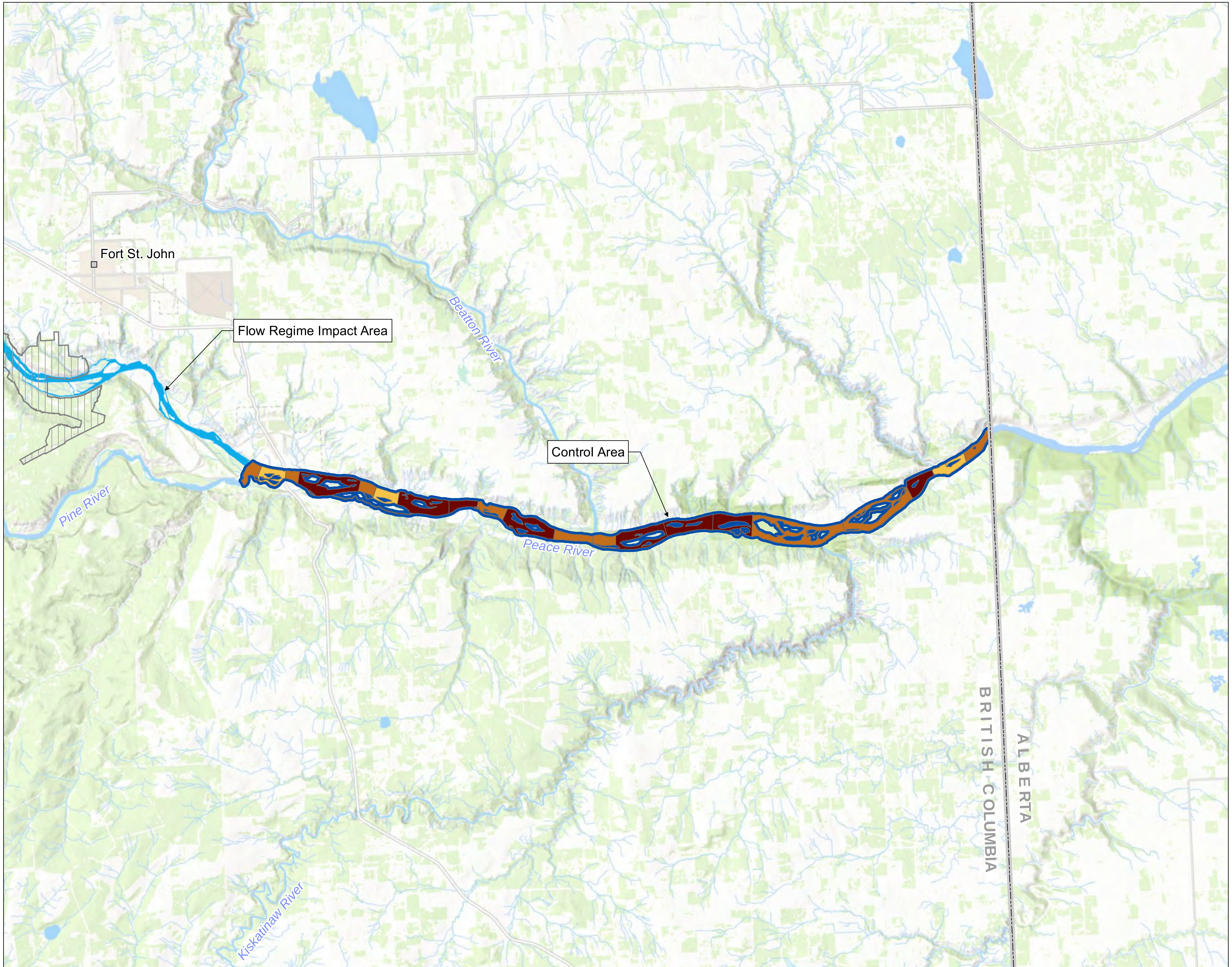
Migratory Waterbird Follow-up Monitoring Program
2017 Report
Site C, Peace River, BC

Density (birds/km) of Spring Migrant Waterbirds in Reaches of the Control Treatment Area





Legend

- Control Area (2,909 hectares)
- Flow Regime Impact Area
- Proposed Dam Site

Count per 1km

- 0
- >0-2
- >2-6
- >6-14
- >14-31

Notes

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Kilometres

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Page Size: 11" x 17"

398-173.07	Production Date: Feb 28, 2018	Figure 11

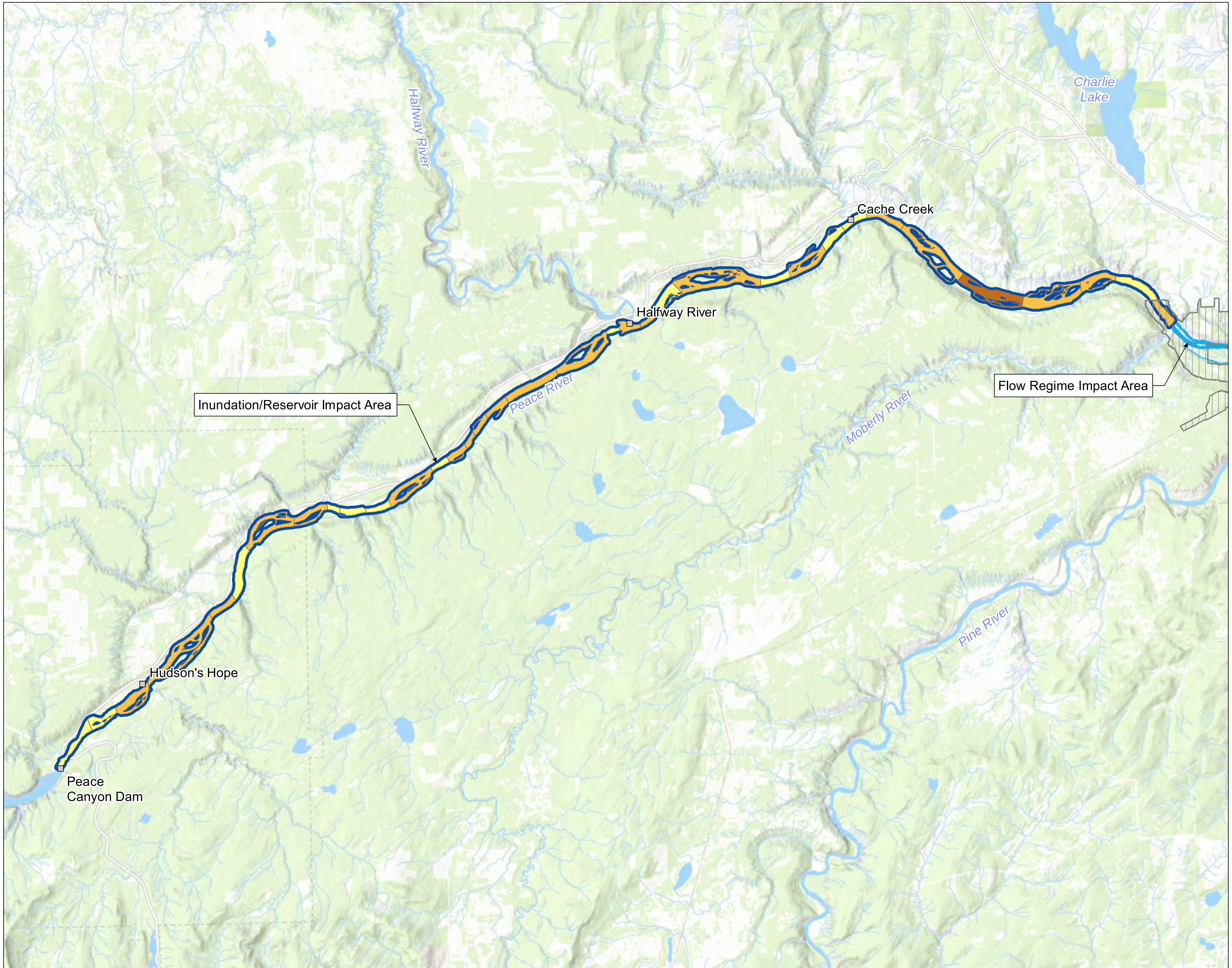
Hemmera An Ausenco Company

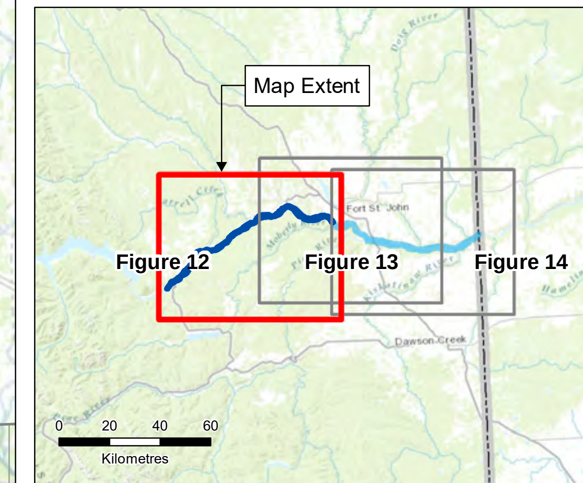
BC hydro

Path: O:\!361-399\398BC-Hydro\173\07_waterfowl\mxd\MonitoringProgram2017\Fig11_398_173_07_Waterbirds_SpringDensity_ControlArea_180228.mxd

Migratory Waterbird Follow-up Monitoring Program
2017 Report
Site C, Peace River, BC

Density (birds/km) of Fall Migrant Waterbirds in Reaches of the Inundation Impact Treatment Area





Legend

- Inundation/Reservoir Impact Area (3,637 hectares)
- Flow Regime Impact Area
- Proposed Dam Site

Count per 1km

- 0
- >0-2
- >2-6
- >6-14
- >14-31

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Kilometres

NAD 1983 UTM Zone 10N

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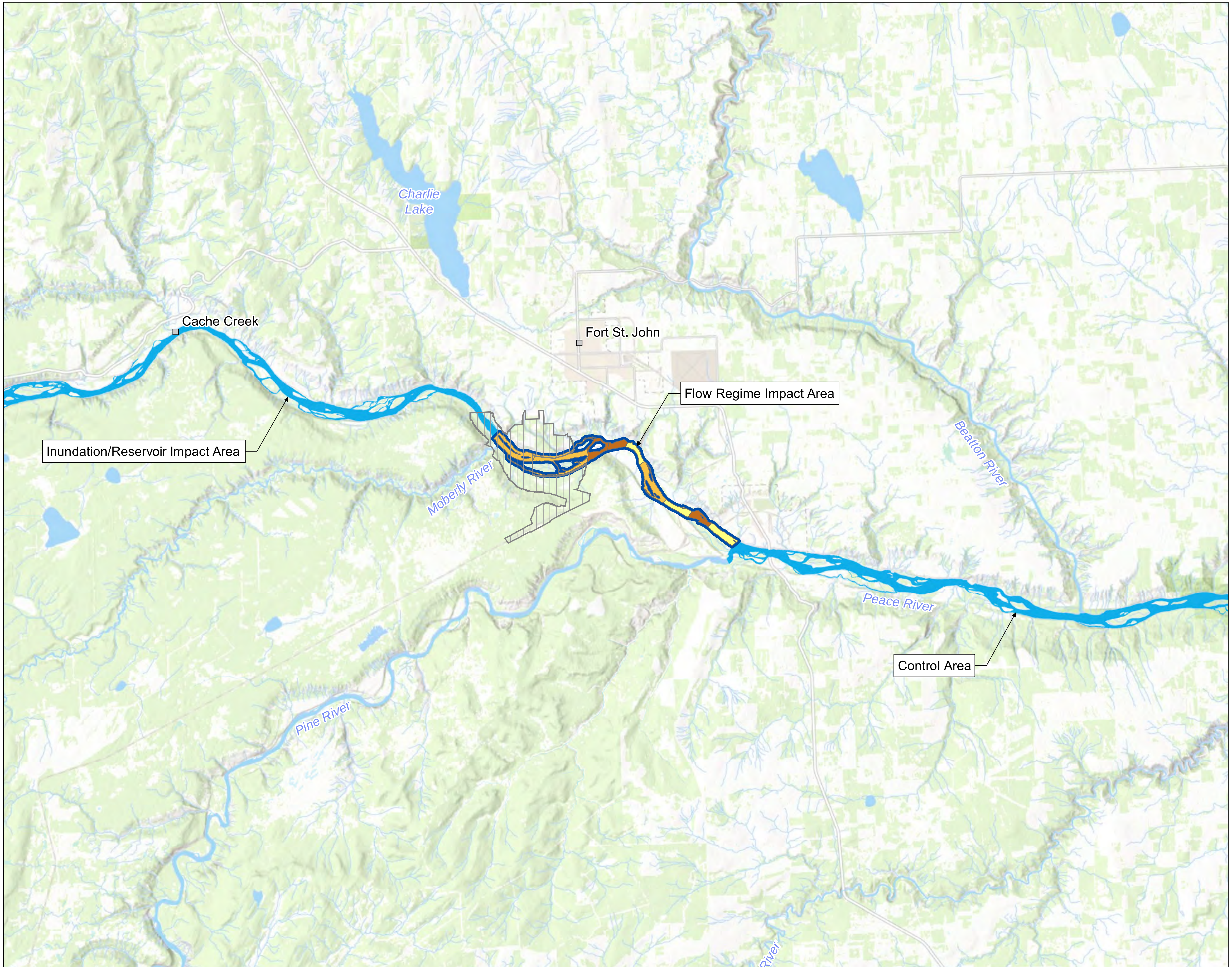
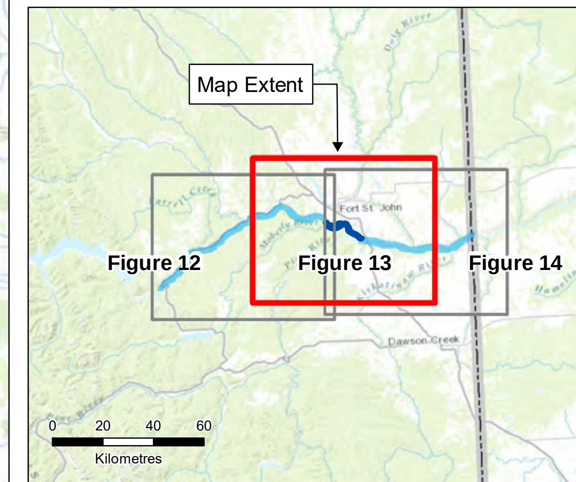
398-173.07	Production Date: Feb 28, 2018	Figure 12

Hemmera An Ausenco Company | BC hydro

Migratory Waterbird Follow-up Monitoring Program
2017 Report
Site C, Peace River, BC

Density (birds/km) of Fall Migrant Waterbirds in Reaches of the Flow Impact Treatment Area





Legend

- Flow Regime Impact Area (703 hectares)
- Inundation/Reservoir Impact Area and Control Area
- Proposed Dam Site

Count per 1km

- 0
- >0-2
- >2-6
- >6-14
- >14-31

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398-173.07	Production Date: Feb 28, 2018	Figure 13

Hemmera
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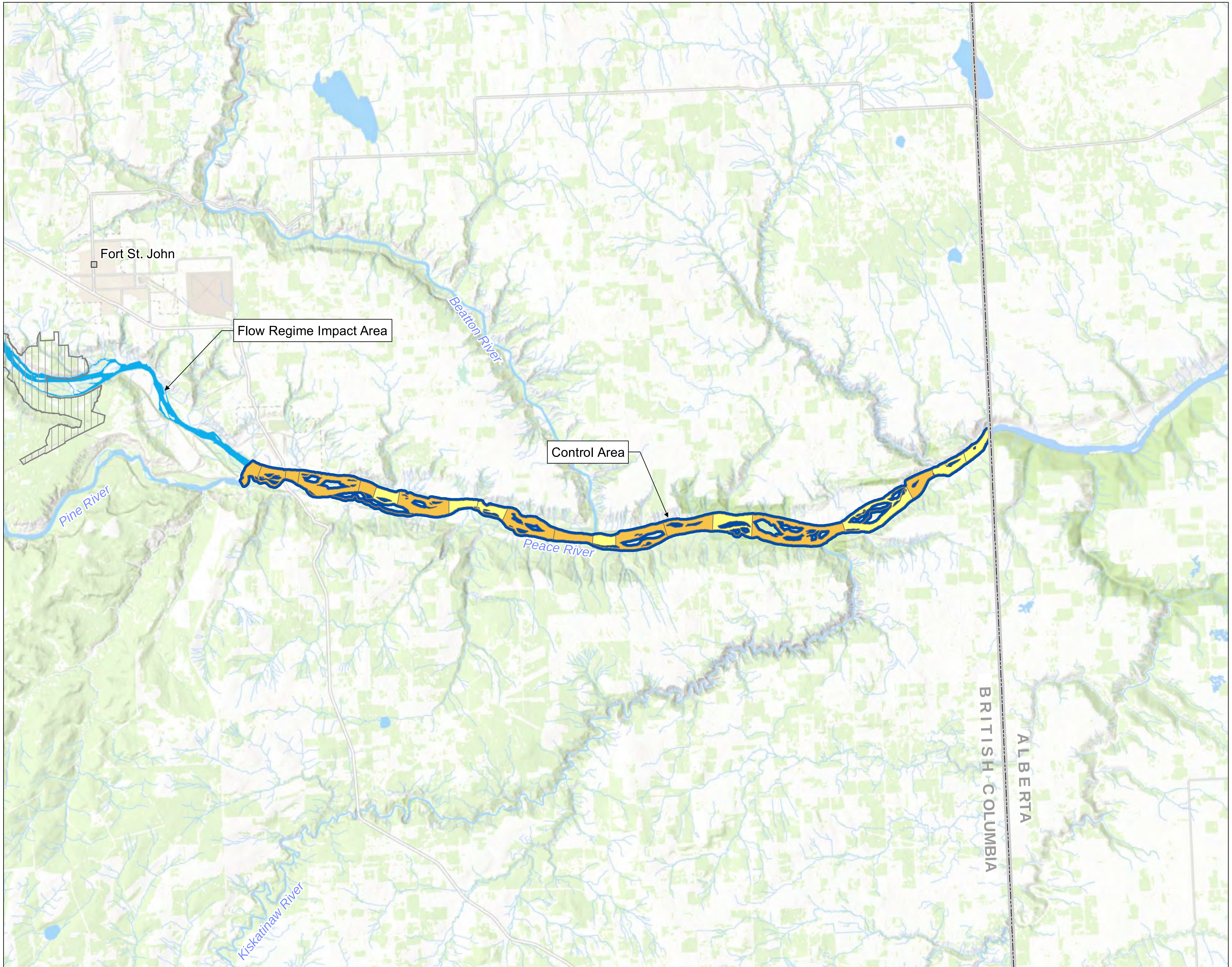
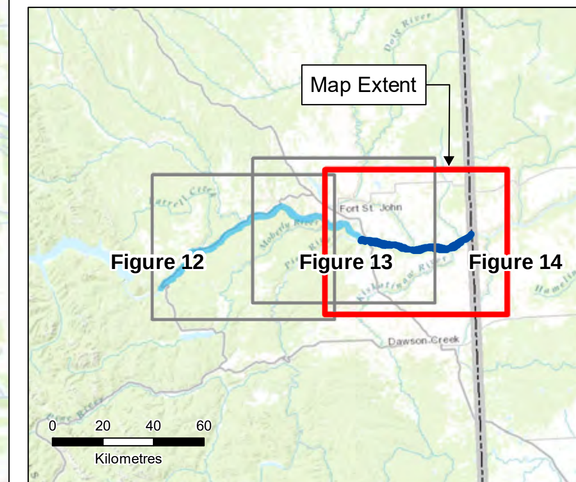


Migratory Waterbird Follow-up Monitoring Program
2017 Report
Site C, Peace River, BC

Density (birds/km) of Fall Migrant Waterbirds in Reaches of the Control Treatment Area



Legend

- Control Area (2,909 hectares)
- Flow Regime Impact Area
- Proposed Dam Site

Count per 1km

- 0
- >0-2
- >2-6
- >6-14
- >14-31

Notes

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Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

398-173.07	Production Date: Feb 28, 2018	Figure 14

Hemmera
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The distribution (i.e., relative densities) of waterbirds across reach types varied by foraging guild (**Table 6, Table 7**). Waterbird distributions across reach types also varied between spring and fall for all foraging guilds except gulls and shorebirds. Gull densities were at least six-fold higher in Confluence reaches than in other reach types, and shorebirds were more than twice as dense in Island reaches as compared to other reach types during spring and fall.

The habitat types that had consistently high densities for each waterbird foraging type across seasons were:

- Dabbling ducks – Off-channel habitat
- Gulls Confluence habitat
- Large dabblers – Off-channel and Island habitat
- Shorebirds – Island habitat
- Piscivorous Divers and Benthic divers – no clear preference

The distribution (i.e., relative densities) of waterbirds across reach types also varied by treatment area and season (**Table 6, Table 7**). Of all foraging guilds, only gulls were observed in higher densities within one treatment area during both seasons. Gull density within the Flow Impact area was more than four-fold densities observed in other treatment areas during fall and spring.

Benthic feeding divers were observed in highest densities within the Inundation Impact area during spring (**Table 6**), and were observed in relatively low densities (0.10 birds/km or lower) across all treatment areas in the fall (**Table 7**). The highest densities of dabbling ducks were observed within the Control area during spring, but this area hosted the lowest density of all areas in the fall. Large dabblers were observed in similar densities across treatment areas in the spring, but relatively low densities within the Flow Impact area during fall. Piscivorous divers in spring were observed in higher densities in Inundation Impact and Flow Impact areas as compared to the Control area, but the Control area hosted the highest densities during fall surveys. Similar densities of shorebirds were observed across treatment areas during spring, but densities were two-fold higher in the Control area as compared to other areas during fall.

Table 6 Density (birds/km) of spring migrant waterbirds in the Peace River study area by river reach category and treatment area

Foraging Guild	River Reach Category				Treatment Area		
	Off-channel	Island	Mainstem	Confluence	Inundation Impact	Flow Impact	Control
Benthic Feeding Divers	0.30	0.78	0.17	0.12	0.54	0.18	0.20
Dabbling Ducks	5.09	6.10	1.87	1.70	2.86	3.46	6.98
Gulls	0.11	0.06	0.10	0.72	0.10	0.43	0.06
Large Dabblers	4.97	8.18	2.46	2.35	4.88	3.72	5.66
Piscivorous Divers	0.90	0.95	0.73	0.89	1.11	0.90	0.40
Shorebirds	0.15	0.52	0.10	0.22	0.25	0.16	0.27
Unidentified Waterbirds	1.66	2.45	0.43	0.31	1.79	1.21	0.92
Total	**13.18**	**19.04**	**5.86**	**6.31**	**11.53**	**10.06**	**14.49**

Note: Densities are calculated as means across all fully completed surveys in spring, 2017 (n = 5). Data from the incomplete second survey event during the early survey period are excluded.

Table 7 Density (birds/km) of fall migrant waterbirds in the Peace River study area by river reach category and treatment area

Foraging Guild	River Reach Category				Treatment Area		
	Off-channel	Island	Mainstem	Confluence	Inundation Impact	Flow Impact	Control
Benthic Feeding Divers	0.07	0.03	0.01	0.00	0.04	0.10	0.01
Dabbling Ducks	1.32	0.69	0.01	0.92	1.01	1.22	0.08
Gulls	1.88	0.02	2.19	36.55	2.16	17.82	0.10
Large Dabblers	2.51	1.62	0.71	2.04	1.67	0.32	2.32
Piscivorous Divers	0.09	0.41	0.14	0.00	0.16	0.05	0.29
Shorebirds	0.35	0.62	0.18	0.04	0.26	0.27	0.57
Unidentified Waterbirds	0.17	0.10	0.00	0.06	0.15	0.04	0.02
Total	**6.39**	**3.49**	**3.24**	**39.61**	**5.45**	**19.82**	**3.39**

Note: Densities are calculated as means across all surveys completed in Fall, 2017 (n = 6).

Substrate data were collected in association with most of the waterbird observations (**Table 8** and **Table 9**). Most foraging guilds used the substrates similarly across seasons, and at some time during either the spring and fall seasons each foraging guilds used all substrate types but boulders to some extent. A third of the spring observations were in vegetated habitat (**Table 8**), of which most were the dabbling ducks and large dabblers that were abundant in the spring (**Table 5**). In the fall, gravel was the most used substrate, mostly by gulls that were abundant at that time (**Table 9**). Few birds used boulder substrates regardless of foraging guild or season (**Table 8** and **Table 9**). No substrate data were collected for benthic feeding divers in the fall due to their low abundance in the study area.

Table 8 Foraging guild abundances across substrate types during spring

Foraging Guild	Number of individuals observed across substrate types						n
	Boulder	Cobble	Gravel	Sand	Silt	Vegetated	
Benthic Feeding Divers	0	4	1	8	5	33	51
Dabbling Ducks	2	164	141	329	168	258	1,062
Gulls	0	1	21	0	4	0	26
Large Dabblers	6	653	274	299	427	1011	2,670
Piscivorous Divers	2	58	23	17	27	43	170
Shorebirds	1	6	9	47	13	7	83
Total	11	886	469	700	644	1,352	**4,062**

Table 9 Foraging guild abundances across substrate types during fall

Foraging Guild	Number of individuals observed across substrate types						n
	Boulder	Cobble	Gravel	Sand	Silt	Vegetated	
Benthic Feeding Divers	0	0	0	0	0	0	0
Dabbling Ducks	0	0	7	0	0	34	41
Gulls	1	1	710	6	-	8	726
Large Dabblers	0	29	16	78	16	78	217
Piscivorous Divers	0	1	9	2	0	0	12
Shorebirds	0	19	12	6	2	0	39
Total	1	50	754	92	18	120	**1,035**

Water current data were collected in association with most waterbird observations (**Table 10**). Slow and no flow conditions had the most observations in the spring, but in the fall no flow conditions had few waterbird observations. Waterbirds were rarely observed using fast current conditions, but in moderate current conditions high proportions of gulls and shorebirds were observed, especially in the fall. Dabbling ducks, large dabblers and piscivorous divers were observed using slow current locations more than other foraging guilds during both seasons. Shorebirds were infrequently observed in waters with fast or no flow, preferring moderate or slow water currents.

The apparent preference for habitat types cannot be determined because the total area (i.e., availability) of each habitat type (sediment / flow conditions) is unknown across the study area. These conditions change daily under a managed water regime.

Table 10 Foraging guild abundances across current speeds in spring and fall

Foraging Guild	Number of waterbirds observed								*n*
	Spring				Fall				
	Fast	Mod.	Slow	None	Fast	Mod.	Slow	None	
Benthic Feeding Divers	0	3	66	2	0	1	0	0	72
Dabbling Ducks	0	142	627	186	0	1	40	20	1,016
Gulls	0	14	7	10	0	111	2	6	150
Large Dabblers	1	166	1,005	703	0	116	70	14	2,075
Piscivorous Divers	5	27	165	72	0	3	41	0	313
Shorebirds	0	43	47	0	0	346	7	5	448
Total	6	395	1,917	973	0	578	160	45	**4,074**

4.1.2 Diversity

A total of 38 waterbird species were detected during 2017 surveys of the Peace River (**Table 11; Appendix A**). Dabbling ducks were the most species rich foraging guild during both the spring (12 species) and fall (eight (8) species), with 13 species documented in total. Waterbird diversity, as described by the Shannon-Weiner Index (SWI), was similar during the spring and fall migrations (SWI = 1.66 and 1.54, respectively); however, the highest species richness and evenness was documented during the middle and late spring survey periods, with the late spring survey period hosting the greatest species richness, evenness, and SWI across all periods (**Table 11**).

Table 11 Diversity of waterbird foraging guilds observed across survey periods on the Peace River during spring and fall migration 2017

Foraging Guild	Spring species richness by survey period			Spring Total	Fall species richness by survey period			Fall Total	*2017 Total*
	Early*	Middle	Late		Early	Middle	Late		
Benthic Feeding Divers	1	2	3	**3**	2	1	2	**3**	***4***
Dabbling Ducks	5	8	11	**12**	5	5	5	**8**	***13***
Gulls	0	3	4	**4**	3	4	3	**5**	***6***
Large Dabblers	2	2	2	**2**	1	2	2	**2**	***2***
Piscivorous Divers	2	4	5	**6**	2	4	4	**5**	***8***
Shorebirds	1	1	2	**3**	4	1	2	**4**	***5***
Total Species Richness	11	20	27	**30**	17	17	18	**27**	***38***
Species Evenness	0.50	0.62	0.64	**0.49**	0.53	0.54	0.42	**0.50**	***0.53***
Shannon-Weiner Index	1.19	1.85	2.10	**1.66**	1.51	1.52	1.20	**1.65**	***1.91***

Note: Individuals not identified to species are excluded from calculations of species evenness of Shannon-Weiner Index. *The early spring survey period only includes data from one survey of the Peace River study area while all other periods incorporate observations from two surveys. This may result in a negative bias for diversity measures during the early spring survey period and for the spring total as compared to the fall total.

Due to an unequal number of reaches and river lengths across habitat categories and treatment areas in the Peace River study area (**Table 4**), diversity indices cannot be compared directly across habitats or areas. However, diversity statistics were calculated for spring and fall to assess variability across seasons, and to provide a baseline for comparison to future survey years (**Table 12, Table 13**).

Waterbird diversity was observed in similar patterns (i.e., relative diversity) across reach types during spring and fall. In both seasons, the highest species richness and SWI was observed in Off-channel reaches, followed by Mainstem and Island reaches, with low species richness and SWI in Confluence reaches. However, species evenness within Confluence reaches during spring was more than double that of fall leading to a corresponding drop in SWI for that reach type. Seasonal variation in diversity across treatment areas was observed. Fewer dabbling ducks in the control area resulted in lower species richness in fall as compared to spring. Species evenness and SWI were also lower in the Flow Impact area during fall as compared to spring.

Table 12 Diversity of spring migrant waterbirds in the Peace River study area by river reach habitat category and treatment area

Foraging Guild	Species richness by river reach habitat category				Species richness by treatment area		
	Off-channel	Island	Mainstem	Confluence	Inundation Impact	Flow Impact	Control
Benthic Feeding Divers	3	2	2	2	3	1	2
Dabbling Ducks	9	10	8	3	10	7	10
Gulls	3	1	3	1	4	1	1
Large Dabblers	2	2	2	1	2	2	2
Piscivorous Divers	5	4	5	2	6	2	4
Shorebirds	2	2	1	1	3	2	1
Total Species Richness	**24**	**21**	**21**	**10**	**28**	**15**	**20**
Species Evenness	**0.59**	**0.54**	**0.59**	**0.68**	**0.52**	**0.71**	**0.57**
Shannon-Weiner Index	**1.88**	**1.66**	**1.80**	**1.56**	**1.73**	**1.92**	**1.71**

Note: Diversity statistics are calculated with all data from fully completed surveys in spring, 2017 (n = 5). Data from the incomplete second survey event during the early survey period are excluded.

Table 13 Diversity of fall migrant waterbirds in the Peace River study area by river reach habitat category and treatment area

Foraging Guild	Species richness by river reach habitat category				Species richness by treatment area		
	Off-channel	Island	Mainstem	Confluence	Inundation Impact	Flow Impact	Control
Benthic Feeding Divers	2	2	2	0	2	3	1
Dabbling Ducks	6	3	2	3	7	5	2
Gulls	4	2	4	3	4	3	3
Large Dabblers	2	2	2	1	2	1	2
Piscivorous Divers	3	3	4	0	4	1	4
Shorebirds	4	2	1	1	3	2	2
Total Species Richness	**21**	**14**	**15**	**8**	**22**	**15**	**14**
Species Evenness	**0.53**	**0.54**	**0.51**	**0.31**	**0.53**	**0.33**	**0.42**
Shannon-Weiner Index	**1.63**	**1.43**	**1.38**	**0.65**	**1.65**	**0.88**	**1.10**

Note: Diversity statistics are calculated with all data from fully completed surveys in fall, 2017 (n = 6).

As noted for abundance (**Section 4.1.1**), diversity cannot be directly compared across substrate types or water current velocities because the variation in occurrence (i.e., area) across the study area is unknown.

4.1.3 Variance Estimates

Waterbird abundance estimates varied more across survey periods in spring as compared to fall, particularly for large dabblers, piscivorous divers, and shorebirds, resulting in lower variance statistics (e.g., standard deviation [SD], coefficient of variation [CV]) from fall data (**Table 14**). In contrast, dabbling ducks and gulls were detected in more consistent numbers in the spring as compared to fall.

Table 14 Summary abundance and variance statistics for waterbird foraging guilds detected on the Peace River across survey periods during spring and fall migrations

Foraging Guild	Spring (3 Survey Periods)			Fall (3 Survey Periods)		
	Mean	SD[1]	CV[2]	Mean	SD[1]	CV[2]
Benthic Feeding Divers	58	46.9	0.81	6	1.4	0.25
Dabbling Ducks	655	171.9	0.26	108	72.9	0.67
Gulls	24	3.5	0.15	502	240.7	0.48
Large Dabblers	932	873.9	0.94	250	146.5	0.59
Piscivorous Divers	158	143.1	0.90	28	11.0	0.40
Shorebirds	30	49.4	1.65	104	136.3	1.31
Unidentified Waterbirds	209	83.6	0.40	14	3.8	0.27
Total	**2,066**	**1,118.1**	**0.54**	**1,012**	**271.4**	**0.27**

[1] SD - standard deviation across mean results from early, middle and late survey periods: Typical variation of a survey period from the mean.
[2] CV - Coefficient of Variation (CV = SD/Mean): Variation of a survey period from the mean expressed as a percentage of the mean.

4.2 AERIAL WATERBIRD SURVEYS (TRANSECTS 2 – 5) – FIXED-WING AIRCRAFT

Six aerial waterbird surveys were conducted from fixed-wing aircraft over the spring (i.e., April 30, May 15, June 1) and fall (i.e., September 4, 19 and 24) migration periods. Average survey length was between three and four hours, but the September 19 survey was half the duration due to inclement weather; only the highest value waterbird habitat (i.e., open water) was surveyed. Data from this survey have been included in summaries presented below.

4.2.1 Relative Abundance

Waterbird observations from 2017 fixed-wing aircraft surveys included trumpeter swan, Canada goose, American coot (*Fulica americana*), green-winged (*Anas crecca*) and blue-winged teal (*Anas discors*), mallard (*Anas platychrynchops*), and bufflehead (*Bucephala albeola*), goldeneye (*Bucephala* spp.) and scaup (*Aythya* spp.); however, species identification was often unreliable or impossible from the height and speed at which the aircraft was traveling (150 m altitude at 150 km/hr). Consequently, results are summarized by species group.

During spring, 4,443 waterbirds were observed, and 2,944 waterbirds were observed during fall (**Table 15**). The majority of spring observations occurred during the middle survey period, while the majority of the fall observations occurred during the early survey period (**Table 15**). Ducks were the most commonly observed waterbirds, with approximately 84% of total waterbird abundance. No shorebirds or marshbirds were detected during fixed-wing surveys.

Table 15 Waterbird abundance from fixed-wing aircraft surveys (transects 2-5)

Species Group	Spring Surveys			Fall Surveys			Total
	30-Apr	15-May	01-Jun	04-Sep	19-Sep*	24-Sep	
Ducks	987	2,152	410	1,237	919	513	6,218
Geese	20	9	20	99	13	20	181
Gulls	525	0	117	17	0	0	659
Swans	56	62	54	50	24	52	298
Unidentified Waterbirds	31	0	0	0	0	0	31
Total	**1,619**	**2,223**	**601**	**1,403**	**956**	**585**	**7,387**
Seasonal Totals			**4,443**			**2,944**	

* The September 19 survey was only conducted for approximately ½ of each transect length as weather in the western portion of the study area was unsafe for flying.

In the spring, waterbirds were most often observed in open water habitat (86% of observations). More ducks and gulls were observed in open water habitat than other habitats, though geese and swans were found in similar abundance in wetlands. The majority of waterbirds observed during spring were ducks, followed by gulls, swans, and geese (**Table 16**).

Table 16 Spring waterbird abundance by habitat type from fixed-wing aircraft surveys

Species Group	Habitat Type				Total
	Unspecified	Open Water	Wetland	Terrestrial	
Ducks	5	3,037	502	5	3,549
Geese	0	27	22	0	49
Gulls	0	642	0	0	642
Swans	0	93	77	2	172
Unidentified Waterbirds	0	125	6	0	31
Total	**5**	**3,824**	**607**	**7**	**4,443**

In the fall, waterbirds were again most often seen in open water habitat. Open water hosted 96% of observations and at least five times the abundance of any other habitat type during fall. Similar to the spring, the majority of observations from the fall were ducks. Gulls were the second most abundant group in the spring, but the least abundant species group during the fall (**Table 16, Table 17**).

Table 17 Fall waterbird abundance by habitat type from fixed-wing aircraft surveys

Species Group	Habitat Type				Total
	Unspecified / Other[1]	Open Water	Wetland	Terrestrial	
Ducks	39	2,573	57	0	2,669
Geese	0	111	21	0	132
Gulls	0	17	0	0	17
Swans	0	115	7	4	126
Total	**39**	**2,816**	**85**	**4**	**2,944**

[1] Other = Waterbirds observed in the Moberly River or flying during surveys.

4.2.2 Diversity

Waterbirds could not be identified to species in most cases during fixed-wing surveys as a result of flight height (minimum 500' elevation). As a consequence, species diversity could not be estimated accurately. Only eight species were positively identified, mostly large birds such as trumpeter swan and Canada goose. Approximately 90% of the observations could not be positively identified beyond the family taxonomic level.

4.2.3 Variance Estimates

Data collected during 2017 fixed-wing aircraft surveys of the Moberly Plateau (transects 2-5) provide estimates of variance for waterbird abundance across survey periods. Overall variance in waterbird numbers was lower across fall survey periods (CV = 0.42) as compared to spring (CV = 0.55), particularly for ducks which were the most abundant species (**Table 18**). In contrast, geese, gulls, and swans were detected in more consistent numbers in the spring as compared to fall.

Table 18 Summary abundance statistics for waterbird species groups detected across aerial survey periods during spring and fall migration

Species Group	Spring Surveys (n=3)			Fall Surveys (n=3)		
	Mean	SD	CV[1]	Mean	SD	CV[1]
Ducks	1,183	887	0.75	890	363	0.41
Geese	16	6	0.39	44	48	1.09
Gulls	214	276	1.29	6	10	1.73
Swans	57	4	0.07	42	16	0.37
Unidentified Waterbirds	10	18	1.73	0	-	-
Total	**1,481**	**820**	**0.55**	**981**	**410**	**0.42**

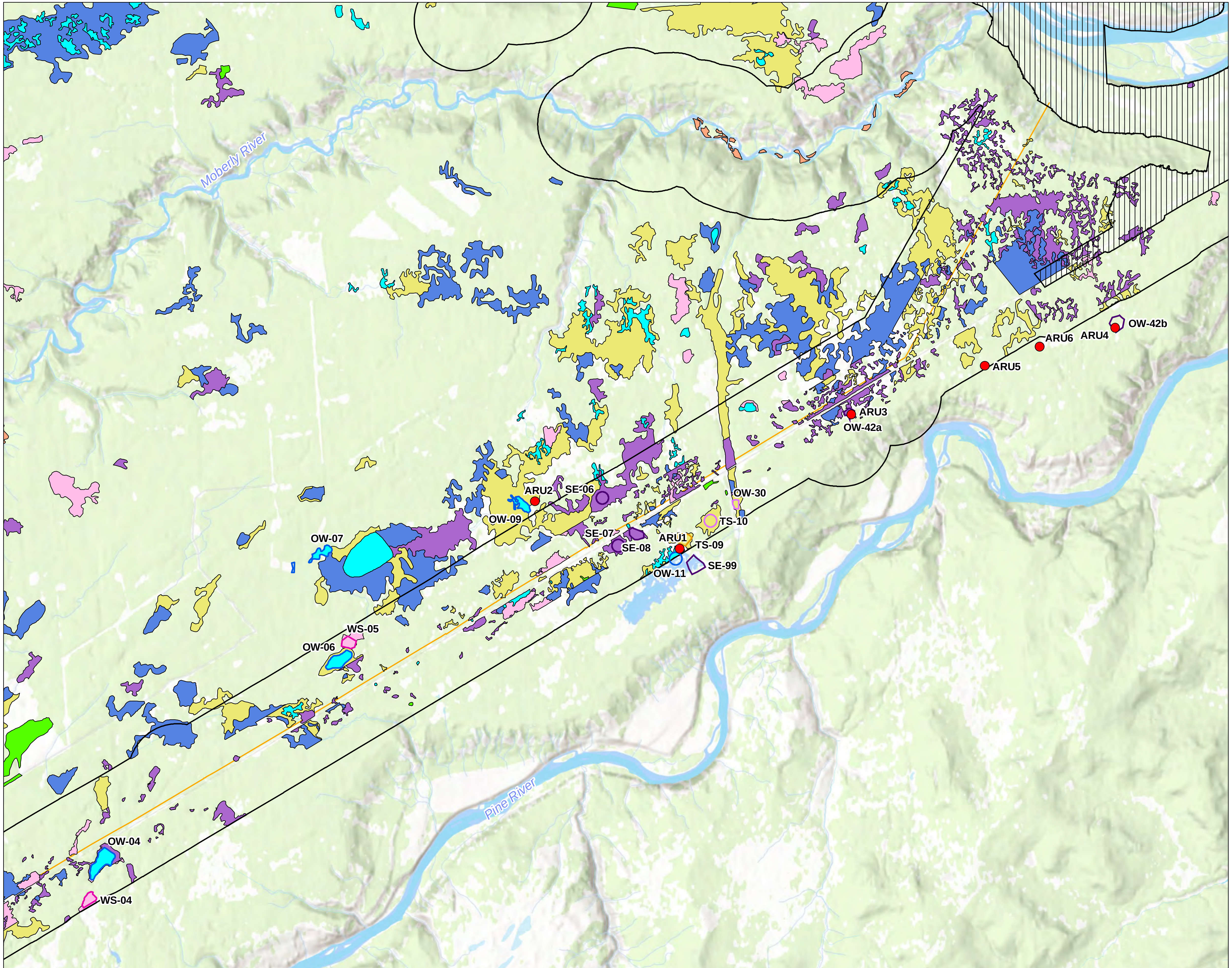
[1] SD - Standard Deviation; CV - Coefficient of Variation (CV = SD/Mean)

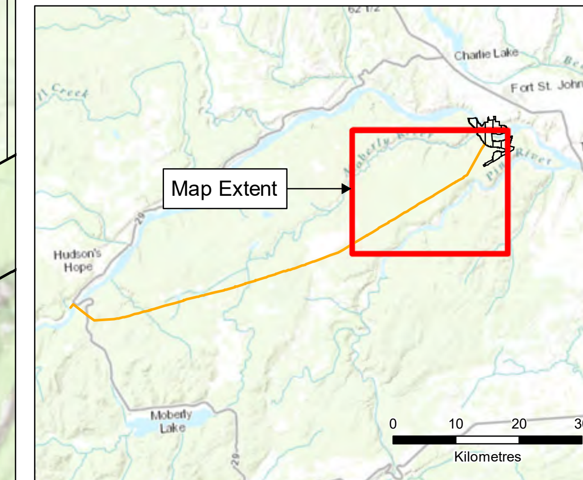
4.3 TRANSMISSION LINE WETLAND SURVEYS (TRANSECT 5)

Point count surveys were conducted at 21 wetland locations (survey stations) along the transmission line route during the spring (April 28 to May 28, 2017) and fall (August 11 to September 26, 2017) migrations (**Figure 15, Figure 16**). The surveys were conducted over a total of 24 days (12 days per season) in suitable wetland habitat types for waterbirds (**Table 19**). Two replicate surveys were conducted at most stations during each survey period (**Table 20**). Survey effort by wetland station (including replicate surveys) is provided in **Appendix C**. Four of the six wetland types identified as potentially suitable habitat for waterbirds were sampled: Open Water, Sedge, Tamarack Sedge, and Willow Sedge. Surveys in the other two, Cultivated Field and Labrador-tea sedge, wetland habitats were unable to be conducted due to access limitations (e.g., road restrictions and private properties where no entry permission was granted). This prevented sampling and inclusion in the study for these wetland types.

Migratory Waterbird Follow-up Monitoring Program
2017 Report
Site C, Peace River, BC

Wetland Survey Stations and ARU Monitoring Locations on the Transmission Line Route (Transect 5, East)





Legend

- Site C LAA
- Proposed Dam Site
- Transmission Line Right-of-Way
- Bioacoustic Monitoring Station

Wetland Survey Station

- Sedge
- Shallow open water
- Shallow open water / Sedge
- Tamarack-sedge
- Willow sedge

Wetland Types

- Cultivated field within 100m of wetland (CF)
- Labrador-tea – sedge (BT)
- Non-forested floodplain wetland (WH)
- Sedge (SE)
- Shallow open water (OW)
- Tamarack-sedge (TS)
- Willow sedge (WS)

Notes

1. OW has been used as the idientfier for Shallow Open Water wetland field locations; however, please note that the wetland classification also includes LA and PD habitat codes.
2. Locations should be considered approximate.
3. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Basemap: ESRI World Topographic Base

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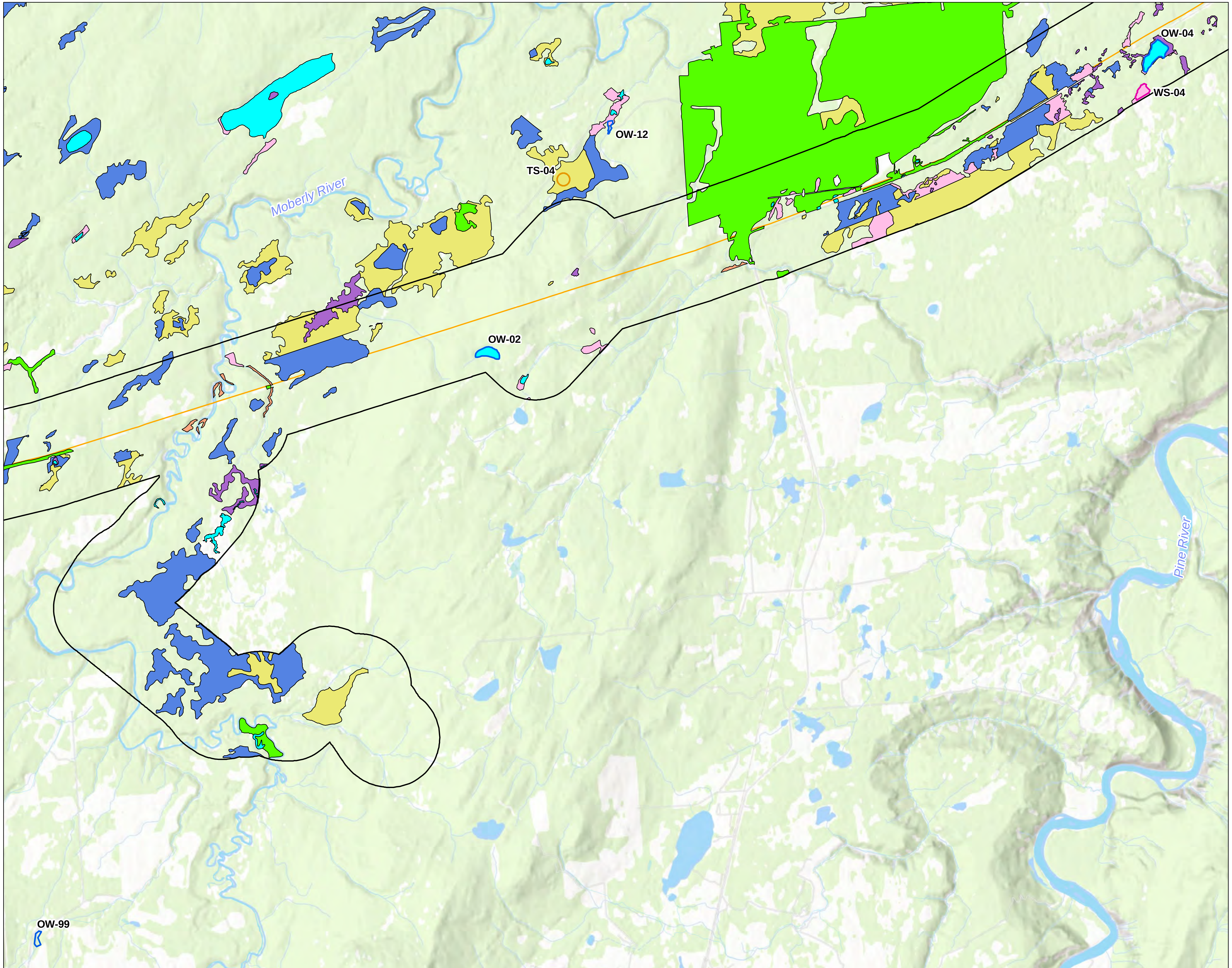
398-173.07	Production Date: Feb 28, 2018	Figure 15

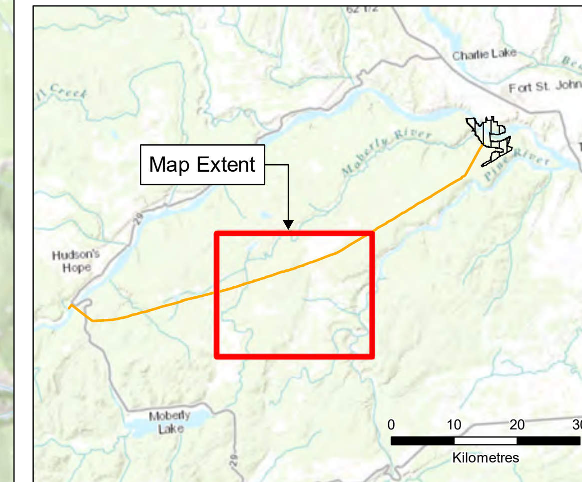
Hemmera
An Ausenco Company

BC hydro

Migratory Waterbird Follow-up Monitoring Program
2017 Report
Site C, Peace River, BC

Wetland Survey Stations Locations on the Transmission Line Route (Transect 5, West)





Legend

- Site C LAA
- Transmission Line Right-of-Way

Wetland Survey Station

- Shallow open water
- Tamarack-sedge
- Willow sedge

Wetland Types

- Cultivated field within 100m of wetland (CF)
- Labrador-tea – sedge (BT)
- Non-forested floodplain wetland (WH)
- Sedge (SE)
- Shallow open water (OW)
- Tamarack-sedge (TS)
- Willow sedge (WS)

Notes

1. OW has been used as the idientfier for Shallow Open Water wetland field locations; however, please note that the wetland classification also includes LA and PD habitat codes.
2. Locations should be considered approximate.
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398-173.07	Production Date: Feb 28, 2018	Figure 16

Hemmera An Ausenco Company

BC hydro

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Table 19 Number of wetland survey stations surveyed on the transmission line route by survey period and habitat type

Habitat Type	Spring			Spring overall	Fall			Fall overall
	Early	Middle	Late		Early	Middle	Late	
Open Water	4	6	5	15	5	5	5	15
Sedge	4	7	8	19	9	9	9	27
Tamarack Sedge	2	1	0	3	1	1	2	4
Willow Sedge	2	2	2	6	2	2	2	6
Total	**12**	**16**	**15**	**43**	**17**	**17**	**18**	**52**

Table 20 Number of wetland surveys conducted (including replicates) on the transmission line route by survey period and habitat type

Habitat Type	Spring			Spring total	Fall			Fall total	Grand Total
	Early	Middle	Late		Early	Middle	Late		
Open Water	5	11	10	26	10	9	10	29	55
Sedge	5	11	15	31	18	17	18	53	84
Tamarack Sedge	2	2	0	4	2	2	4	8	12
Willow Sedge	3	4	4	11	4	4	4	12	23
Total	**15**	**28**	**29**	**72**	**34**	**32**	**36**	**102**	**174**

Bioacoustic ARU monitoring for marsh birds (i.e., sora, yellow rail, and American bittern) was conducted in six wetlands (**Figure 15**). The ARU recorded 320 hours of acoustic data from May 19 to June 27, 2017.

4.3.1 Relative Abundance and Density

A total of 1,436 individuals across 30 waterbird species were observed during wetland surveys conducted on the transmission line route during spring and fall migrations in 2017 (**Appendix B**). At various times waterbirds that could not be identified to species were observed during the surveys. These observations were grouped as: unidentified ducks (n=178), scaups (n=89), teals (n=18), waterbirds (n=12), shorebirds (n=6), grebes (2), and an unidentified goldeneye (1). Mean abundances of waterbirds recorded during point count surveys are summarized by foraging guild for each survey period during spring and fall (**Table 21**, **Appendix A**).

More waterbirds were recorded on wetlands on the transmission line during the latter part of the spring migration period and the early part of the fall migration period (**Table 21**). Dabbling ducks were the most abundant group in both seasons (**Figure 17**) and more waterbirds were observed during fall surveys as compared to spring (**Table 21**).

Table 21 Mean relative abundance (per survey) of waterbird foraging guilds during wetland surveys on the transmission line route (transect 5) during spring and fall

Foraging Guild	Spring			Fall		
	Early	Middle	Late	Early	Middle	Late
Benthic Feeding Divers	0.9	1.1	0.7	0.6	1.3	2.3
Dabbling Ducks	4.5	12.7	10.7	10.6	5.6	6.0
Gulls	0.0	0.0	0.1	0.0	0.0	0.0
Large Dabblers	0.6	0.3	0.8	0.4	0.8	0.5
Marsh Birds	0.1	2.8	3.5	0.9	0.1	0.1
Piscivorous Divers	0.0	0.3	0.5	0.9	0.0	1.2
Shorebirds	0.0	0.3	0.8	1.4	0.0	0.4
Grand Total	6.2	17.4	17.5	14.9	7.7	11.0

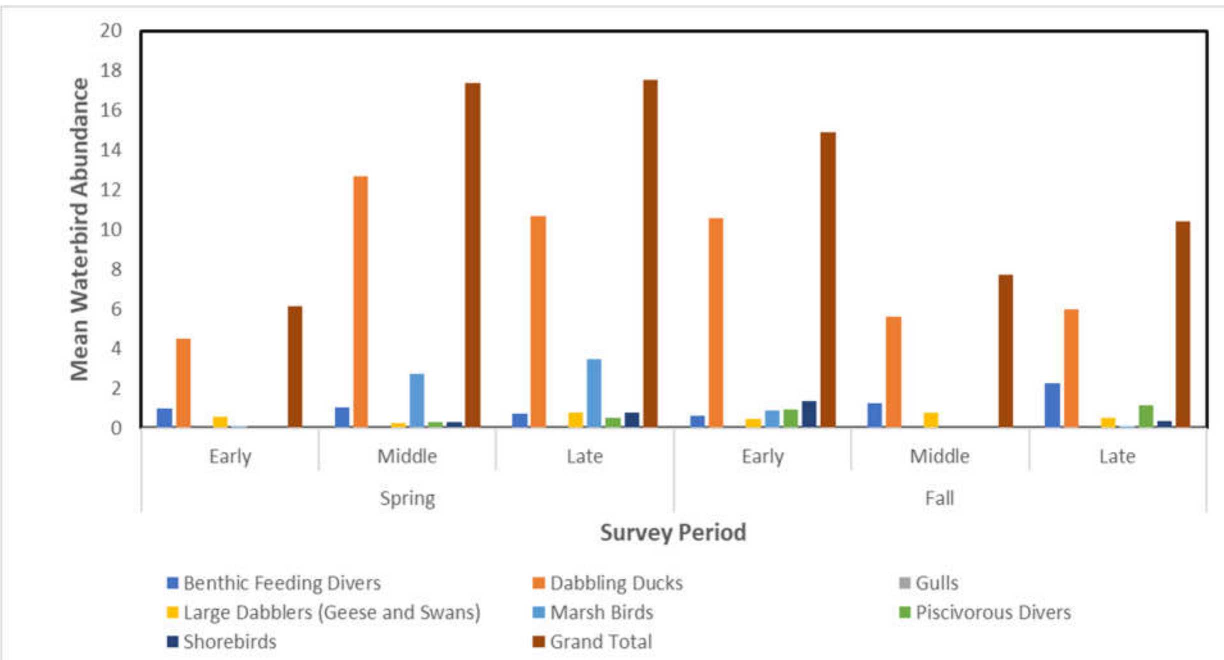

Figure 17 Mean relative abundances (per survey) of waterbird foraging guilds from wetland surveys on the transmission line route (transect 5) during spring and fall

Waterbirds were observed in every wetland type surveyed. All foraging guilds were present on the transmission line wetlands, but only one individual gull was observed, a Franklin's gull (*Larus pipixcan*), on Open Water habitat in the spring survey. Open Water wetland habitat had the most waterbirds in both the spring and fall migration periods (**Tables 22 and 23**). Sedge and Willow Sedge wetland habitats had the next highest number of waterbirds. In spring, Open Water and Willow Sedge habitats accounted for 45% (mean = 46.4) and 33% (mean = 33.5), of the total number of waterbirds observed, and combined represent more than three-quarters of the overall mean abundance of waterbirds (**Table 22**). Waterbird observations in open water habitat during the fall monitoring period accounted for 65% of all detections with a mean relative abundance of 74.4, while waterbird observations in Willow Sedge habitat made up 17% (mean = 19.5) of the total fall mean abundance (**Table 23**).

Table 22 Mean relative abundance of waterbirds (spring) by wetland type and foraging guild

Foraging Guild	Habitat Type				Overall Mean
	Open Water	Sedge	Tamarack Sedge	Willow Sedge	
Benthic Feeding Divers	4.5	0.3	0.0	0.5	5.3
Dabbling Ducks	33.4	14.5	0.0	17.0	64.9
Gulls	0.1	0.0	0.0	0.0	0.1
Large Dabblers	2.4	0.4	0.0	0.5	3.3
Marsh Birds	3.4	4.9	1.5	14.0	23.8
Piscivorous Divers	1.5	0.1	0.0	0.0	1.6
Shorebirds	1.1	0.4	1.0	1.5	4.0
Grand Total	46.4	20.5	2.5	33.5	102.9

Table 23 Mean relative abundance of waterbirds (fall) by wetland type and foraging guild

Foraging Guild	Habitat Type				Overall Mean
	Open Water	Sedge	Tamarack Sedge	Willow Sedge	
Benthic Feeding Divers	15.0	0.1	0.0	0.5	15.6
Dabbling Ducks	42.8	16.2	0.0	15.0	74.0
Gulls	0.0	0.0	0.0	0.0	0.0
Large Dabblers	6.0	0.2	0.0	0.0	6.2
Marsh Birds	0.8	0.7	0.0	4.0	5.5
Piscivorous Divers	7.8	0.0	0.0	0.0	7.8
Shorebirds	2.0	2.0	1.0	0.0	5.0
Grand Total	74.4	19.2	1.0	19.5	114.1

Bioacoustic monitoring with ARU devices detected sora at all six survey locations but yellow rail and American bittern were not detected.

4.3.2 Diversity

Species diversity was highest during the late spring and late fall migration periods (**Table 24**). Dabbling ducks, in addition to having the highest abundance (**section 4.4.1**), had the highest diversity of the foraging guilds. Mallards, blue-winged teal, green-winged teal, bufflehead and sora were the most-frequently observed species, and the most-abundant. Three species at risk, all in small numbers were observed; Franklin's gull, and horned (*Podiceps auratus*) and eared (*Podiceps nigricollis*) grebes.

Table 24 Diversity of waterbird foraging guilds in spring and fall 2017 during wetland surveys

Foraging Guild	Mean species richness (# of species) by season and survey period								
	Spring			Spring Total	Fall			Fall Total	2017 Total
	Early	Middle	Late		Early	Middle	Late		
Benthic Feeding Divers	2	1	2	2	2	2	2	2	2
Dabbling Ducks	6	8	8	11	6	6	7	11	12
Gulls	0	1	0	1	0	0	0	0	1
Large Dabblers	1	2	1	2	2	1	1	2	2
Marsh Birds	1	2	2	2	2	2	1	2	2
Piscivorous Divers	0	3	2	3	4	3	0	5	6
Shorebirds	0	4	3	5	3	2	0	4	5
Total Species Richness	**10**	**21**	**18**	**26**	**19**	**16**	**11**	**26**	**30**
Species Evenness	**0.35**	**0.30**	**0.40**	**0.32**	**0.34**	**0.27**	**0.50**	**0.35**	**0.33**
Shannon-Weiner Index	**0.79**	**0.90**	**1.16**	**1.04**	**1.01**	**0.74**	**1.21**	**1.13**	**1.12**

Open Water wetland habitat supported the greatest species diversity during spring (SWI = 1.02, **Table 25**) and fall (SWI = 1.23, **Table 26**). Willow Sedge was the second-most diverse habitat for waterbirds in both spring (SWI = 0.97, **Table 25**) and fall (SWI = 0.62, **Table 26**).

Table 25 Spring waterbird foraging guild diversity, in habitat types, during wetland surveys

Foraging Guild	Mean species richness (# of species) by habitat type				
	Open Water	Sedge	Tamarack Sedge	Willow Sedge	Total
Benthic Feeding Divers	2	1	0	1	2
Dabbling Ducks	10	8	0	7	11
Gulls	1	0	0	0	1
Large Dabblers	2	2	0	1	2
Marsh Birds	2	2	1	2	2
Piscivorous Divers	3	1	0	0	3
Shorebirds	4	3	1	3	5
Total Species Richness	**24**	**17**	**2**	**14**	**26**
Species Evenness	**0.32**	**0.29**	**0.97**	**0.37**	**0.33**
Shannon-Weiner Index	**1.02**	**0.82**	**0.67**	**0.97**	**1.06**

Table 26 Fall waterbird foraging guild diversity, in habitat types, during wetland surveys

Foraging Guild	Mean species richness (# of species) by habitat type				
	Open Water	Sedge	Tamarack Sedge	Willow sedge	Total
Benthic Feeding Divers	2	1	0	1	2
Dabbling Ducks	9	6	0	4	11
Gulls	0	0	0	0	0
Large Dabblers	2	1	0	0	2
Marsh Birds	1	2	0	2	2
Piscivorous Divers	5	0	0	0	5
Shorebirds	2	3	1	0	4
Total Species Richness	**21**	**13**	**1**	**7**	**26**
Species Evenness	**0.40**	**0.22**	**-**	**0.32**	**0.37**
Shannon-Weiner Index	**1.23**	**0.57**	**0.00**	**0.62**	**1.19**

- = insufficient observations to calculate richness indices.

4.3.3 Variance Estimates

Across the spring and fall migration periods the numbers of benthic feeding divers, dabbling ducks, and large dabblers was relatively consistent, but the numbers of marsh birds, piscivorous divers, gulls and shorebirds species was more variable (**Table 27**). Foraging guilds generally showed more variability in numbers during the spring than the fall, and overall variance was higher during the spring (CV = 0.2) compared to fall (CV = 0.1).

Table 27 Summary abundance and variance statistics for waterbird foraging guilds detected on the wetland point count surveys during spring and fall migrations

Foraging Guild	Spring (3 survey periods)			Fall (3 survey periods)		
	Mean	SD[1]	CV[2]	Mean	SD[1]	CV[2]
Benthic Feeding Divers	2.0	0.2	0.1	4.1	0.8	0.2
Dabbling Ducks	20.9	4.3	0.2	21.4	2.8	0.1
Gulls	0.1	0.0	0.8	0.0	0.0	0.0
Large Dabblers	1.2	0.3	0.2	1.7	0.2	0.1
Marsh Birds	4.9	1.8	0.4	1.0	0.5	0.5
Piscivorous Divers	0.7	0.3	0.4	2.1	0.6	0.3
Shorebirds	0.9	0.4	0.5	1.7	0.7	0.4
Total	**30.4**	**6.5**	**0.2**	**31.8**	**3.6**	**0.1**

[1] SD - Standard Deviation; [2] CV - Coefficient of Variation (CV = SD/Mean)

5.0 DISCUSSION AND RECOMMENDATIONS

5.1 HABITAT ASSESSMENTS

Habitat data associated with waterbird observations were obtained during surveys to provide habitat characteristics associated with each waterbird observation. Interpretations of these observations have been presented in association with the relative abundance and diversity results below.

Flow data from the Peace River for each of the three treatment areas demonstrated that surveys were conducted under flow rates that are representative of the spring and fall migration periods. Flow data may influence waterbird abundances and / or diversity, and will be considered in the future in models used to analyse the relative abundance and diversity of waterbirds within habitat types.

While TEM-based mapping has been conducted for the study area, such mapping does not include landform information pertinent to waterbird presence on the Peace River. Mapping of Peace River reaches into landform categories in 2017 delimited four types of reaches (i.e., Off-channel, Islands, Mainstem, and Confluence), each of which is present in various proportions in the three treatment areas (see **Table 4**). Future re-mapping of the reaches will provide comparisons of habitat availability relative to project-related changes. The presence of waterbirds within each of the reach types across the two seasons is presented in **Section 5.2**.

Collectively, these habitat data provide the information required to support future analyses examining the influence of habitat factors on waterbird abundance and diversity. The more-precise waterbird habitat associations collected in 2017 improve on the data available prior to 2017, where bird observations were recorded within 5 km segments and were not associated with habitat characteristics. Additional habitat data on the Peace River were also identified as potentially useful for analyses. Specifically, river bank steepness and the height of shoreline vegetation could affect the abundance and distribution of fish and other prey as well as the safety of habitat for waterbirds from predators.

5.2 PEACE RIVER WATERBIRD SURVEYS (TRANSECT 1)

Boat and UAV surveys of the Peace River provided estimates of relative abundance and diversity throughout the spring and fall migrations of 2017 as per the requirements for achieving the monitoring objectives (**Section 1.2**). All target taxa, including shorebirds, were observed during boat surveys, and UAV surveys enabled access to backchannel habitat. Over 90% of waterbird observations were identified to species and 38 distinct species were enumerated. These results demonstrate a clear improvement over fixed-wing aerial surveys which failed to detect shorebirds during previous surveys of the Peace River, and in 2016 were only able to identify 80% of observations to species; eight species during spring, and 13 in fall (Hemmera 2016). In 2015, nine species were identified and 75% of observations were identified to species (Mushanski et al 2015, 2016). In 2006 and 2008 combinations of aerial, ground and boat surveys documented 59 species of waterbirds, but over a much larger study area than used in the 2017 surveys (EIS, appendix R, part 4).

The majority of shorebird observations were from boat surveys, indicating that shorebird detection rates in the backchannels using the UAV platform might be relatively low. Future UAV surveys will be conducted at lower elevations and flight speeds in an attempt to increase the detection of shorebirds, particularly during the late spring, early fall, and mid fall survey periods when shorebird abundances were highest in parts of the river surveyed by riverboat.

Waterbird abundance on the Peace River is highest during the early spring, likely because wetland habitat and smaller tributary rivers in other parts of the region are frozen at this time and not available for foraging use by waterbirds. Blood (1979) noted that early migrating swans made considerable use of the river in early spring when the surrounding lakes were still frozen. This observation was confirmed in 2017; during reconnaissance surveys snow and frozen conditions appeared to limit waterbird use of wetlands adjacent to the transmission line (transect 5) in early spring. The transmission line wetland surveys (**Section 5.4**) noted an increase in waterbird relative abundance and diversity at the end of the spring migration period; possibly as birds using the Peace River move to wetlands on the Moberly Plateau. Future Peace River surveys will continue to be conducted during early spring to document waterbirds using the Peace River and future reservoir area (i.e., Inundation Impact area) during the early migration. Ice formation in the reservoir, as identified during the EIS, poses a risk to availability of these habitats for waterbirds.

While waterbird numbers were highest during early spring, waterbird diversity peaked during the middle and late spring. Thus, large numbers of fewer species (e.g., ducks and piscivorous divers) were present during the early spring migration, but greater diversity was observed later in the spring migration. Waterbird numbers were more consistent across the fall migration period than in the spring, when there was high variance in the numbers of waterbirds observed during each survey. There are no regular within-season waterbird survey data against which to compare these findings of temporal change in relative abundance and diversity, but monitoring from this program in future years will assess this trend.

Off-channel and Island reaches had the greatest abundance of waterbirds in both spring and fall of 2017, a finding consistent with that of Robertson (1999) who noted moderately productive waterfowl habitat in backchannels for mallards and dabbling ducks. Such reaches contain more vegetated habitat, which 2017 results show was used by more waterbirds than other substrate types on the Peace River. Although the results of the 2006 and 2008 surveys showed that the river (not backchannels) had the most observations of waterbirds (EIS, appendix R, part 4), this inconsistency between 2017 habitat data and the 2006/2008 habitat data could be related to the availability of UAV survey techniques that enable surveyors to access backchannels that the boats used in 2006 and 2008 could only infrequently access. A sample of backchannels was surveyed on foot in 2006 and 2008, but we anticipate that the coverage of backchannels was greater in 2017. Differences in habitat definitions / classifications between survey years, may also explain the discrepancy. For example, in 2017 gravel Confluence reaches were distinguished from Mainstem reaches, but in 2006 and 2008 there was no Confluence habitat classification. Ongoing surveys for the waterbird monitoring program will use habitat classifications consistent with the 2017 study and reduce uncertainties stemming from varied survey protocols across years.

Survey methods applied during the 2017 monitoring program were more successful in documenting shorebirds than for surveys conducted in previous years, with 493 individuals from 200 independent records reported across all surveys. The only abundant migratory shorebird on the Peace River was spotted sandpiper (*Actitis macularius*). The 423 spotted sandpipers observed comprised over 85% of all shorebirds and over 95% of those identified to species. This indicates that the Peace River is not used to a substantial extent by other shorebirds, and challenges the hypothesis that the Peace River supports substantial numbers of other migratory shorebirds (Blood et al. 1979).

The most common waterbird species observed on the Peace River in 2017 were Canada goose (5,580), mallard (2,743), Bonaparte's gull (*Chroicocephalus philadelphia*) (2,431), common merganser (*Mergus merganser*) (830), and northern pintail (*Anas acuta*) (603). A similar suite of species was observed from aerial surveys in 2016, where Canada goose comprised over 50% of the observed waterbirds, followed by bufflehead, American wigeon (*Anas americana*), common goldeneye (*Bucephala clangula*) and Franklin's gull. Aerial surveys between 1996 and 1999, and 1999 ground surveys found Canada goose comprised about 50% of observations (Robertson 1999, Robertson and Hawkes 2000). In 2006, Canada goose and Franklin's gull were the most commonly observed species (EIS, appendix R, part 4).

Observations of waterbirds from 2017 surveys of the Peace River are considered to have resulted in similar findings to those of earlier surveys, particularly for common and frequently observed species. The 2017 data, however, with regular surveys through the spring and fall periods, provide additional detail on the timing of peak abundances, variations in diversity across the two seasons, and more precise locations and habitat associations for the foraging guilds. With better location data, detecting the change in relative abundance and diversity of waterbirds relative to the habitat present and project-related changes (i.e., control vs impact areas) is achievable. Future analyses that seek to understand change are possible with these new data, and investigations to the species level are possible.

The following designated species at risk were observed during the surveys, as per provincial, *Species at Risk Act* (SARA), or Committee on the Status of Endangered Wildlife in Canada (COSEWIC) listings:

- California gull (*Larus californicus),* BC listing (Blue)
- Surf scoter (*Melanitta perspicillata*), BC listing (Blue)
- Horned grebe, COSEWIC (special concern (SC)), SARA (SC)

- Western grebe (*Aechmophorus occidentalis*), BC listing (Red), COSEWIC (SC), SARA (SC)
- Red-necked phalarope (*Phalaropus lobatus*), BC listing (Blue)

No species at risk were observed from 2015 or 2016 surveys. In addition to the species at risk observed in 2017, surveys in 2006 and 2008 over a wider study area also documented the following species at risk: tundra swan (*Cygnus columbianus*), American golden plover (*Pluvialis dominica*), cackling goose (*Branta hutchinsii*), Caspian tern (*Sterna caspia*), double-crested cormorant (*Phalacrocorax auritus*), great blue heron (*Ardea herodias*), long-tailed duck (*Clangula hyemalis*), upland sandpiper (*Bartramia longicauda*) and western grebe.

In 2018, minor changes to the survey methods are planned to be included in field studies; lower and slower UAV flights in the backchannels that are inaccessible to the river boat to increase the detection of shorebirds.

5.3 Aerial Waterbird Surveys (Transects 2 – 5) – Fixed-Wing Aircraft

Fixed-wing aircraft surveys provide estimates of relative abundance across the Moberly Plateau during the spring and fall migrations of 2017. Survey results provide some of the data required to meet the monitoring objectives (**Section 1.2**); however, as with aerial surveys in previous years, species identification could not be readily determined during aerial surveys, and some wetland habitats where waterbirds are expected had no observations. The surveys provide high-level abundance estimates and habitat association data for waterbirds across wetlands on transects 2-5 (Moberly Plateau), but the data have limitations for use in the program.

As expected based on historical trends of migration patterns, spring surveys of wetlands along transects 2-5 found the greatest waterbird abundances during the middle period (May 15) which is the peak of migration for most waterbirds in the Peace District (Siddle 2010) and lower abundances in the early (April 30) and late (June 1) surveys. In contrast, fall surveys documented the highest abundances during the early survey on September 4th. Two factors could explain the relatively low abundances during the middle portion of the fall survey period on September 19th:

- Fall surveys were not conducted until September due to weather constraints, and may have missed the true early migration period during August; and
- The middle survey was abbreviated when inclement weather in the west portion of the study area forced early abandonment, and therefore provided a lower estimate of abundance than if the entire survey had been conducted.

The majority of waterbirds observed during aerial surveys were associated with open water habitat. While this result was anticipated given that waterbirds spend much of their time and forage in open waterbodies, detection rates may also contribute to the differences in abundance across habitat types. Open water habitat provides clear lines of sight and waterfowl are more easily observed (i.e., higher detection rates) as compared to terrestrial or other wetland habitats where vegetation can obscure birds. Swans were especially easy to detect as the contrast of white plumage on a dark water surface allowed observers to detect them from greater distances. Trumpeter swans were also observed in relatively high numbers during 2015 fall (Mushanski et al 2015) and 2016 spring and fall aerial surveys (Mushanski et al 2016, Hemmera 2016). As with previous surveys using aerial platforms, waterbirds were difficult to identify to species; eight species were positively identified, but most were identified only to family. In fall 2015, 11 species were identifiable (Mushanski et al 2015), eight species were identified in spring 2016 (Mushanski et al 2016), and 14 species identified in fall 2016 (Hemmera 2016). The proportion of unidentifiable waterbirds ranged from 5.5% (spring 2015, Mushanski et al 2015) to 27.0% (spring 2016, Mushanski et al 2016). For 2017 the data are presented at the family level only.

The issues associated with these surveys suggest limited utility for achieving the monitoring objectives. The absence of waterbird observation data from wetland types other than open water habitat limits habitat representativeness, and the absence of road access away from the transmission line precludes the use of more sensitive ground-based survey types to access other wetland types. Observability, particularly for shorebirds but also for species-specific identification of waterbirds, limits the development of abundance and diversity metrics from these surveys. Only ten shorebirds have been observed during aerial surveys: nine in fall 2015 (Mushanski et al 2015) and one in fall 2016 (Hemmera 2016), and none identified to species. Lastly, the aerial survey platform provides less-precise habitat information associated with these waterbird observations as compared to that collected with ground or water-based methods. Given these limitations, and the availability of more-robust techniques described in this monitoring plan to survey waterbirds on the transmission line, it is recommended that the use of aerial surveys on the Moberly Plateau (transects 2- 4) be discontinued.

5.4 Transmission Line Wetland Surveys (Transect 5)

Wetland point count and ARU surveys successfully provided estimates of spring and fall relative abundance and diversity of waterbirds along the transmission line route in suitable wetland habitat types. Survey results provide the data required to meet the study's monitoring objectives (**Section 1.2**). A representative suite of sampling stations has been established, and consistent monitoring of these will be conducted in future years.

Some adaptations are required to improve the precision of the data collection for the study. Two habitat types were unable to be surveyed due to private land access restrictions, and alternative locations with practical access will be sought to achieve more representative sampling in 2018. One of the un-sampled wetland habitat types is Cultivated Fields, which are all on private lands, and the other is Labrador Tea Sedge wetlands, which were uncommon and inaccessible in the transmission line part of the study area. Incidental observations of cultivated fields in 2017 suggest that this wetland type hosted limited numbers of waterfowl in the spring when the fields were wet, but in the fall when fields were dry there were few to no waterfowl present. The lack of survey data from cultivated fields is not viewed as a limitation based on these observations, but BC Hydro continues to seek private land access to add this wetland type to the survey regime. The Labrador Tea Sedge wetland type comprises 7,243 ha of the study area and is the largest wetland type on the Moberly Plateau. However, no waterbird surveys were conducted in the Labrador Tea Sedge wetland type because it is not common on the transmission line route part of the Moberly Plateau, and there were private land access challenges in accessing the wetlands of this type that are present. Also, some mapped Labrador Tea Sedge wetlands that were accessible were found to be either not wetlands or were misidentified in the TEM as other wetland types. Incidental observations that were made within Labrador Tea Sedge wetlands suggest this habitat type hosts small numbers of Wilson's snipe (*Callinago gallinago*), but few other waterbirds.

Wetlands in the west end of the transmission line are not well-represented in the sampling regime. This reflects both the smaller area of wetlands in the west, and access limitations caused by several large rivers / ravines that are difficult to cross. Representativeness of habitat types (aside from the Cultivated Field and Labrador Tea Sedge wetlands) is achieved, but geographical representativeness is not. As the construction access routes are improved to the west of the transmission line route a more geographically representative sampling regime can be included in the study.

Thirty species were detected during wetland surveys in 2017, similar to the 24 species that were detected during transmission line surveys in 2008 (EIS, appendix R, part 4); the difference likely reflecting the increased repetition used for 2017 surveys. Dabbling ducks were the most commonly recorded foraging guild in wetlands on the transmission line, and mallards, blue- and green-winged teals and northern shoveler were among the most-numerous species observed. Bufflehead, a diving duck, and sora, a marshbird, were also commonly-observed. These observations were similar to findings from 2006 and 2008, when mallards and American wigeons accounted for 69% of the observations in wetlands (EIS, appendix R, part 4). Open water wetlands such as lakes and ponds had the greatest number of waterbird observations, and the highest diversity; mostly of dabbling ducks. Again, this is consistent with the 2006 – 2008 studies in the transmission line route area (EIS, appendix R, part 4). The timing of peak waterbird abundance and diversity is possibly linked to spring thaw and the Open Water habitats on the transmission line becoming available. This coincides with reduced numbers of waterbirds on the Peace River, suggesting waterbirds might switch from river to upland wetland locations in late spring.

Species at risk observed in low numbers during 2017 were Franklin's gull (BC status unknown), horned grebe (COSEWIC (SC), SARA (SC)) and eared grebe (BC blue). Species at risk observations from earlier studies on the transmission line cannot be compared with 2017 results because few were observed during aerial surveys, and the Peace River and transmission line observations of species at risk from the 2006 and 2008 ground and water based surveys (EIS, appendix R, part 4) are not presented separately.

Sora were detected in wetlands on the transmission line route, from both ARU and point counts surveys, but not yellow rail or American bittern. In 2006 - 2011 studies conducted for the EIS, sora were observed during formal point count and waterfowl surveys, and incidentally (EIS, appendix R, part 4), and yellow rail were identified in the Del Rio area (EIS, appendix R, part 4). No American bittern have been observed as part of Site C wildlife studies.

Wetland surveys on the transmission line in 2017 utilized a representative sampling regime that can be applied in future years, with adaptations to address habitat types and locations that cannot be surveyed at this time, as noted above. With the sampling sites for ongoing monitoring largely selected, the more-detailed habitat data collection (i.e., wetland field forms) can be conducted in 2018. The ARU for recording crepuscular / nocturnal observations successfully operated and recorded data and continuation of this method is proposed in 2018 and beyond. The addition of the UAV survey platform used successfully on the Peace River boat surveys is proposed as an addition to the wetland survey program. This observation technique will provide for better standardization of survey effort across habitats (5 ha survey stations, 20-minute surveys) because some survey stations have unstable floating vegetation and / or water channels that are hazardous or impossible to traverse on foot. This substantially limits the area that can be surveyed from the wetland edge, especially for the non-Open Water wetland habitats. UAV monitoring will improve observability across habitat types and will improve the habitat data associated with each observation.

6.0 CLOSING

This Report has been prepared by Hemmera, based on fieldwork conducted by Hemmera, for sole benefit and use by BC Hydro. In performing this Work, Hemmera has relied in good faith on information provided by others, and has assumed that the information provided by those individuals is both complete and accurate. This Work was performed to current industry standard practice for similar environmental work, within the relevant jurisdiction and same locale. The findings presented herein should be considered within the context of the scope of work and project terms of reference; further, the findings are time sensitive and are considered valid only at the time the Report was produced. The conclusions and recommendations contained in this Report are based upon the applicable guidelines, regulations, and legislation existing at the time the Report was produced; any changes in the regulatory regime may alter the conclusions and/or recommendations.

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APPENDIX A

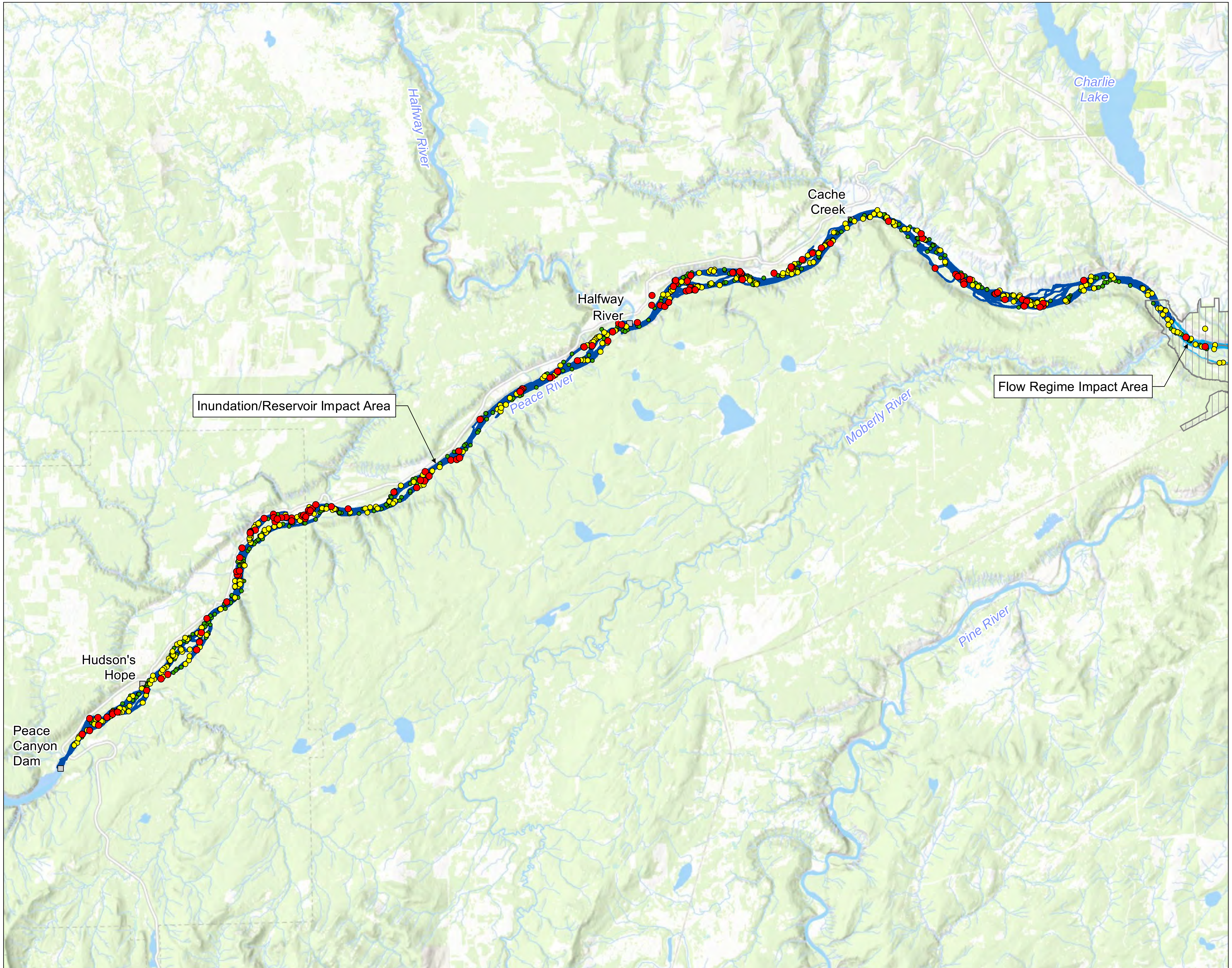
Waterbird Species List and Foraging Guild Categories

Foraging Guild	English Name	Scientific Name	BC List Status [a]	COSEWIC Status [b]	SARA Status [c]	Peace River Survey Abundance [d]	Transmission Line Wetland Survey Abundance [e]
Benthic Feeding Divers						**390**	**117**
	Common Goldeneye	*Bucephala clangula*	Yellow	-	-	264	10
	Unidentified Goldeneye	*n/a*	-	-	-	87	1
	Bufflehead	*Bucephala albeola*	Yellow	-	-	18	106
	Surf Scoter	*Melanitta perspicillata*	Blue	-	-	15	0
	White-winged Scoter	*Melanitta fusca*	Yellow	-	-	6	0
Dabbling Ducks						**4538**	**848**
	Mallard	*Anas platyrhynchos*	*Yellow*	-	-	2743	219
	Northern Pintail	*Anas acuta*	*Yellow*	-	-	603	4
	American Wigeon	*Anas americana*	*Yellow*	-	-	346	35
	Green-winged Teal	*Anas crecca*	*Yellow*	-	-	273	104
	Blue-winged Teal	*Anas discors*	*Yellow*	-	-	240	198
	Unidentified Teal	*n/a*	-	-	-	101	18
	Northern Shoveler	*Anas clypeata*	*Yellow*	-	-	94	74
	Unidentified Scaup	*n/a*	-	-	-	53	89
	Lesser Scaup	*Aythya affinis*	*Yellow*	-	-	32	4
	Gadwall	*Anas strepera*	*Yellow*	-	-	24	8
	Canvasback	*Aythya valisineria*	*Yellow*	-	-	15	4
	Redhead	*Aythya americana*	*Yellow*	-	-	7	3
	Ring-necked Duck	*Aythya collaris*	*Yellow*	-	-	4	52
	Cinnamon Teal	*Anas cyanoptera*	*Yellow*	-	-	2	0
	American Coot	*Fulica americana*	*Yellow*	*NAR (1991)*	-	1	36
Gulls						**3107**	**1**
	Bonaparte's Gull	*Chroicocephalus philadelphia*	*Yellow*	-	-	2431	0
	Unidentified Gull	*n/a*	-	-	-	396	0
	Ring-billed Gull	*Larus delawarensis*	*Yellow*	-	-	154	0
	Mew Gull	*Larus canus*	*Yellow*	-	-	94	0
	California Gull	*Larus californicus*	*Blue*	-	-	22	0
	Franklin's Gull	*Leucophaeus pipixcan*	*Unknown*	-	-	8	1
	Black-headed Gull	*Chroicocephalus ridibundus*	*Accidental*	-	-	2	0
Large Dabblers						**5641**	**55**
	Canada Goose	*Branta canadensis*	*Yellow*	-	-	5580	14
	Trumpeter Swan [f]	*Cygnus buccinator*	*Yellow*	*NAR (1996)*	-	61	41
Marsh Birds						**0**	**116**
	Wilson's Snipe	*Gallinago delicata*	*Yellow*	-	-	0	36
	Sora	*Porzana carolina*	*Yellow*	-	-	0	80
Piscivorous Divers						**919**	**54**
	Common Merganser	*Mergus merganser*	*Yellow*	-	-	836	9
	Barrow's Goldeneye	*Bucephala islandica*	*Yellow*	-	-	37	0
	Belted Kingfisher	*Megaceryle alcyon*	*Yellow*	-	-	20	0
	Red-necked Grebe	*Podiceps grisegena*	*Yellow*	*NAR (1982)*	-	17	4
	Common Loon	*Gavia immer*	*Yellow*	*NAR (1997)*	-	6	17
	Unidentified Tern	*n/a*	-	-	-	1	0
	Western Grebe	*Aechmophorus occidentalis*	*Red*	*SC (2014)*	*1-SC (2017)*	1	0
	Horned Grebe	*Podiceps auritus*	*Yellow*	*SC (2009)*	*1-SC*	1	3
	Unidentified Grebe	*n/a*	-	-	-	0	2
	Eared Grebe	*Podiceps nigricollis*	*Blue*	-	-	0	14
	Pied-billed Grebe	*Podilymbus podiceps*	*Yellow*	-	-	0	5
Shorebirds						**493**	**55**
	Spotted Sandpiper	*Actitis macularius*	*Yellow*	-	-	423	6
	Unidentified Shorebird	*n/a*	-	-	-	48	6
	Red-necked Phalarope	*Phalaropus lobatus*	*Blue*	*SC (2014)*	-	11	0
	Killdeer	*Charadrius vociferus*	*Yellow*	-	-	6	2
	Solitary Sandpiper	*Tringa solitaria*	*Yellow*	-	-	3	20
	Greater Yellowlegs	*Tringa melanoleuca*	*Yellow*	-	-	2	16
	Lesser Yellowlegs	*Tringa flavipes*	*Yellow*	-	-	0	5
Unknown Waterbirds						**1236**	**190**
	Unidentified Duck	*n/a*	-	-	-	1122	178
	Unidentified Waterbird	*n/a*	-	-	-	114	12
Grand Total						**16324**	**1436**

Notes:
[a] BC List: Red = species that are extirpated, endangered, or threatened; Blue = species of special concern; Yellow = all species not found on the red or blue lists; Accidental = Species occurring infrequently and unpredictably, outside their usual range.
Unknown = Uncertain whether the entity is native (Red, Blue or Yellow), introduced (Exotic) or accidental in BC
[b] COSEWIC: SC = Special Concern (a wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats); NAR = A species that has been evaluated and found to be not at risk.
[c] *SARA – Species at Risk Act*: Schedule 1 is the official list of wildlife species at risk in Canada. It includes species that are extirpated (extinct in Canada), endangered, threatened, and of special concern. SC = A species of special concern because of characteristics that make it is particularly sensitive to human activities or natural events.
[d] - Includes flying records as birds were often flushed to flight in front of boat.
[e] - Excludes flying records and those from stations where access was not permitted.
[f] - All swans were assumed trumpeter swans, but some proportion of tundra is likely based on documented presence of the species (eBird).

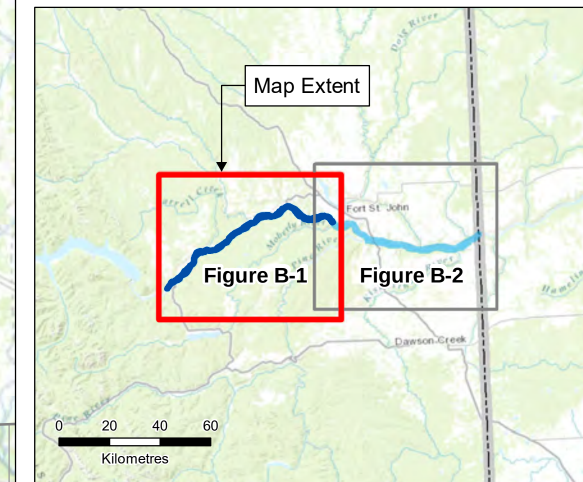
APPENDIX B

Number of Bird Observations in Peace River Study Area in Spring and Fall (Figures B-1 to B-4)



Migratory Waterbird Follow-up Monitoring Program
2017 Report
Site C, Peace River, BC

Inundation/Reservoir Impact Area
Spring



Legend

- Inundation/Reservoir Impact Area (3,637 hectares)
- Flow Regime Impact Area
- Proposed Dam Site

Number of Bird Observations

- 1-2 birds
- 3-9 birds
- 10 or more birds

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Basemap: ESRI World Topographic Base

N

1:220,000

0 5 10 15
Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

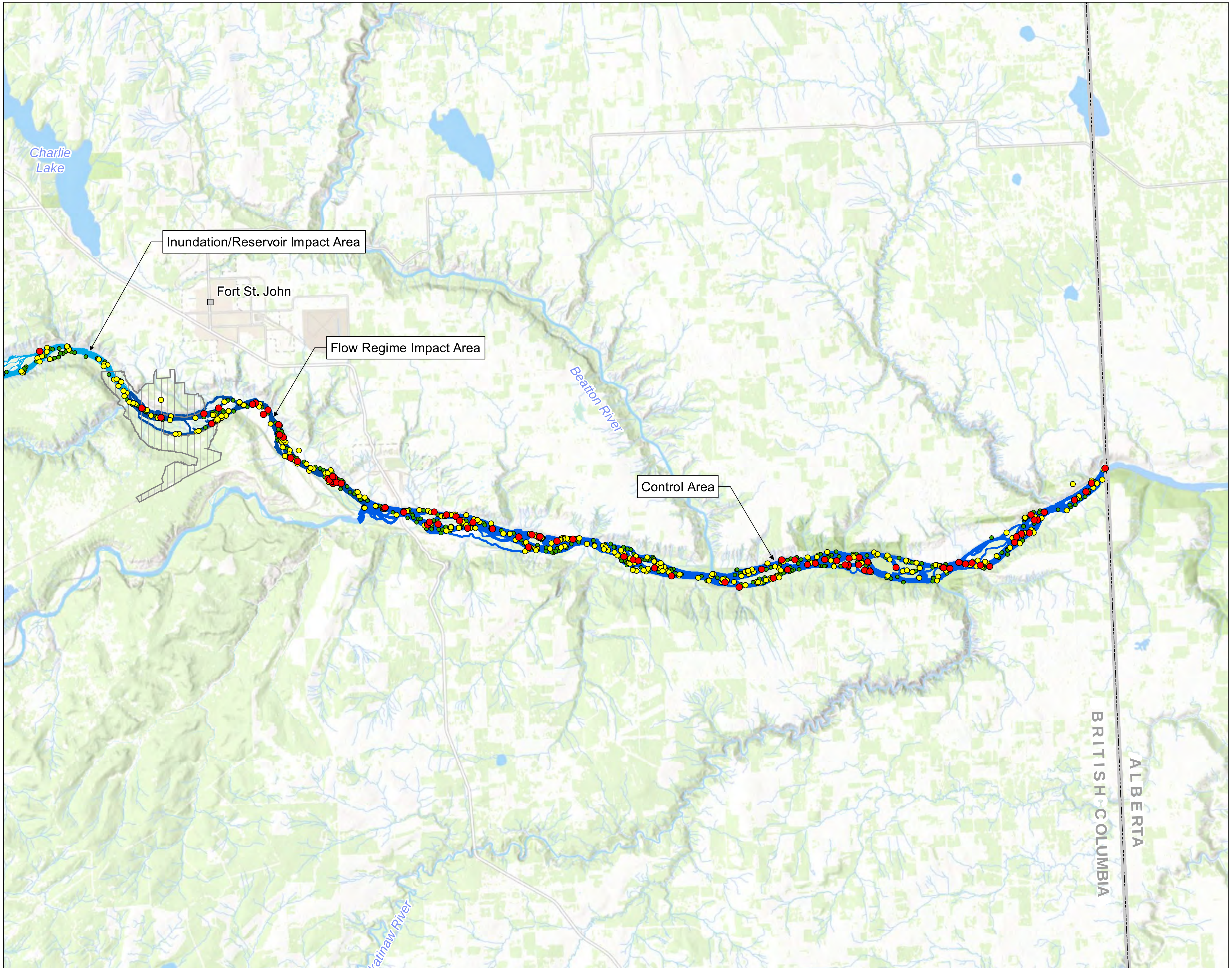
398-173.07	Production Date: Feb 28, 2018	Figure B-1

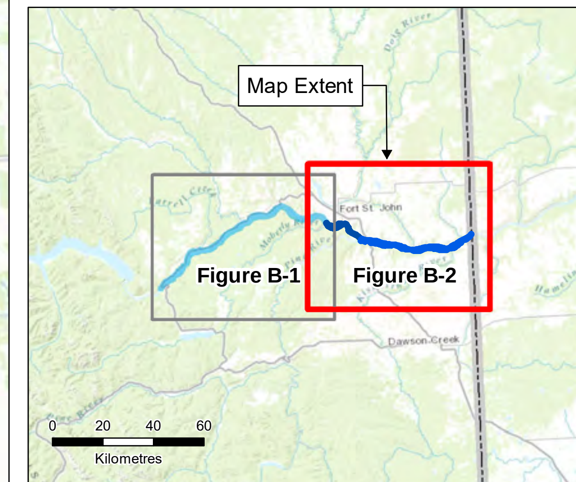
Hemmera An Ausenco Company

BC hydro

Migratory Waterbird Follow-up Monitoring Program
2017 Report
Site C, Peace River, BC

Flow Regime Impact Area and Control Area
Spring





Legend

- Flow Regime Impact Area (703 hectares)
- Control Area (2,909 hectares)
- Inundation/Reservoir Impact Area
- Proposed Dam Site

Number of Bird Observations

- 1-2 birds
- 3-9 birds
- 10 or more birds

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Basemap: ESRI World Topographic Base

N

1:220,000

0 5 10 15
Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

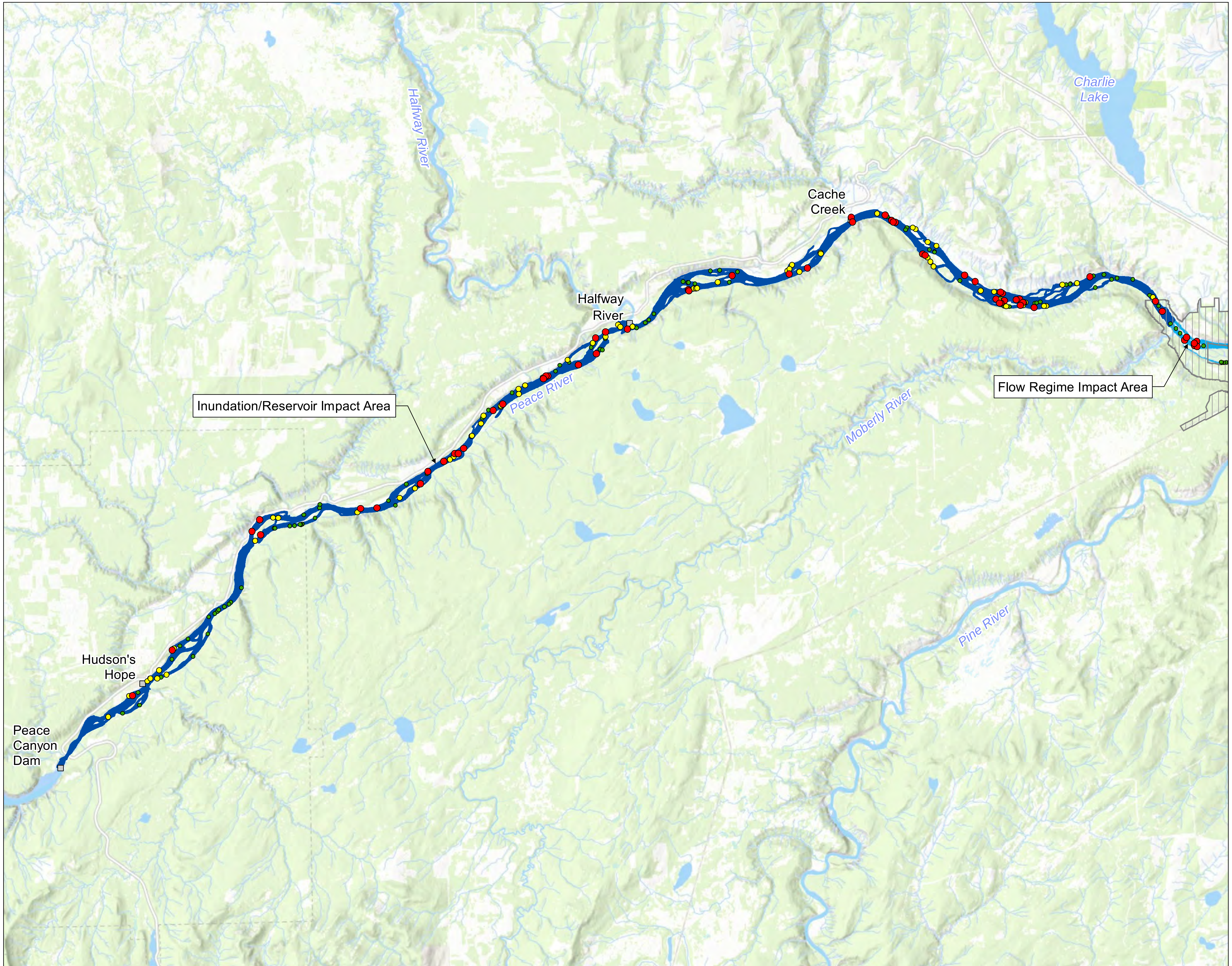
398-173.07	Production Date: Feb 28, 2018	Figure B-2

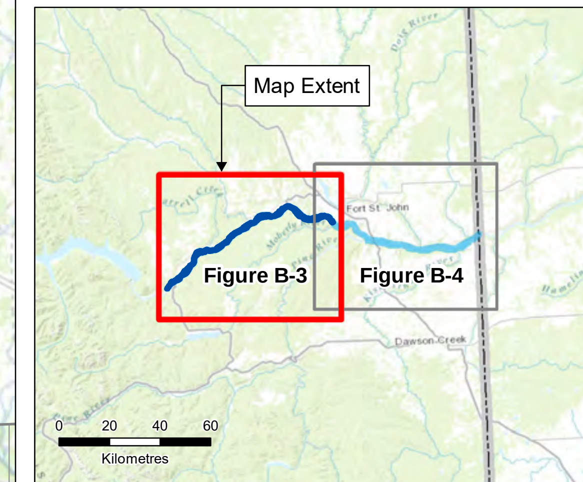
Hemmera
An Ausenco Company

BC hydro

Migratory Waterbird Follow-up Monitoring Program
2017 Report
Site C, Peace River, BC

Inundation/Reservoir Impact Area
Fall





Legend

- Inundation/Reservoir Impact Area (3,637 hectares)
- Flow Regime Impact Area
- Proposed Dam Site

Number of Bird Observations

- 1-2 birds
- 3-9 birds
- 10 or more birds

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a “stand-alone” document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Basemap: ESRI World Topographic Base

N

1:220,000

0 5 10 15
Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

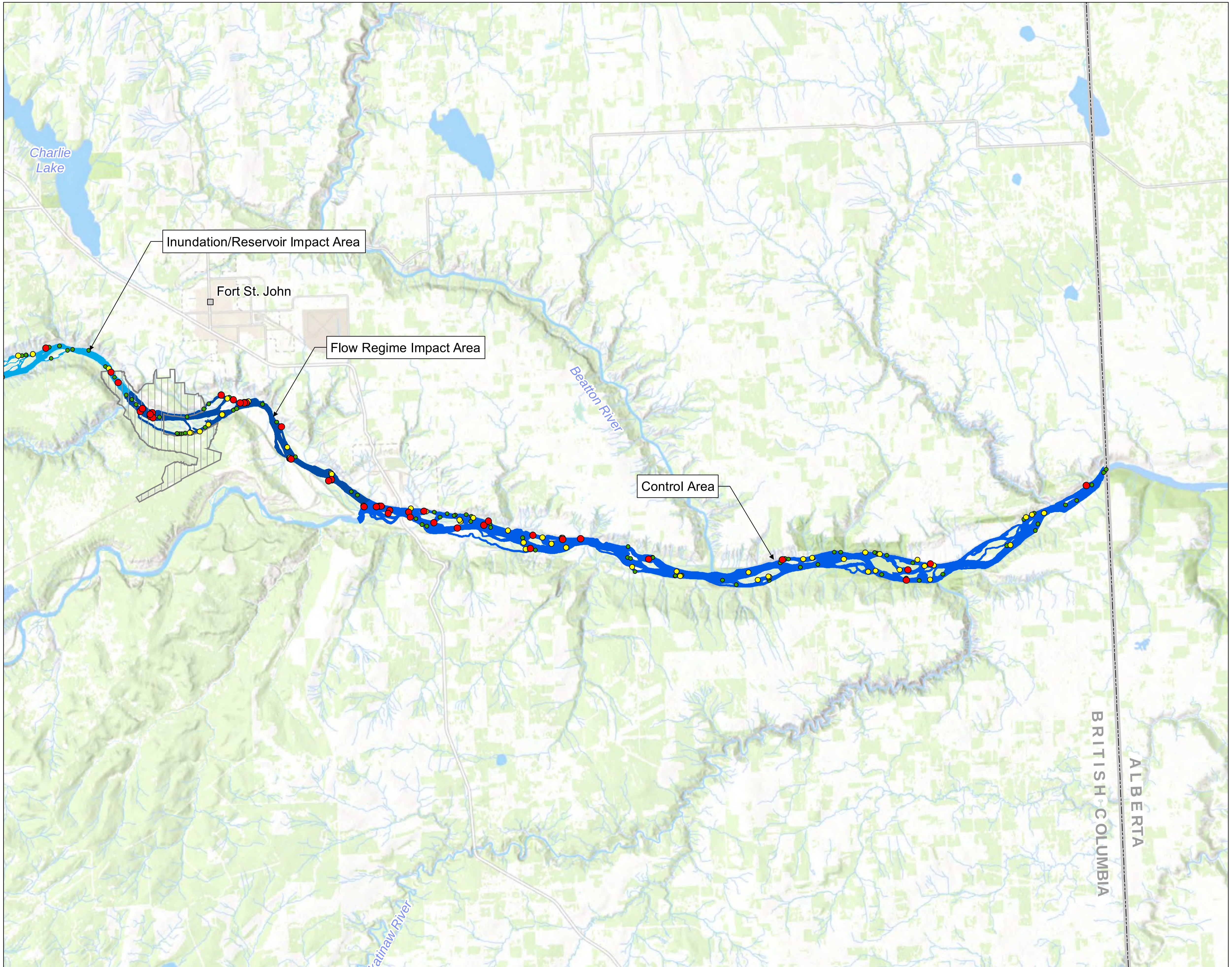
398-173.07	Production Date: Feb 28, 2018	Figure B-3

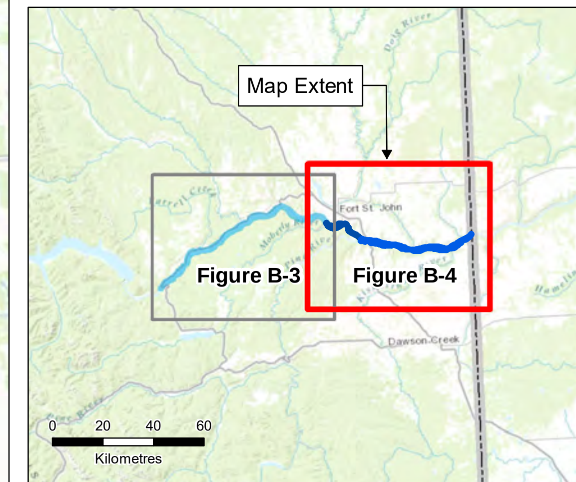
Hemmera An Ausenco Company

BC hydro

Migratory Waterbird Follow-up Monitoring Program
2017 Report
Site C, Peace River, BC

Flow Regime Impact Area and Control Area
Fall





Legend

- Flow Regime Impact Area (703 hectares)
- Control Area (2,909 hectares)
- Inundation/Reservoir Impact Area
- Proposed Dam Site

Number of Bird Observations

- 1-2 birds
- 3-9 birds
- 10 or more birds

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Basemap: ESRI World Topographic Base

N

1:220,000

0 5 10 15

Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

398-173.07	Production Date: Feb 28, 2018	Figure B-4

Hemmera
An Ausenco Company
BC hydro

APPENDIX C

Wetland Survey Effort by Survey Station

Wetland Type	Station ID	Spring			Fall			
		Early	Middle	Late	Early	Middle	Late	Grand Total
Open Water (OW)		**5**	**11**	**10**	**10**	**9**	**10**	**55**
	OW-02	1	0	0	0	0	0	1
	OW-04	1	2	2	2	2	2	11
	OW-06	1	2	2	2	2	2	11
	OW-07	0	2	2	2	2	2	10
	OW-12	0	0	0	2	2	2	6
	OW-14	0	0	0	2	1	2	5
	OW-30*	0	2	2	0	0	0	4
	OW-99	0	1	0	0	0	0	1
	TS-10*	2	2	2	0	0	0	6
Sedge (SE)		**5**	**11**	**15**	**18**	**17**	**18**	**84**
	OW-09	2	2	2	2	2	2	12
	OW-30*	0	0	0	2	2	2	6
	OW-42a	0	1	2	2	2	2	9
	OW-42b	0	1	2	2	2	2	9
	SE-06	0	0	2	0	0	0	2
	SE-08	1	2	2	2	2	2	11
	SE-99	0	2	2	2	2	2	10
	TS-09	1	2	2	2	2	2	11
	TS-10*	0	0	0	2	1	2	5
	WS-05	1	1	1	2	2	2	9
Tamarack Sedge (TS)		**2**	**2**	**0**	**2**	**2**	**4**	**12**
	TS-04	1	0	0	0	0	2	3
	WS-04	1	2	0	2	2	2	9
Willow Sedge (WS)		**3**	**4**	**4**	**4**	**4**	**4**	**23**
	OW-11	2	2	2	2	2	2	12
	SE-07	1	2	2	2	2	2	11
Total		**15**	**28**	**29**	**34**	**32**	**36**	**174**

*Field verified habitat changed between seasons due to wetting/drying of wetland

Appendix 5. Review of Site C *Erigeron pacalis* and *Rorippa calycina*

MEMORANDUM

To:	Brock Simons, MSc, RPBio (BC Hydro)
From:	Randy Krichbaum, MSc, RPBio, PBiol (Eagle Cap Consulting Ltd)
Date:	October 24, 2017
Re:	Review of Site C *Erigeron pacalis* and *Rorippa calycina* issues

Introduction

As rare plant mitigation efforts for the Site C Project have progressed, two species in particular have proved challenging to address: *Rorippa calycina* (persistent-sepal yellowcress) and *Erigeron pacalis* (Peace daisy). Despite repeated efforts by project botanists to locate the previously reported occurrences of these two species in the Project area, no individuals of either taxa have been found.

This memorandum summarizes the current state of knowledge regarding the two species, and describes efforts made to verify occurrences in the Project area. In addition, recommendations for future mitigation options are presented.

Persistent Sepal Yellowcress (*Rorippa calycina*)

Background

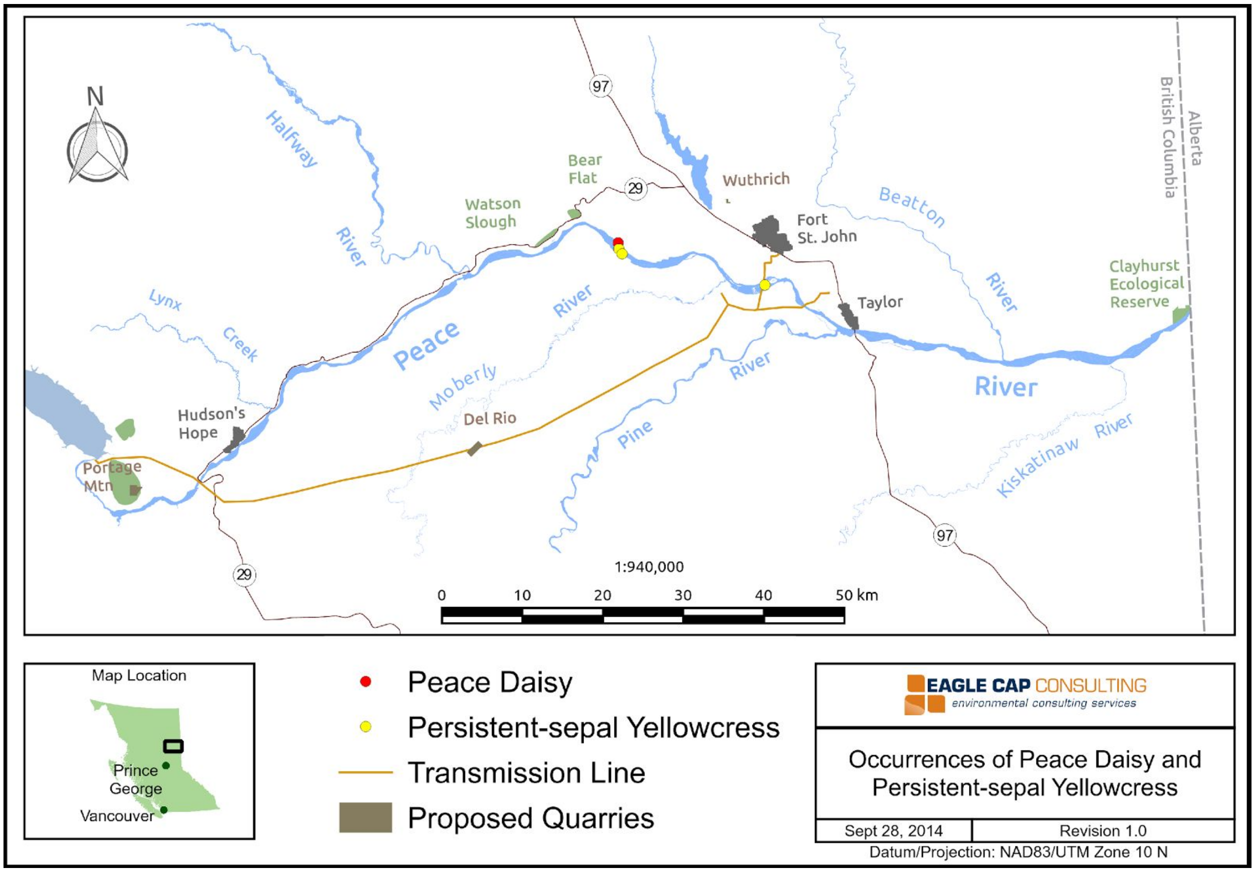
Persistent-sepal yellowcress is a spreading perennial herb in the *Brassicaceae* (mustard family). The species grows along streams and around lakes, reservoirs, and ponds (Al-Shehbaz 2010). Persistent-sepal yellowcress is currently known only from Wyoming, although historical records of the taxon exist from Montana, North Dakota, and Nebraska. A disjunct occurrence has also been documented in the Northwest Territories (Al-Shehbaz 2010; NatureServe 2017).

Three occurrences of persistent-sepal yellowcress were documented in the Site C Local Assessment Area (LAA) during Project-specific rare plant surveys conducted in 2008. The occurrences were mapped along the right bank of the Peace River between Bear Flat and the confluence of the Pine River (Figure 1). Each site was estimated to be 10 square metres in size, and to contain from 1–50 individuals (Abundance Class A). The persistent-sepal yellowcress plants were reportedly growing on open gravel bars with other herbs. Prior to these surveys, the species was not known from BC, and was therefore not assigned a status by the BC Conservation Data Centre (BCCDC).

In 2013 the BCCDC assigned persistent-sepal yellowcress a provincial ranking of S1S2, and placed the taxon on the Province's Red list (species that have, or are candidates for, Extirpated, Endangered or Threatened status in BC). In 2015, the provincial rank of the species was revised to S1 (Critically

Imperilled). The global rank of persistent-sepal yellowcress is G3 (Vulnerable), and all reported subnational rankings confer some degree of rarity: S3 (Vulnerable) in Wyoming, S1 (Critically Imperilled) in Montana and Nebraska, and SH (Possibly Extirpated) in North Dakota. No rank has been provided by the Northwest Territories (NatureServe 2017).

Figure 1: Occurrences of Peace Daisy and Persistent-sepal Yellowcress reported in 2008



Subsequent Surveys

Since the initial reported discovery of the three persistent-sepal yellowcress occurrences, several botanists working on the Project have attempted to find the species at the three sites:

- In 2011, two botanists from Eagle Cap Consulting visited each of the three sites. Despite several hours of intensive search, only the common *Rorippa palustris* (marsh yellowcress) was found.
- In 2014, the same two botanists returned to the three sites, again searching intensively for several hours. As in 2011, only marsh yellowcress was found.

- In 2016, the same botanists re-visited each site searching for persistent-sepal yellowcress. Marsh yellowcress was the only *Rorippa* found.
- In 2017, one botanist under contract to EcoLogic Consultants visited all three sites. As with the previous surveys, only marsh yellowcress was found.

In addition, since 2008 numerous rare plant surveys have been conducted along the Peace River from Hudson's Hope to the Alberta border:

- In 2011 and 2012, botanists from Eagle Cap Consulting surveyed 21 transects in riparian zones along the Peace River within the Site C Project Area. No persistent-sepal yellowcress was found, although numerous populations of marsh yellowcress were observed.
- In 2014, botanists from Eagle Cap Consulting performed targeted surveys outside the Project Area in an attempt to find additional occurrences of persistent-sepal yellowcress. A total of 44 transects were walked along the Peace River between the dam site and the Alberta border. Numerous occurrences of marsh yellowcress were discovered, but no persistent-sepal yellowcress plants were found.
- In 2017, two botanists working with EcoLogic Consultants surveyed various areas along the Peace River as part of the rare plant mitigation program. As with the other surveys, they found many occurrences of marsh yellowcress, but no persistent-sepal yellowcress.

Discussion

Despite repeated intensive searches over several years by different surveyors, no trace of the three 2008 persistent-sepal yellowcress occurrences could be found. There are several possible explanations for this:

- The three occurrences may have been extirpated by the extreme flood events which occurred in 2011. When these sites were visited in 2011 after the flooding, there was evidence of significant scouring and sediment deposition at all three sites. Vegetation had been washed away in places, and buried under sediment and gravel in others. If present, the yellowcress populations may have been extirpated during those flood events.
- The original identification of the persistent-sepal yellowcress may have been made in error. No voucher specimens have been located from the 2008 occurrences, and discussions with the botanist who made the original discovery have been inconclusive. A single high-resolution photo, presumably from one of the occurrences and titled, "*Rorippa calycina Peace River New to BC*", has been obtained and reviewed by the four botanists currently working on the Project. All four identified the plant in the photo as a common subspecies of marsh yellowcress (*Rorippa palustris* ssp. *hispida*).

- The repeated re-visits to the three sites may have overlooked the persistent-sepal yellowcress individuals, or they have been dormant underground. This is unlikely, however. While no rare plant survey can confirm absence of a species with 100% certainty, the searches have taken place over multiple years, by several botanists, during times of the year when the persistent-sepal yellowcress should have been identifiable. The surveys were intensive and sought to locate and identify all *Rorippa* individuals present. It is probable that if persistent-sepal yellowcress was still present at these sites, it would have been detected during at least one of the surveys.

Recommendations

At this point, the available evidence strongly suggests that the three persistent-sepal yellowcress occurrences reported in 2008 on the Peace River are not extant. Either they were originally misidentified, or they have been extirpated in the intervening years. Either way, additional attempts to locate the sites would likely prove futile, and survey effort should be directed toward other rare species with a greater chance of success.

Persistent-sepal yellowcress should, however, remain on the species target list for future Site C rare plant survey work. Although the potential for occurrence of the taxon in the Peace Region is low, it cannot be ruled out entirely. Future surveys should continue to consider persistent-sepal yellowcress as potentially occurring in suitable habitat.

Should additional evidence emerge, such as the discovery of valid voucher specimens from the 2008 occurrences, these recommendations would have to be reconsidered.

Peace Daisy (*Erigeron pacalis*)

Background

Peace daisy, characterized as a small upland perennial in the *Asteraceae* (sunflower family), was reported during Project-specific rare plant surveys in 2008. The species was first described formally in 2013 (Björk 2013). The only documented occurrence for Peace daisy is the type locality, above the left bank of the Peace River upstream from Wilder Creek.

Because only one small occurrence of Peace daisy has been reported globally, NatureServe assigns the species a G1 (Critically Imperilled) ranking (NatureServe 2017). Likewise, Peace daisy is ranked S1 (Critically Imperilled) by the BCCDC and is on the province's Red List (BCCDC 2017).

The single occurrence of Peace daisy is reported from grassland habitat on a dry south-facing slope above the Peace River (Figure 1). The occurrence was recorded as containing fewer than 50 individuals and covering an area of approximately 10 square metres.

Subsequent Surveys

Since the initial reported discovery of Peace daisy in 2008, several botanists working on the Project have attempted to find the species at the site:

- In the summer of 2014, two botanists from Eagle Cap Consulting visited the site and searched the area intensively for several hours. The growing season was particularly hot and dry in 2014, and the *Erigeron* individuals observed were well past their optimal identification period. Because of the advanced phenology, only inconclusive results could be gained. No definite Peace daisy individuals were found, although many plants that keyed to *Erigeron glabellus* var. *pubescens* (smooth daisy) were present.
- In 2016, the same botanists re-visited the site to search for Peace daisy. The summer was cooler and wetter than in 2014, and the *Erigeron* individuals in the area appeared to be within their optimal identification period. The two surveyors spent 4 hours at the site, and covered 5.7 km of survey transect. No Peace daisy plants were found. The *Erigeron* species present were keyed to smooth daisy.
- In 2017, botanists working with EcoLogic Consultants visited the site. They spent several hours searching the area, but again, no Peace daisy individuals were found, and the only *Erigeron* present was smooth daisy.

In addition, since 2008 numerous rare plant surveys have been performed in habitat thought to be suitable for Peace daisy:

- In 2011 and 2012, botanists from Eagle Cap Consulting surveyed numerous transects in grassland breaks along the Peace River within the Site C Project Area. No Peace daisy was found.
- In 2014, botanists from Eagle Cap Consulting performed surveys outside the Project Area in a targeted attempt to find additional occurrences of Peace daisy. Numerous transects were walked in grassland habitat along the Peace and Beatton Rivers between the dam site and the Alberta border. Again, no Peace daisy plants were found.
- From 2015 through 2017, botanists from Eagle Cap Consulting performed pre-construction rare plant surveys for the Site C project in grassland habitats along the Peace River. Peace daisy was not found during any of the surveys.
- In 2017, botanists working with EcoLogic Consultants surveyed various grassland areas along the Peace River, as part of the rare plant mitigation program. As with the other surveys, no Peace daisy individuals were found.

Discussion

Although the single Peace daisy site has been intensively surveyed by several different botanists in three different years since it was initially reported, no individuals have been found. There are several possible reasons for this:

- The longitude and latitude of the site as given in the original paper describing the species may be incorrect, so the subsequent surveys may have searched the wrong location. However, in 2016, two botanists spent more than four hours searching for Peace daisy in all suitable grassland habitat within 200 metres of the location given in the original paper, with negative results. It is possible that the coordinates given are more than 200 metres off however, and that the actual type locality has never been re-visited.
- The plants found in 2008 may not warrant status as a separate taxon. The specimens may have been diminutive individuals of a common *Erigeron* species stunted by drought stress or other environmental factors. *Erigeron glabellus* var. *pubescens* (smooth daisy) was found at the site, and has certain morphological similarities to those described for Peace daisy. The Peace daisy holotype specimen was examined at the UBC herbarium by three botanists currently working on the Site C Project, but no definitive conclusions about the validity of the taxon could be drawn without further research.
- The Peace daisy population may have been extirpated between its discovery in 2008 and the first revisit in 2014. The exact number of individuals in the population, as well as the actual size of the population in 2008, are unknown. The element occurrence data recorded in 2008 indicates that there were less than 50 individuals in a 10 square metre area. It is quite possible

that a small population like this could be extirpated by stochastic events or by low-level disturbance from a variety of sources.

Recommendations

It is unlikely that revisits to the site will locate any Peace daisy individuals. Multiple botanists have spent hours intensively surveying the site and surrounding habitats over several seasons without success. The population may have been extirpated, the locational information may be incorrect and the surveyors are looking in the wrong place, or the plants described as *Erigeron pacalis* in 2008 may have been misidentified at the time. In any case, returning to the site location, as it is currently understood, would likely not be productive.

Clarification on the location should be sought from the original botanist who discovered and described the taxon. At the same time, additional documentation (e.g. photos, field notes) could be requested to help clarify the taxonomy of the specimens.

In addition, the specimens should be investigated further to clarify the validity of the taxon. Genetic work, additional comparison with other *Erigeron* specimens, and discussions with *Erigeron* experts are all avenues that could be productive.

As with persistent-sepal yellowcress, Peace daisy should remain on the species target list for future Site C rare plant survey work. Future surveys should continue to consider Peace daisy as potentially occurring in suitable grassland habitat.

References

Al-Shehbaz, I.A. 2010. *Rorippa*. In: Flora of North America Editorial Committee ed. *Flora of North America North of Mexico*. New York, New York: Oxford University Press.

BC Conservation Data Centre (BCCDC) 2017. BC Species and Ecosystems Explorer [Online]. Available at: http://a100.gov.bc.ca/pub/eswp [Accessed: 20 October 2017].

Björk, C.R. 2013. *Erigeron pacalis* (Asteraceae), a New Species from Western Canadian Boreal Grasslands. *Novon: A Journal for Botanical Nomenclature* 22(3), pp. 271–275.

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