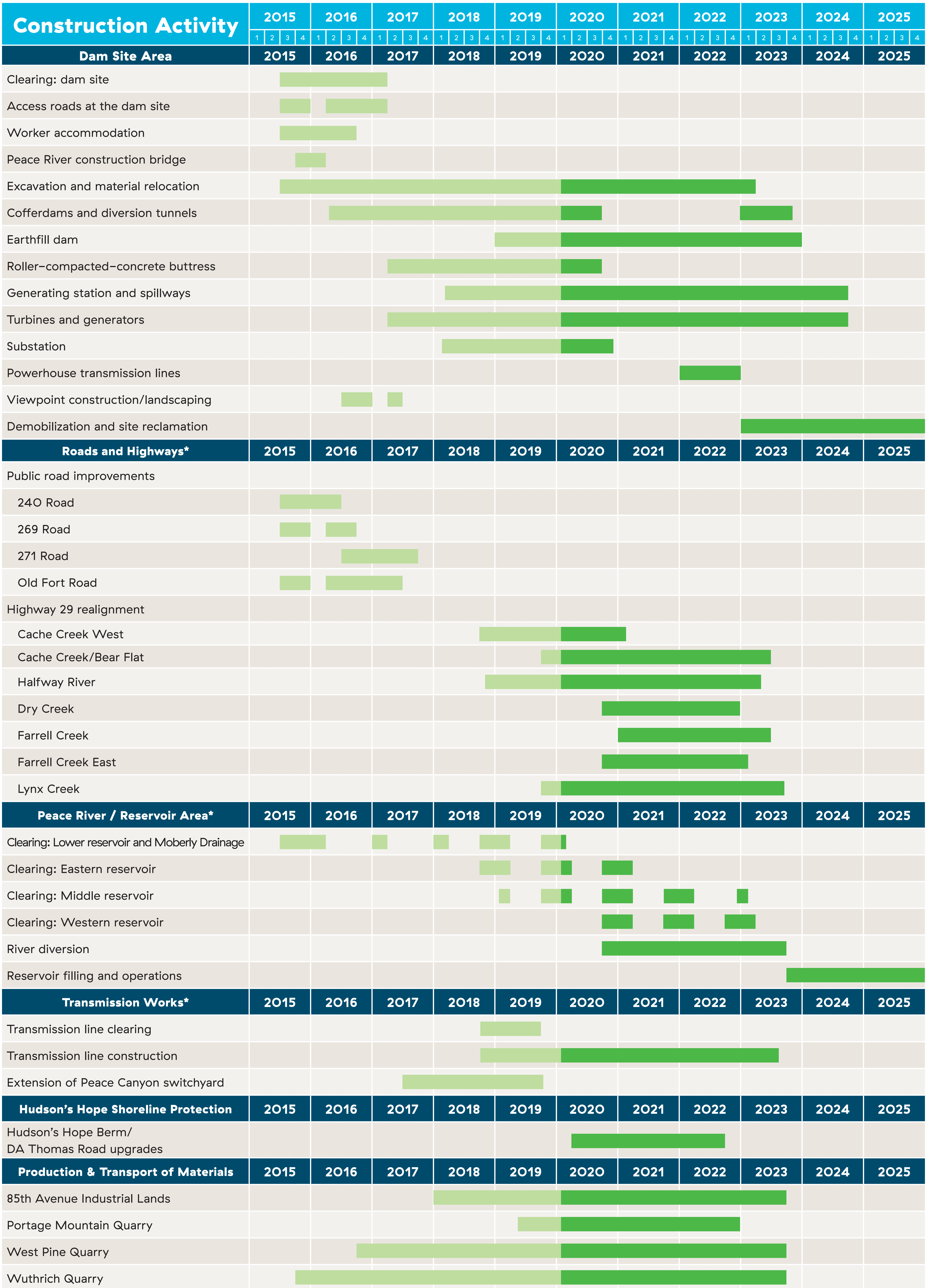
Appendix 1. Site C Clean Energy Project Construction Schedule

Site C Construction Schedule

February 2020
BCH20-176



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.

* Timelines do not include site preparation or wood disposal.

BC Hydro
Power smart

Appendix 2. Breeding Bird Follow-up Monitoring – Songbirds 2020 Annual Report

Site C Clean Energy Project
Breeding Bird Follow-up Monitoring – Songbirds
2021 Annual Report

PRESENTED TO

BC Hydro and Power Authority

JANUARY 14, 2022
ISSUED FOR USE
FILE: 704-ENW.PENW03042-02.SONG
REVISION 1

Saulteau EBA Environmental Services Joint Venture
Suite 1000 – 10th Floor, 885 Dunsmuir Street
Vancouver, BC V6C 1N5   CANADA
Tel 604.685.0275 Fax 604.684.6241

Site C Clean Energy Project Breeding Bird Follow-Up Monitoring - Songbirds 2021 Annual Report

FILE: 704-ENW.PENW03042-02.SONG
January 14, 2022

PRESENTED TO

Site C Clean Energy Project
BC Hydro and Power Authority
P.O. Box 49260
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PRESENTED BY

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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", the Project) in spring and summer 2021. The surveys were part of BC Hydro's Breeding Bird Follow-up Monitoring Program for songbirds[1]. Songbirds are passerines, hummingbirds, swifts, doves, kingfisher, and pigeons (i.e., all members of the orders *Passeriformes*, *Apodiformes*, *Columbiformes*, and *Coraciiformes*). Songbird baseline surveys were conducted in 2006, 2008, 2011 and 2012. Surveys were again conducted in 2016 through 2021 as part of the follow-up monitoring program. This report describes the methods used to conduct the 2021 surveys and a summary of the results.

Surveys were conducted June 3-24, 2021 at 103 stations in the Peace River Valley and around the Project footprint. Each station was surveyed two times to maximize the detection of early and late breeders. Birds were surveyed using unlimited-radius point counts.

A total of 92 bird species were detected, of which 76 were songbirds. Nine 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 median number of songbird species detected per point count survey was 8 (range 1 to 18).

Surveys conducted in 2021 represent a continuation in monitoring of semi-permanent monitoring stations that will be monitored through to 10 years post-construction.

[1] Woodpecker and Common Nighthawk surveys are also included under BC Hydro's Breeding Bird Follow-up Monitoring Program.

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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", the Project) in spring and summer 2021. The surveys were part of BC Hydro's Breeding Bird Follow-up Monitoring Program for songbirds[2]. Songbirds are passerines, hummingbirds, swifts, doves, kingfisher, and pigeons (i.e., all members of the orders *Passeriformes*, *Apodiformes*, *Columbiformes*, and *Coraciiformes*). Songbird baseline surveys were conducted in 2006, 2008, 2011 and 2012. Surveys were again conducted in 2016, 2017, 2018, 2019, 2020 and 2021 as part of the follow-up monitoring program.

The objectives of the Breeding Bird Follow-up Monitoring Program for songbirds are to:

1. Determine the distribution and abundance of songbirds within habitat lost or otherwise affected by the Project to verify the predictions made in the Environmental Impact Statement (EIS).
2. Identify species-habitat relationships to help identify areas for offsetting impacts.
3. Conduct effectiveness monitoring to determine the degree to which mitigation areas offset impacts to songbirds and their habitat and determine further songbird mitigation requirements.
4. Determine changes to the songbird community in the Peace River valley (to 10 years post-construction).

The annual report prepared in 2019 (SEES JV 2019) provided an analysis of the data collected 2006-2019 in support of objectives 1 and 2. Mitigation areas (currently the Marl Fen, Rutledge and Wilder Creek properties) were comprehensively surveyed in 2016 and 2017. BC Hydro intends to conduct the next comprehensive surveys of the mitigation properties when the reservoir has been inundated or when there are land-use changes or habitat modification in the mitigation properties, whichever occur first. The point count data obtained from surveys in 2021 were primarily in support of objective 4 and will form part of the long-term monitoring data to assess changes in the songbird community over time (baseline to 10 years post-construction).

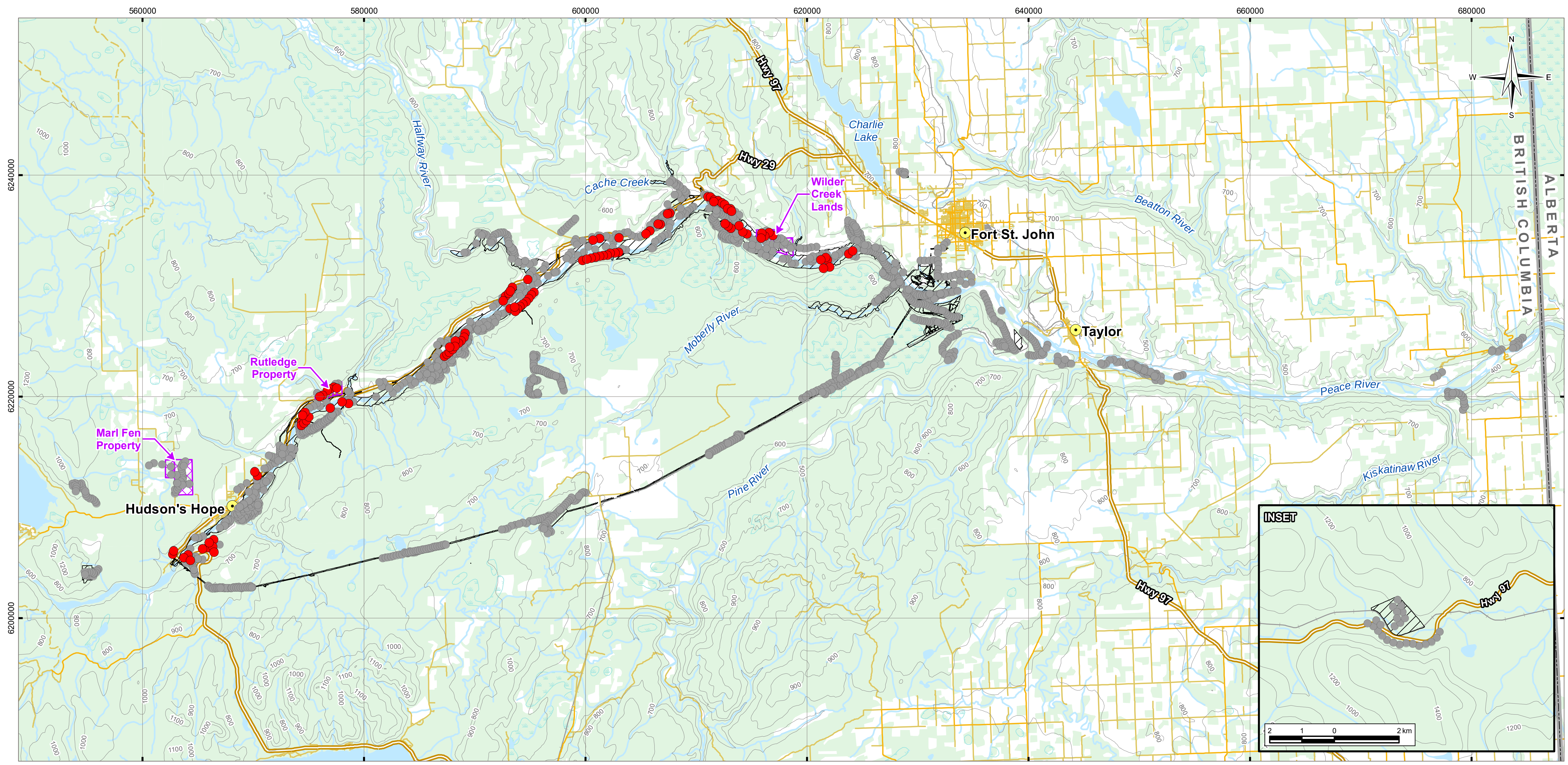
2.0 METHODS

2.1 Survey Locations

Point counts for the baseline and the follow-up monitoring programs have been conducted throughout the Peace River valley (and its tributaries) and in the adjacent plateau areas, both inside and outside the Project footprint (Figure 1). Clearing of the dam site area was completed in 2016. Clearing of the reservoir commenced in 2017 and has incrementally progressed westward from the dam site in each year. By May 2021, most portions of the reservoir footprint along the Peace River from the dam site to the mouth of the Halfway River, including the Moberly River and Cache Creek reservoir footprints, and some islands west of the Halfway River had been cleared [3]. Point counts in 2021 were predominantly located outside the reservoir footprint, though a small number were in cleared portions of the footprint and in the uncleared Watson Slough area.

[2] Woodpecker and Common Nighthawk surveys are also included under BC Hydro's Breeding Bird Follow-up Monitoring Program.

[3] The Watson Slough area along Highway 29 remains largely uncleared, with clearing planned the winter of 2022/2023.



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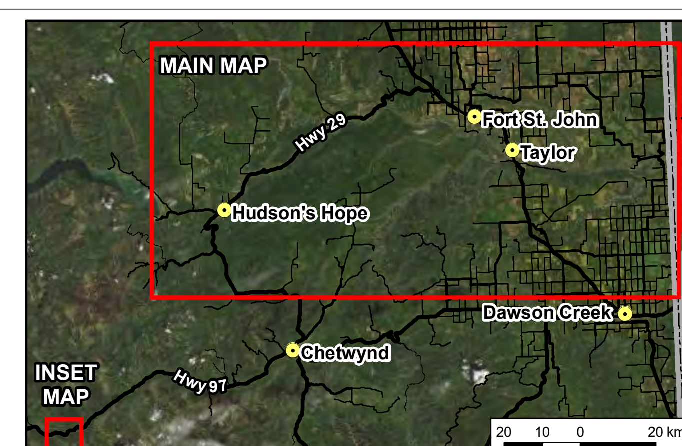
LEGEND

Songbird Survey Locations

Survey Year

- 2021
- 2006 to 2020
- Project Footprint
- Potential Mitigation Property
- Populated Place
- Highway
- Main Road
- Local Road
- Resource/Recreational Road
- Railway
- Residential Area
- Contour (100 m)
- Watercourse
- Waterbody
- Wetland
- Wooded Area
- Provincial Boundary



NOTES
Base data source: CanVec 1:250,000.

STATUS
ISSUED FOR USE

SITE C SONGBIRD 2021 ANNUAL REPORT

Songbird Survey Locations

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	BC Hydro Power smart

Scale: 1:350,000
5 2.5 0 5
Kilometres

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DATE	PROJECT NO.
November 8, 2021	ENW.PENW03042-02

Figure 1

Surveys conducted in 2021 represent a continuation of monitoring at the semi-permanent monitoring stations established in 2020. In 2020, 97 semi-permanent monitoring stations were established at randomly located points within the Peace River valley. Each station was located outside the reservoir footprint in accessible areas (slopes that can be traversed on foot) and stratified by bird habitat class in proportion to the mapped area of each class in the Peace River valley (see Section 3.0 for classes). Some survey stations were located within the Rutledge and Wilder Creek mitigation properties as these two properties are within the Peace River valley (the Marl Fen property is located outside the Peace River valley). Candidate locations were then manually adjusted to be 100 m from a habitat edge (e.g. forest-wetland transition) where possible and some locations were linked to form a sequence of survey locations that can be visited on foot. To allow for sampling of all bird habitat classes, some stations were located within uncleared portions of the footprint west of the Halfway River for bird habitat classes that do not exist outside the footprint (e.g., riparian forest that currently only exists in the valley bottom footprint).

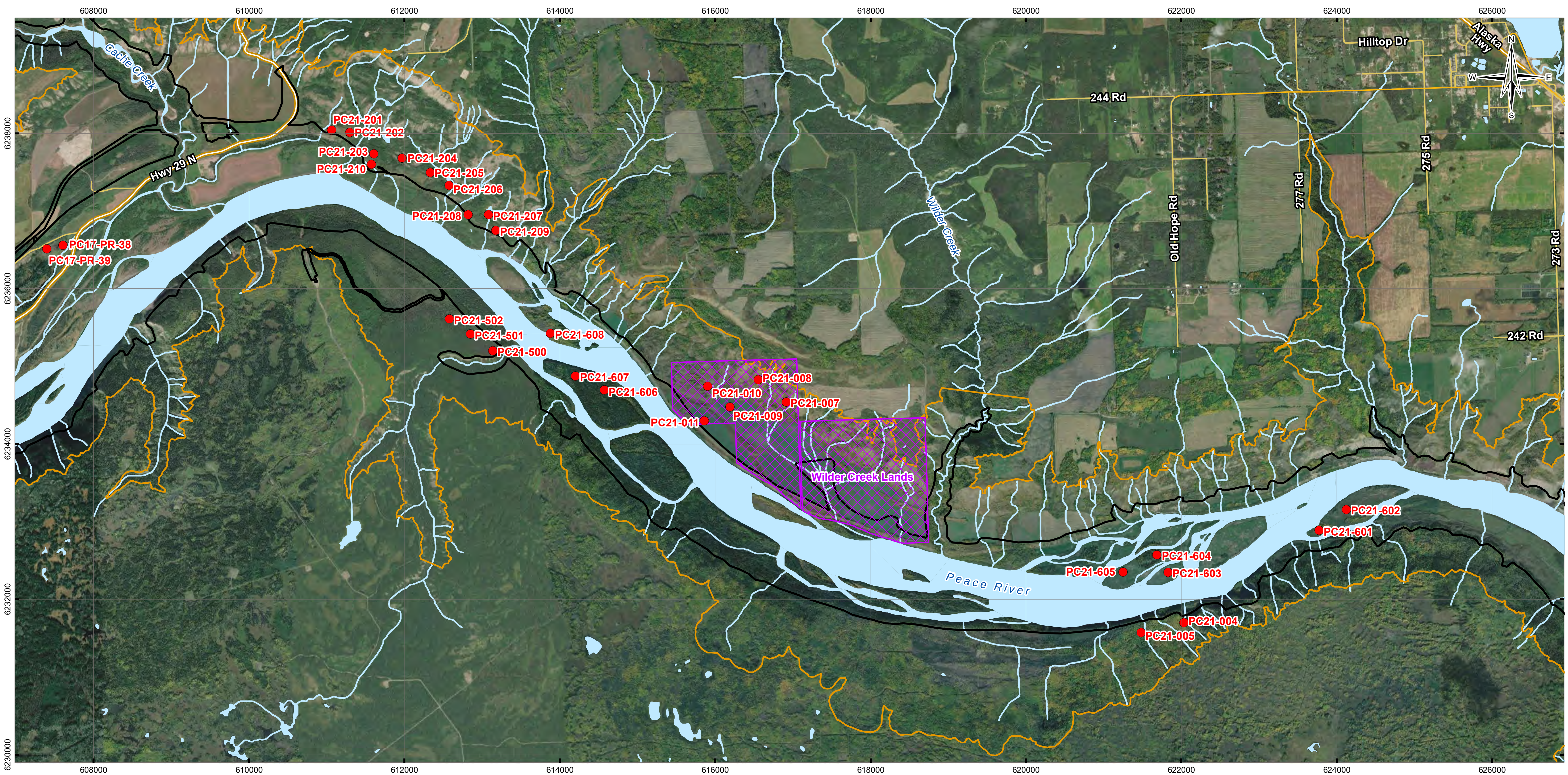
Eight of the 97 survey stations established in 2020 were not surveyed again in 2021 due to accessibility issues. Fourteen new survey stations were established in 2021 on cleared islands and at Watson Slough to provide a more accurate representation of the bird community in the Peace River Valley. In total, 103 stations were surveyed in 2021 (Figures 2a to 2d; Appendix A).

2.2 Point Count Surveys

Point counts were conducted on June 3-24, 2021 by two teams. Each team was composed of a biologist with songbird survey experience and an assistant (Appendix B). Each station was surveyed (visited) two times, with at least two weeks between visits, to maximize the detection of early and late breeders.

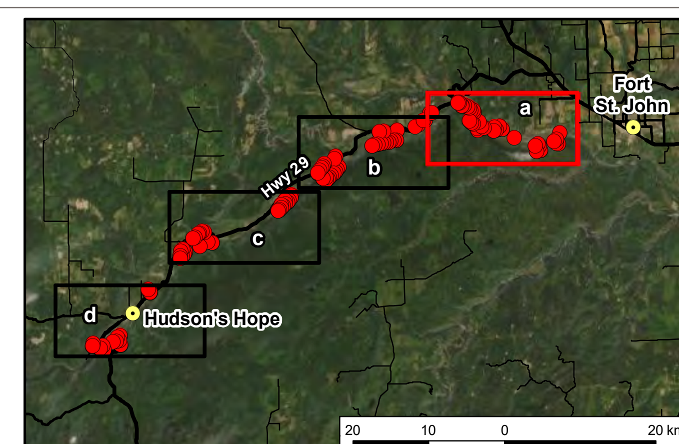
Point count surveys were conducted as unlimited-radius point counts with distance-to-detection intervals set at 0-50 m, 51-100 m and >100 m. Each point count survey was conducted over ten minutes and bird detections were recorded in three intervals: 0-3 minutes, 3-5 minutes and 5-10 minutes. Point counts took place from sunrise to approximately four hours after sunrise. After arriving at each station, the surveyor waited one minute, then commenced the 10-minute survey period and recorded all birds seen and/or heard. Data were recorded on a standardized data form.

Incidental observations were recorded when non-songbird species were observed during surveys, or when any bird species listed under the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) or *Species at Risk Act* (SARA) 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, date, time, GPS location, gender, behavior and habitat were recorded.



LEGEND

- 2021 Songbird Survey Location
- Project Footprint
- Potential Mitigation Property
- Peace River Valley
- Highway
- Main Road
- Local Road
- Watercourse
- Waterbody



NOTES
Base data source:
CanVec 1:50,000 (2019)
Imagery from ESRI; Maxar

STATUS
ISSUED FOR USE

SITE C SONGBIRD 2021 ANNUAL REPORT

2021 Songbird Survey Locations

PROJECTION	DATUM
UTM Zone 10	NAD83

Scale: 1:50,000
1 0.5 0 1
Kilometres

CLIENT: BC Hydro Power smart

TETRA TECH

FILE NO.
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OFFICE	DWN	CKD	APVD	REV
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DATE	PROJECT NO.
November 8, 2021	ENW.PENW03042-02

Figure 2a

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3.0 RESULTS AND DISCUSSION

Surveys were conducted in 15 bird habitat classes (Table 1). Each of the 103 point count stations were surveyed twice in June 2021 for a total of 206 surveys.

Table 1: Number of Songbird Point Count Stations and Surveys Conducted in 2021 by Bird Habitat Class

Bird Habitat Class	Stations	Surveys
Coniferous-shrub	4	8
Coniferous-young forest	8	16
Coniferous-mature forest	18	36
Deciduous-shrub	12	24
Deciduous-young forest	12	24
Deciduous-mature forest	13	26
Riparian-mixed shrub	8	16
Riparian-mixed young forest	3	6
Riparian-mixed mature forest	1	2
Fen/bog-shrub	2	4
Wetland-graminoid	3	6
Wetland-shrub	5	10
Dry slopes-grassland	2	4
Dry slopes-shrubland	8	16
Cultivated	4	8
Total	**103**	**206**

A total of 92 bird species were detected, of which 76 were songbirds (Table 2). Nine species listed under COSEWIC, SARA and/or British Columbia's Red and Blue lists were observed during the surveys. The median number of songbird species detected per point count survey was 8 (ranging from 1 to 18). Other bird species not classified as songbirds were recorded as incidental observations and are listed in Appendix C.

Surveys conducted in 2021 represent a continuation in monitoring of semi-permanent monitoring stations that will be monitored through to 10 years post-construction. In each future year, some stations may be lost to land use changes or access, and others will be added as needed to address the objective to characterize changes in the bird community of the Peace River Valley over time.

Table 2: Songbird Species Observed during the 2021 Point Count Surveys

English Name	Scientific Name	BC List	COSEWIC	SARA Status	Survey Detections
Northern Flicker*	*Colaptes auratus*	Yellow	-	-	2
Downy Woodpecker*	*Dryobates pubescens*	Yellow	-	-	2
Hairy Woodpecker*	*Dryobates villosus*	Yellow	-	-	3
Pileated Woodpecker*	*Dryocopus pileatus*	Yellow	-	-	3
American Three-toed Woodpecker*	*Picoides dorsalis*	Yellow	-	-	6
Yellow-bellied Sapsucker*	*Sphyrapicus varius*	Yellow	-	-	17
Olive-sided Flycatcher	*Contopus cooperi*	Blue	Special Concern	Threatened	11
Western Wood-Pewee	*Contopus sordidulus*	Yellow	-	-	31
Alder Flycatcher	*Empidonax alnorum*	Yellow	-	-	42
Pacific-slope Flycatcher	*Empidonax difficilis*	Yellow	-	-	4
Hammond's Flycatcher	*Empidonax hammondii*	Yellow	-	-	2
Least Flycatcher	*Empidonax minimus*	Yellow	-	-	125
Eastern Kingbird	*Tyrannus tyrannus*	Yellow	-	-	4
Warbling Vireo	*Vireo gilvus*	Yellow	-	-	30
Red-eyed Vireo	*Vireo olivaceus*	Yellow	-	-	169
Philadelphia Vireo	*Vireo philadelphicus*	Yellow	-	-	1
Blue-headed Vireo	*Vireo solitarius*	Yellow	-	-	8
American Crow	*Corvus brachyrhynchos*	Yellow	-	-	24
Common Raven	*Corvus corax*	Yellow	-	-	27
Blue Jay	*Cyanocitta cristata*	Yellow	-	-	1
Canada Jay	*Perisoreus canadensis*	Yellow	-	-	11
Black-billed Magpie	*Pica hudsonia*	Yellow	-	-	15
Cedar Waxwing	*Bombycilla cedrorum*	Yellow	-	-	33
Black-capped Chickadee	*Poecile atricapillus*	Yellow	-	-	18
Cliff Swallow	*Petrochelidon pyrrhonota*	Yellow	-	-	3
Bank Swallow	*Riparia riparia*	Yellow	Threatened	Threatened	12
Tree Swallow	*Tachycineta bicolor*	Yellow	-	-	5
Violet-green Swallow	*Tachycineta thalassina*	Yellow	-	-	2
Ruby-crowned Kinglet	*Regulus calendula*	Yellow	-	-	4
Golden-crowned Kinglet	*Regulus satrapa*	Yellow	-	-	5
Marsh Wren	*Cistothorus palustris*	Yellow	-	-	3
Red-breasted Nuthatch	*Sitta canadensis*	Yellow	-	-	12
House Wren	*Troglodytes aedon*	Yellow	-	-	4
Brown Creeper	*Certhia americana*	Yellow	-	-	4

English Name	Scientific Name	BC List	COSEWIC	SARA Status	Survey Detections
Gray Catbird	*Dumetella carolinensis*	Yellow	-	-	8
Hermit Thrush	*Catharus guttatus*	Yellow	-	-	6
Swainson's Thrush	*Catharus ustulatus*	Yellow	-	-	126
American Robin	*Turdus migratorius*	Yellow	-	-	90
Purple Finch	*Haemorhous purpureus*	Yellow	-	-	2
Pine Siskin	*Spinus pinus*	Yellow	-	-	38
Canada Warbler	*Cardellina canadensis*	Blue	Special Concern	Threatened	20
Wilson's Warbler	*Cardellina pusilla*	Yellow	-	-	7
Mourning Warbler	*Geothlypis philadelphia*	Yellow	-	-	4
Common Yellowthroat	*Geothlypis trichas*	Yellow	-	-	43
Orange-crowned Warbler	*Leiothlypis celata*	Yellow	-	-	32
Tennessee Warbler	*Leiothlypis peregrina*	Yellow	-	-	14
Black-and-white Warbler	*Mniotilta varia*	Yellow	-	-	28
Connecticut Warbler	*Oporornis agilis*	Blue	-	-	1
Northern Waterthrush	*Parkesia noveboracensis*	Yellow	-	-	8
Ovenbird	*Seiurus aurocapilla*	Yellow	-	-	137
Bay-breasted Warbler	*Setophaga castanea*	Red	-	-	1
Yellow-rumped Warbler	*Setophaga coronata*	Yellow	-	-	73
Magnolia Warbler	*Setophaga magnolia*	Yellow	-	-	13
Black-throated Gray Warbler	*Setophaga nigrescens*	Yellow	-	-	2
Yellow Warbler	*Setophaga petechia*	Yellow	-	-	142
American Redstart	*Setophaga ruticilla*	Yellow	-	-	21
Blackpoll Warbler	*Setophaga striata*	Yellow	-	-	1
Cape May Warbler	*Setophaga tigrina*	Blue	-	-	1
Black-throated Green Warbler	*Setophaga virens*	Blue	-	-	12
Red-winged Blackbird	*Agelaius phoeniceus*	Yellow	-	-	87
Brewer's Blackbird	*Euphagus cyanocephalus*	Yellow	-	-	3
Baltimore Oriole	*Icterus galbula*	Blue	-	-	12
Brown-headed Cowbird	*Molothrus ater*	Yellow	-	-	15
Common Grackle	*Quiscalus quiscula*	Yellow	-	-	2
Dark-eyed Junco	*Junco hyemalis*	Yellow	-	-	49
Swamp Sparrow	*Melospiza georgiana*	Yellow	-	-	17
Lincoln's Sparrow	*Melospiza lincolnii*	Yellow	-	-	43
Song Sparrow	*Melospiza melodia*	Yellow	-	-	45

English Name	Scientific Name	BC List	COSEWIC	SARA Status	Survey Detections
Savannah Sparrow	*Passerculus sandwichensis*	Yellow	-	-	2
Fox Sparrow	*Passerella iliaca*	Yellow	-	-	2
Vesper Sparrow	*Pooecetes gramineus*	Yellow	-	-	13
Clay-colored Sparrow	*Spizella pallida*	Yellow	-	-	81
Chipping Sparrow	*Spizella passerina*	Yellow	-	-	22
White-throated Sparrow	*Zonotrichia albicollis*	Yellow	-	-	260
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	Yellow	-	-	67
Western Tanager	*Piranga ludoviciana*	Yellow	-	-	62

* Includes woodpeckers. Though not songbirds, woodpeckers are also part of the Breeding Bird Follow-up Monitoring Program (surveyed separately from songbirds) and are regularly detected during points counts.

4.0 REFERENCES

Saulteau EBA Environmental Services Joint Venture (SEEJ JV) 2019. Site C Clean Energy Project Breeding Bird Follow-up Monitoring – Songbirds. 2020 Annual Report. Prepared by Tetra Tech Canada Inc. for BC Hydro and Power Authority.

APPENDIX A
2021 POINT COUNT STATIONS

Table A1: Songbird Point Count Stations Surveyed in 2021

Station	UTM Zone	UTM Easting	UTM Northing	Survey 1 Date	Survey 1 Time	Survey 2 Date	Survey 2 Time	Bird Habitat Class
PC21-601	10	623773	6232892	2021-06-03	06:12	2021-06-19	05:40	Riparian-mixed young forest
PC21-602	10	624125	6233158	2021-06-03	06:17	2021-06-19	05:46	Riparian-mixed shrub
PC21-603	10	621827	6232349	2021-06-03	04:50	2021-06-19	04:28	Riparian-mixed shrub
PC21-604	10	621685	6232571	2021-06-03	05:09	2021-06-19	05:50	Riparian-mixed shrub
PC21-605	10	621248	6232354	2021-06-03	05:32	2021-06-19	05:11	Riparian-mixed shrub
PC21-606	10	614571	6234696	2021-06-03	07:07	2021-06-19	06:28	Coniferous-shrub
PC21-607	10	614201	6234874	2021-06-03	07:27	2021-06-19	06:48	Riparian-mixed shrub
PC21-608	10	613880	6235428	2021-06-03	09:24	2021-06-19	08:48	Riparian-mixed shrub
PC21-500	10	613140	6235203	2021-06-03	08:14	2021-06-19	07:30	Deciduous-young forest
PC21-501	10	612849	6235419	2021-06-03	08:40	2021-06-19	08:02	Deciduous-mature forest
PC21-502	10	612581	6235611	2021-06-03	09:16	2021-06-19	08:32	Deciduous-mature forest
PC21-004	10	622034	6231701	2021-06-03	05:04	2021-06-19	04:40	Deciduous-mature forest
PC21-005	10	621480	6231575	2021-06-03	05:31	2021-06-19	05:08	Deciduous-young forest
PC21-007	10	616913	6234543	2021-06-03	08:08	2021-06-19	07:36	Dry slopes-grassland
PC21-008	10	616553	6234827	2021-06-03	07:44	2021-06-19	07:06	Dry slopes-shrubland
PC21-009	10	616192	6234479	2021-06-03	08:33	2021-06-19	07:59	Cultivated
PC21-010	10	615902	6234745	2021-06-03	07:12	2021-06-19	06:34	Dry slopes-shrubland
PC21-011	10	615862	6234301	2021-06-03	08:49	2021-06-19	08:15	Cultivated
PC21-019	10	603014	6234339	2021-06-08	04:21	2021-06-22	04:21	Dry slopes-grassland
PC21-021	10	601274	6234292	2021-06-08	04:48	2021-06-22	04:48	Deciduous-shrub
PC21-024	10	600679	6234123	2021-06-08	05:21	2021-06-22	05:18	Deciduous-shrub

Station	UTM Zone	UTM Easting	UTM Northing	Survey 1 Date	Survey 1 Time	Survey 2 Date	Survey 2 Time	Bird Habitat Class
PC21-027	10	605811	6234955	2021-06-06	09:50	2021-06-22	08:46	Fen/bog-shrub
PC21-032	10	594779	6230591	2021-06-08	05:50	2021-06-22	07:50	Coniferous-shrub
PC21-035	10	593385	6229860	2021-06-07	04:34	2021-06-22	05:49	Deciduous-shrub
PC21-038	10	592767	6229065	2021-06-07	05:25	2021-06-22	06:50	Dry slopes-shrubland
PC21-PR-38	10	607605	6236561	2021-06-08	07:23	2021-06-24	08:53	Wetland-graminoid
PC21-PR-39	10	607396	6236515	2021-06-07	05:46	2021-06-24	08:35	Wetland-shrub
PC21-039	10	592553	6228662	2021-06-08	07:45	2021-06-22	07:10	Cultivated
PC21-040	10	593058	6229341	2021-06-07	05:10	2021-06-22	06:28	Dry slopes-shrubland
PC21-PR-46	10	606770	6235559	2021-06-08	06:55	2021-06-22	09:04	Wetland-graminoid
PC21-050	10	593202	6229554	2021-06-07	04:52	2021-06-22	06:11	Dry slopes-shrubland
PC21-PR-56	10	605447	6234696	2021-06-06	09:28	2021-06-22	08:28	Coniferous-mature forest
PC21-069	10	577259	6220860	2021-06-06	08:31	2021-06-23	08:35	Dry slopes-shrubland
PC21-070	10	576921	6220683	2021-06-06	08:00	2021-06-23	07:59	Dry slopes-shrubland
PC21-071	10	576686	6220531	2021-06-06	07:37	2021-06-23	07:40	Deciduous-shrub
PC21-072	10	576256	6220108	2021-06-06	07:07	2021-06-23	07:06	Riparian-mixed young forest
PC21-073	10	576001	6219985	2021-06-06	06:45	2021-06-23	06:46	Cultivated
PC21-076	10	570355	6212864	2021-06-06	05:33	2021-06-23	05:36	Coniferous-young forest
PC21-077	10	570134	6213209	2021-06-06	05:54	2021-06-23	05:58	Coniferous-young forest
PC21-078	10	565870	6206360	2021-06-06	04:37	2021-06-23	04:38	Deciduous-mature forest
PC21-080	10	566416	6207084	2021-06-06	05:05	2021-06-23	05:11	Deciduous-shrub
PC21-081	10	566341	6206470	2021-06-06	05:48	2021-06-23	05:56	Wetland-shrub
PC21-082	10	564101	6205711	2021-06-06	07:02	2021-06-23	07:15	Deciduous-mature forest

Station	UTM Zone	UTM Easting	UTM Northing	Survey 1 Date	Survey 1 Time	Survey 2 Date	Survey 2 Time	Bird Habitat Class
PC21-084	10	566021	6206826	2021-06-06	05:29	2021-06-23	05:37	Deciduous-shrub
PC21-085	10	563734	6205440	2021-06-06	07:39	2021-06-23	07:55	Fen/bog-shrub
PC21-086	10	564312	6205213	2021-06-06	08:13	2021-06-23	08:31	Deciduous-shrub
PC21-087	10	565416	6206263	2021-06-06	04:15	2021-06-23	04:16	Deciduous-shrub
PC21-088	10	562713	6205763	2021-06-06	04:20	2021-06-23	04:21	Deciduous-mature forest
PC21-089	10	562800	6206063	2021-06-06	04:50	2021-06-23	04:54	Deciduous-mature forest
PC21-101	10	566447	6205946	2021-06-06	06:15	2021-06-23	06:22	Coniferous-young forest
PC21-104	10	577541	6220783	2021-06-06	08:52	2021-06-23	08:58	Deciduous-young forest
PC21-144	10	606558	6235589	2021-06-08	08:19	2021-06-24	07:51	Wetland-graminoid
PC21-201	10	611065	6238042	2021-06-07	04:20	2021-06-22	04:19	Dry slopes-shrubland
PC21-202	10	611295	6238013	2021-06-07	04:43	2021-06-22	04:36	Deciduous-young forest
PC21-203	10	611606	6237736	2021-06-07	05:52	2021-06-22	05:22	Deciduous-mature forest
PC21-204	10	611968	6237681	2021-06-08	07:30	2021-06-22	05:55	Deciduous-young forest
PC21-205	10	612332	6237495	2021-06-08	07:00	2021-06-22	06:30	Deciduous-mature forest
PC21-206	10	612573	6237329	2021-06-08	06:21	2021-06-22	06:57	Wetland-shrub
PC21-207	10	613084	6236953	2021-06-08	05:42	2021-06-22	08:18	Wetland-shrub
PC21-208	10	612820	6236955	2021-06-08	04:54	2021-06-22	07:32	Deciduous-shrub
PC21-209	10	613174	6236752	2021-06-08	05:16	2021-06-22	07:55	Deciduous-young forest
PC21-210	10	611575	6237602	2021-06-07	05:22	2021-06-22	04:58	Wetland-shrub
PC21-A1	10	602990	6233046	2021-06-04	04:53	2021-06-20	04:40	Deciduous-mature forest
PC21-A10	10	599738	6232286	2021-06-04	08:56	2021-06-20	08:15	Coniferous-mature forest
PC21-A2	10	602661	6232990	2021-06-04	04:32	2021-06-20	04:16	Deciduous-shrub

Station	UTM Zone	UTM Easting	UTM Northing	Survey 1 Date	Survey 1 Time	Survey 2 Date	Survey 2 Time	Bird Habitat Class
PC21-A3	10	602233	6232962	2021-06-04	05:30	2021-06-20	05:10	Deciduous-shrub
PC21-A4	10	601952	6232770	2021-06-04	05:57	2021-06-20	05:35	Coniferous-mature forest
PC21-A5	10	601607	6232742	2021-06-04	06:25	2021-06-20	06:02	Coniferous-mature forest
PC21-A6	10	601260	6232688	2021-06-04	06:49	2021-06-20	06:25	Coniferous-mature forest
PC21-A7	10	600890	6232601	2021-06-04	07:29	2021-06-20	06:50	Coniferous-mature forest
PC21-A8	10	600496	6232512	2021-06-04	08:02	2021-06-20	07:17	Coniferous-mature forest
PC21-A9	10	600121	6232427	2021-06-04	08:30	2021-06-20	07:47	Coniferous-mature forest
PC21-B1	10	595349	6229423	2021-06-04	05:07	2021-06-20	04:48	Coniferous-young forest
PC21-B10	10	593197	6227928	2021-06-04	08:56	2021-06-20	08:20	Coniferous-shrub
PC21-B2	10	595098	6229182	2021-06-04	05:29	2021-06-20	05:09	Coniferous-mature forest
PC21-B3	10	594882	6228865	2021-06-04	05:58	2021-06-20	05:32	Coniferous-young forest
PC21-B4	10	594639	6228571	2021-06-04	06:33	2021-06-20	05:57	Coniferous-young forest
PC21-B5	10	594340	6228348	2021-06-04	06:56	2021-06-20	06:21	Deciduous-young forest
PC21-B6	10	594087	6228135	2021-06-04	07:21	2021-06-20	06:48	Deciduous-young forest
PC21-B7	10	593863	6227915	2021-06-04	07:43	2021-06-20	07:13	Deciduous-young forest
PC21-B8	10	593646	6227692	2021-06-04	08:10	2021-06-20	07:40	Coniferous-young forest
PC21-B9	10	593609	6228086	2021-06-04	08:37	2021-06-20	08:02	Coniferous-shrub
PC21-C1-1	10	589114	6225713	2021-06-05	07:52	2021-06-21	07:22	Deciduous-shrub
PC21-C1-2	10	589021	6225353	2021-06-05	08:23	2021-06-21	07:52	Coniferous-mature forest
PC21-C1-3	10	588775	6225032	2021-06-05	08:51	2021-06-21	08:22	Coniferous-mature forest
PC21-C1-4	10	588528	6224817	2021-06-05	09:15	2021-06-21	08:46	Coniferous-mature forest
PC21-C1-5	10	588244	6225026	2021-06-05	09:50	2021-06-21	09:18	Riparian-mixed mature forest

Station	UTM Zone	UTM Easting	UTM Northing	Survey 1 Date	Survey 1 Time	Survey 2 Date	Survey 2 Time	Bird Habitat Class
PC21-C2-1	10	587264	6223631	2021-06-05	07:51	2021-06-21	07:12	Deciduous-young forest
PC21-C2-2	10	587483	6223815	2021-06-05	08:22	2021-06-21	07:42	Deciduous-young forest
PC21-C2-3	10	587687	6224007	2021-06-05	08:40	2021-06-21	08:00	Deciduous-young forest
PC21-C2-4	10	587990	6224257	2021-06-05	09:04	2021-06-21	08:26	Coniferous-young forest
PC21-C2-5	10	588205	6224535	2021-06-05	09:28	2021-06-21	09:00	Coniferous-mature forest
PC21-C2-6	10	587739	6224475	2021-06-05	09:58	2021-06-21	09:29	Riparian-mixed shrub
PC21-D1-1	10	574364	6217723	2021-06-05	04:30	2021-06-21	04:14	Riparian-mixed young forest
PC21-D1-2	10	574335	6217385	2021-06-05	04:58	2021-06-21	04:40	Coniferous-mature forest
PC21-D1-3	10	574574	6217605	2021-06-05	05:20	2021-06-21	05:03	Coniferous-mature forest
PC21-D1-4	10	574823	6217844	2021-06-05	05:48	2021-06-21	05:35	Deciduous-mature forest
PC21-D1-5	10	575018	6218149	2021-06-05	06:16	2021-06-21	05:58	Coniferous-mature forest
PC21-D2-1	10	578611	6219365	2021-06-05	05:43	2021-06-21	04:27	Coniferous-mature forest
PC21-D2-2	10	578018	6219525	2021-06-05	05:01	2021-06-21	05:00	Coniferous-mature forest
PC21-D2-3	10	576950	6218948	2021-06-05	04:32	2021-06-21	05:28	Riparian-mixed shrub
PC21-D2-4	10	574657	6218563	2021-06-05	06:29	2021-06-21	05:59	Deciduous-mature forest
PC21-D2-5	10	574463	6218308	2021-06-05	06:51	2021-06-21	06:18	Deciduous-mature forest

APPENDIX B
PROJECT QUALIFIED ENVIRONMENTAL PROFESSIONALS

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

APPENDIX C
INCIDENTAL BIRD OBSERVATIONS

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

English Name	Scientific Name	BC List	COSEWIC	SARA Status	Detections
Green-winged Teal	*Anas crecca*	Yellow	-	-	1
Mallard	*Anas platyrhynchos*	Yellow	-	-	6
Canada Goose	*Branta canadensis*	Yellow	-	-	2
Bufflehead	*Bucephala albeola*	Yellow	-	-	1
Northern Shoveler	*Spatula clypeata*	Yellow	-	-	3
Blue-winged Teal	*Spatula discors*	Yellow	-	-	1
Ruffed Grouse	*Bonasa umbellus*	Yellow	-	-	2
Sora	*Porzana carolina*	Yellow	-	-	11
Spotted Sandpiper	*Actitis macularius*	Yellow	-	-	2
Wilson's Snipe	*Gallinago delicata*	Yellow	-	-	23
Solitary Sandpiper	*Tringa solitaria*	Yellow	-	-	4
Red-tailed Hawk	*Buteo jamaicensis*	Yellow	Not at Risk	-	2
Broad-winged Hawk	*Buteo platypterus*	Blue	-	-	1
Bald Eagle	*Haliaeetus leucocephalus*	Yellow	Not at Risk	-	1
Great Horned Owl	*Bubo virginianus*	Yellow	-	-	1
Merlin	*Falco columbarius*	Yellow	Not at Risk	-	2

APPENDIX D
LIMITATIONS ON THE USE OF THIS DOCUMENT

LIMITATIONS ON USE OF THIS DOCUMENT

NATURAL SCIENCES

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During the performance of the work and the preparation of this Professional Document, SEES JV may have relied on information provided by third parties other than the Client.

While SEES JV endeavours to verify the accuracy of such information, SEES JV accepts no responsibility for the accuracy or the reliability of such information even where inaccurate or unreliable information impacts any recommendations, design or other deliverables and causes the Client or an Authorized Party loss or damage.

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The Client, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

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1.7 ENVIRONMENTAL ISSUES

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.

1.8 NOTIFICATION OF AUTHORITIES

SEES JV professionals are bound by their ethical commitments to act within the bounds of all pertinent regulations. In certain instances, observations by SEES JV of regulatory contravention may require that regulatory agencies and other persons be informed. The client agrees that notification to such bodies or persons as required may be done by SEES JV in its reasonably exercised discretion.

Appendix 3. Waterbird Migration Follow-up Monitoring Program – 2020

Hemmera
An Ausenco Company

Site C Vegetation and Wildlife Waterbird Migration Follow-up Monitoring Program – 2021 Annual Report

Photo Credit: C.T.St.Clair

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March 11, 2022

EXECUTIVE SUMMARY

The Site C Waterbird Migration Follow-up Monitoring Program is being conducted to fulfill, in part, the requirements and conditions set forth in the Site C Clean Energy Project's (Project) Provincial Environmental Assessment Certificate and the Federal Decision Statement (FDS). In accordance with these requirements and conditions, the objectives of the Site C waterbird monitoring program are as follows:

- Assess changes in waterbird wetland and non-wetland habitat on the Peace River and the transmission line right-of-way from Project construction through to the first 10 years of Project operations to assess Project-related impacts relative to those predicted in the EIS.
- Document changes in waterbird abundance and diversity across habitats (Peace River and wetlands) during the first 10 years of Project operations relative to pre-reservoir and transmission line conditions to assess Project-related impacts relative to those predicted in the EIS.
- Monitor waterbird use of natural and created compensatory wetland features from Project construction through to the first 10 years of Project operations to evaluate the effectiveness of mitigation and compensation measures.

The monitoring program has been implemented annually for 5 years, from 2017 through 2021, within study areas along the Peace River and wetlands along the Project transmission line right of way (ROW) on the Moberly Plateau. Standwatch and transect surveys conducted on foot, river boat surveys, and bioacoustics monitoring surveys using autonomous recording units (ARUs) were applied to determine waterbird abundance and diversity within the habitat types present and used by waterbirds, including baseline data on measures of abundance, density, species presence and habitat use (i.e., associations) for waterbirds, required by conditions of the FDS. The results collected to date are summarized as a whole and for the most recent monitoring year within this annual report. Monitoring data collected thus far will inform future annual efforts and, together with data collected under future project operations conditions, will be used to evaluate changes to baseline conditions in habitat, abundance and diversity of waterbirds, including species at risk, as per the objectives described above.

Results presented in this annual monitoring report describe the survey effort and the observed waterbird abundance and diversity within and between the spring migration (April 1 to May 30) and fall migration (August 1 to October 30), as well as variation in these parameters across habitat types and study areas. Results are summarized for cumulative counts of all waterbird species and for 7 foraging guilds comprised of species with similar morphology and foraging strategies: large dabblers, dabbling ducks, benthic feeding divers, piscivorous divers, shorebirds, gulls and surface feeding terns, and marsh birds. A summary of 2021 monitoring efforts and results from 2017 through 2021 are provided below for monitoring conducted along the Peace River between Hudson's Hope and the Alberta border, followed by results from wetlands surveys conducted on and adjacent to the transmission line ROW on the Moberly Plateau.

During the current year of reporting (2021) within the Peace River study area, a total of 2 surveys were conducted during waterbird migrations in spring (Apr 6 to Apr 13, 2021) and 3 surveys were conducted during waterbird migrations in fall (Aug 9 to Sept 28). Wetlands along and adjacent to the Project transmission line ROW were also surveyed during 2 and 3 survey rounds over the spring (May 3 to May 16, 2021) and fall migration periods (August 11 to October 6, 2021), respectively. ARU surveys in 2021 were conducted at a total of 7 locations on the Moberly Plateau during May, June, July and early August. Survey results specific to the current monitoring year are provided within the body of the report.

Surveys of the Peace River in 2017 through 2021 provide 5 years of data primarily reflecting baseline conditions. These data will be used together with data collected following Project construction to assess potential impacts of the Project on waterbirds within a before-after control-impact study design framework. A total of 76,197 waterbirds of 64 species were recorded during boat-based surveys conducted during the spring and fall of 2017 through 2021. From these results, summary statistics were calculated using pooled data from 45 surveys of the Peace River across all seasons and years. As reported in previous years, all 7 foraging guilds occurring within areas of anticipated Project-related effects were also recorded in the Control portion of the study area. These results confirm that areas of the Peace River downstream of the Pine River provide an appropriate control for assessing background variation for waterbirds, a key assumption of the before-after control-impact study framework within which Project-related changes to waterbirds in the Peace River will be assessed.

To describe variation in waterbird abundance across habitat types, sections of the river with similar habitat features (e.g., water flow volumes and depth, substrate type, and aquatic vegetation) were categorized into habitat types associated with flow rates and connectivity to the Peace River. The 3 habitat types assessed in this study are: Mainstem of the river (where water flow rates, depths and substrate size are greatest), Moderate Flow (consistently connected to the river and with moderate flows, generally no impediment to boat travel), and Limited Connectivity to the river (backchannels with limited connectivity to the river, typically only on the downstream end, and relatively low flow rate, access by boat is restricted in some areas, particularly when water levels are low). Abundance and diversity statistics are presented for each of these river habitat types, demonstrating that most birds (63%) were found in mainstem habitat (the largest habitat type by area), although higher densities were found in other habitat types. The greatest densities of waterbirds were observed in Limited Connectivity habitat, where they were more than 4-fold the densities observed in Moderate Flow habitat and more than 5-fold those in Mainstem habitat in both spring and fall.

Wetland surveys conducted from 2017 through 2021 (100-metre transects, and 20-minute stationary standwatch surveys) detected a total of 8,184 waterbirds of 46 species within 23 areas containing wetland habitat used by waterbirds (i.e., wetland survey stations). These surveys provide season-specific estimates of abundance and diversity in habitats regularly used by waterbirds within 3 kilometres of the transmission line ROW. Wetland survey stations contained varying combinations of open water, sedge, and willow-sedge habitat types. Survey methods appropriate for each method were applied and abundance and diversity statistics are presented for each. Standwatch surveys of open water habitat detected 7,837 individuals across 44 waterbird species in 2017 through 2021. Fewer individuals and species (347 individuals of 19 species) were observed within sedge and willow-sedge habitat with low water depth (i.e., less than 50 centimetres) surveyed by walking transects in 2018 through 2021. Transect surveys were conducted over the past 4 years, as compared to 5 years for standwatch and river surveys, and transect surveys provide data for habitat types with greater detection constraints (e.g., tall and thick vegetation) and for more cryptic species such as marsh birds.

Bioacoustics monitoring using ARUs provides additional data on marsh bird species, which can be detected more effectively using audio rather than visual survey methods. Bioacoustics monitoring in 2017 through 2021 was conducted at a total of 18 locations during May, June, July, and early August, when marsh bird species' vocalizations are most frequent. ARUs were deployed to record bird vocalizations within sedge and willow-sedge habitat in addition to the edge of open water and upland forested areas.

Sora (*Porzana carolina*) was detected at all locations where ARUs were deployed, and yellow rail (*Coturnicops noveboracensis*) was detected at approximately 40 percent of those locations. Virginia rail (*Rallus limicola*), a species only recently known to occur in the region and not reported from baseline studies, was detected at 3 of 13 locations where ARUs were deployed in 2020 and 2021. In contrast, American bittern (*Botaurus lentiginosus*) was not detected at any location in any year of monitoring. These surveys provide data on sora complimentary to those from transect surveys, demonstrating the species' ubiquity within vegetated wetlands. ARU survey results also confirm the rarity of American bittern in the region, the continued presence of yellow rail and the apparently emerging presence of Virginia rail within wetlands along and adjacent to the transmission line ROW, particularly within sedge-dominated habitat with low water levels.

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ACRONYMS AND ABBREVIATIONS

Acronym / Abbreviation	Definition
ARU	Autonomous Recording Unit
BACI	before-after, control-impact
BC	British Columbia
cm	centimetre
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
dB	decibel
EAC	Environmental Assessment Certificate
EIS	Environmental Impact Statement
FDS	Federal Decision Statement
GPS	global positioning system
kHZ	kilohertz
km	kilometres
km^2	kilometres squared
km/h	klometres per hour
m	metre
QA	quality assurance
QC	quality control
ROW	right-of-way
SC	special concern
SARA	Species at Risk Act
sec	second
TEM	terrestrial ecosystem mapping
UTM	Universal Transverse Mercator
VWTC	Vegetation and Wildlife Technical Committee
%	percent
<	lesser than
>	greater than

GLOSSARY

Term	Definition
Absolute abundance	A measure of the true and exact number of individuals.
Control area	The Peace River from the Pine River confluence to the Alberta border.
Flow Impact area	The geographical area of the Peace River from the Site C dam to the Pine River confluence with the Peace River.
Foraging guild	Species groups comprised of waterbird species with similar morphology and foraging strategies.
Inundation Impact area	The geographical area of the Site C reservoir from Hudson's Hope to the Project site.
Relative abundance	A measure, or index, of abundance that can reveal changes over time (e.g., between baseline and Project operations conditions).
Peace River study area	The geographical area of the Peace River between Hudson's Hope and the Alberta border.
Species evenness	The degree of similarity in abundance of each species
Species richness	The number of species
Study area	The geographical area where all aspects of the study take place. The study area encompasses all sub-areas (e.g., **treatment areas**) including **control areas**, the **impact areas** and other defined areas as applicable.
Survey day	Survey effort in a given day, which covers only a portion of the transmission line right-of-way **wetlands or Peace River study areas**.
Survey period	A period of time which encompasses a defined period of spring or fall migration, including the peak migration of one or more species groups (i.e., foraging guilds).
Survey round	A group of **survey days**, which together encompass the entire **Peace River study area** or all wetland survey stations within **wetland study area**.
Treatment area	Geographical areas that are sub-areas of the **study area** in which either the impact or control condition is present and measured. There are two types of treatment areas within this BACI study: **control areas**, **impact area**.
Waterbird	The collective name for shorebirds, marsh birds, waterfowl, and other birds associated with aquatic and wetland habitats.
Wetland study area	The geographical area of wetland habitat on the Moberley Plateau within 3 kilometres of the Project transmission line.

1.0 INTRODUCTION

This report describes the combined annual results of the 2017 to 2021 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 being conducted to fulfill, in part, 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) (BC Hydro 2013).

1.1 Background

In the Site C Environmental Impact Statement (EIS), BC Hydro assessed the potential effects of the Site C Clean Energy Project (Project) on Wildlife Resources 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 effects of the Project on waterfowl and shorebirds as high magnitude because of 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 future 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, 2008 and 2012 through 2014. 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), using the same methods, expanded the focus to include Charadriiformes (e.g., snipe, sandpipers, phalaropes, plovers, gulls, terns, avocets), Gruiformes (e.g., rails), and Pelecaniformes (e.g., bitterns). 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, as well as challenges in species identification from helicopters, prompted the VWTC to request that a follow-up monitoring program better suited to detecting and identifying a boader range of bird species be developed to provide a more complete assessment of waterbird use of the Peace River during spring and fall migration periods. The Waterbird Migration Follow-up Monitoring Program was designed in conjunction with the VWTC to meet this objective. This report presents Waterbird Migration Follow-up Monitoring Program data collected annually from 2017 through 2021 using methods designed to survey the full range of waterbird species present in the study area, including improved species identification of shorebirds and other small waterbirds.

Data from surveys before 2017 were not compared to or compiled with those collected for this follow-up monitoring program due to inconsistencies in the timing of historical surveys and discrepancies between historic methods and those used in the updated survey protocols.

1.2 Monitoring Objectives

The overall objective of the Waterbird Migration 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). The specific objectives of the monitoring program are as follows:

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

The data collected satisfy the waterbird monitoring requirements of the FDS and EAC by evaluating the effectiveness of mitigation and compensation measures for waterbirds and by verifying the accuracy of the predictions made in the EIS regarding waterbirds and their habitat. The survey methods applied in this monitoring program provide data on waterbird relative abundance and diversity within habitat types present and used by waterbirds in the study area. Distance and repeated survey data were collected (as described in **Section 2.1.2** and **2.2.2.1**) to provide measures of detectability and allow for estimates of absolute abundance in future analyses. Baseline measures of abundance, density, species presence, and habitat use (i.e., associations) for waterbirds are required by conditions of the FDS.

The study is designed to assess changes in abundance and diversity of waterbirds for each of 7 foraging guilds comprised of species with similar morphology and foraging strategies: dabbling ducks (i.e., small waterfowl that feed primarily on aquatic vegetation), large dabblers (i.e., large waterfowl [e.g., geese and swans] that feed primarily on vegetation), piscivorous divers (i.e., diving birds that forage on fish), benthic feeding divers (i.e., small waterfowl and sea ducks that feed primarily on benthic invertebrates), gulls and surface-feeding terns (i.e., small to large size birds that forage on fish and insects near the water's surface, and occasionally garbage), hereafter referred to simply as 'gulls', shorebirds (i.e., plovers and sandpipers that feed primarily on or near the shoreline), and unidentified waterbirds. Foraging groups are used to categorize waterbird species because forage is expected to be an important driver of waterbird abundance during migration. The use of foraging groups also generally follows the waterbird species categorization approach used in the Environmental Impact Statement (EIS), which facilitates the comparison of measured to predicted effects of the Project.

1.3 Study Area and Temporal Scope

The overall study area for the Waterbird Migration Follow-up Monitoring Program comprises the Peace River between Hudson's Hope and the Alberta border, and wetland habitat on the Moberly Plateau within 3 kilometres (km) of the Project transmission line (**Figure 1**). Hereafter, these 2 areas are referred to separately as the Peace River study area and the wetlands study area. Additional wetland habitat within the Moberly Plateau that was surveyed from fixed-wing aircraft during 2017 was not surveyed in subsequent years because species identification was seldom possible from the elevations required for safe flight, and access from the ground is limited. Sites with newly enhanced and created compensation wetlands with waterbird habitat will be included in the study as they are identified.

Waterbird survey data will be collected each year through Project construction and for the first 10 years of Project operations, as per EAC Condition 21. The monitoring program has been focused on spring migration (i.e., April and May) and fall migration (i.e., August, September, October) 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; eBird 2021).

To inform the timing and number of surveys conducted in 2020, 2021, and subsequent years, a power analysis was conducted using the Peace River waterbird survey data collected by boat in 2017, 2018, and 2019 (**Appendix A**). The results of the analysis indicated that 2 surveys during the early spring migration (April 1 to 15) and one survey during each of the first 3 fall migration survey periods (encompassing August 1 to October 14) would be sufficient to meet the study objectives. That is, they would allow for detection, with 80 percent (%) certainty, of a 50% change in abundance of each foraging guild in the Impact treatment area. Surveys in 2020 and 2021 were conducted in accordance with these recommendations.

Surveys within the Peace River and wetlands study areas were conducted concurrently during the fall. However, during spring, Peace River surveys were started earlier than wetland surveys to document waterbirds using the river before upland wetlands thaw. Prior to thawing, wetlands along the transmission line ROW are unavailable for waterbird foraging use and waterbirds primarily use habitat along the Peace River.

Within subsequent sections of this report, the following terminology is used to define the temporal scope of survey efforts:

- Survey day – Survey effort in a given day, which covers only a portion of the transmission line ROW wetlands or Peace River study areas
- Survey round – A group of survey days, which together encompass the entire Peace River study area or all wetland survey stations within the wetlands study area
- Survey period – A period of time which encompasses a defined period of spring or fall migration, including the peak migration of one or more species groups (i.e., foraging guilds).

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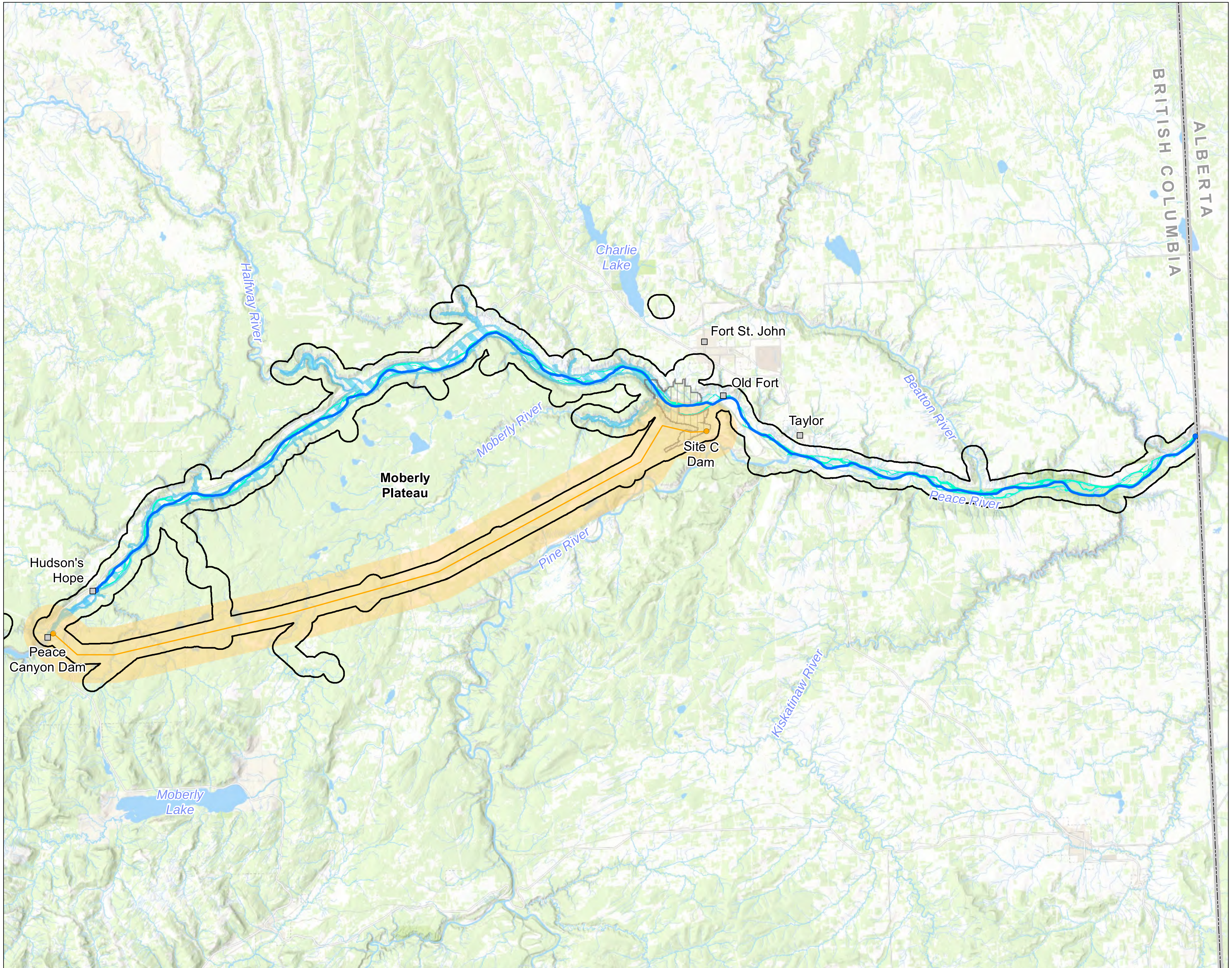
Figure 1 - Study Areas of the Waterbird Monitoring Program on the Peace River and Moberly Plateau



Legend

- Site C Local Assessment Area
- Proposed Dam Site
- Proposed Reservoir
- Peace River Study Area
- Wetlands Study Area
- Transmission Line
- Extent of Peace River Waterbird Surveys
- 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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2.0 MONITORING METHODS

Survey methods developed to meet the monitoring program objectives were developed using guidance from Resource Inventory Standards Committee protocols, with review from the VWTC and subsequent input from Environment and Climate Change Canada and Native Plant Solutions of Ducks Unlimited Canada. The survey methods employed during the 2021 field program and prior years are described in the following sections. Additional rationale for the methods is presented in the Site C Vegetation and Wildlife Waterbird Migration Follow-up Monitoring Program (BC Hydro 2018). Differences in site accessibility and detection constraints across habitat types and waterbird species required distinct survey methods for the Peace River study area and wetlands adjacent to the Project transmission line ROW. These methods are detailed in the following sections.

2.1 Peace River Waterbird Surveys

Surveys of the Peace River were conducted to assess the abundance and diversity of waterbirds using wetland and non-wetland habitats within the Peace River as per study objectives to document baseline conditions and to assess potential Project-related change. The approach by which Project-related change will be assessed, as per Condition 11.4.3 of the FDS, is presented in **Section 2.2.1**. The methods used to conduct surveys in the Peace River study area are described in **Section 2.1.2**.

2.1.1 Approach to Evaluating Change

A before-after, control-impact (BACI) study design has been applied to allow Project-related changes in waterbird abundance and diversity to be detected and distinguished from background (e.g., natural) variation within waterbird communities in the Peace River valley. Within the BACI study design framework, the areas surveyed to assess impacts are as follows:

- Inundation Impact area - the Site C reservoir from Hudson’s Hope to the Project site, to assess impact from inundation (**Figure 2**)
- Flow Impact area - the Peace River from the Site C dam to the Pine River confluence with the Peace River, to assess impact from change in flow regime (**Figure 3**)
- Control area - the Peace River from the Pine River confluence to the Alberta border, to assess background conditions (**Figure 4**).

Below the confluence of the Peace and Pine rivers, Project-related changes in flow regime will be moderated by inputs from the Pine River. Control and impact areas within the Peace River study area are, hereafter, collectively and individually referred to as *treatment areas*. The before period for the BACI design will be the time prior to reservoir filling, which is planned to occur in fall 2023. Widespread impacts are expected once reservoir filling begins. The river diversion period (occurring from 2020 through reservoir filling) will be part of the before period because water volumes and flow rates are expected to be mostly unchanged outside the immediate construction area and small headpond during this time. However, survey data from areas immediately impacted by construction activity will ultimately be excluded from the before period dataset in future analyses of Project-related change.

Following collection and analysis of relative abundance data from both the before and after study periods, the BACI design will permit determination of Project-related impacts through assessing statistical significance of the interaction effect between treatment (i.e., control vs. impact) and survey period (before versus after [during Project operations]) factors.

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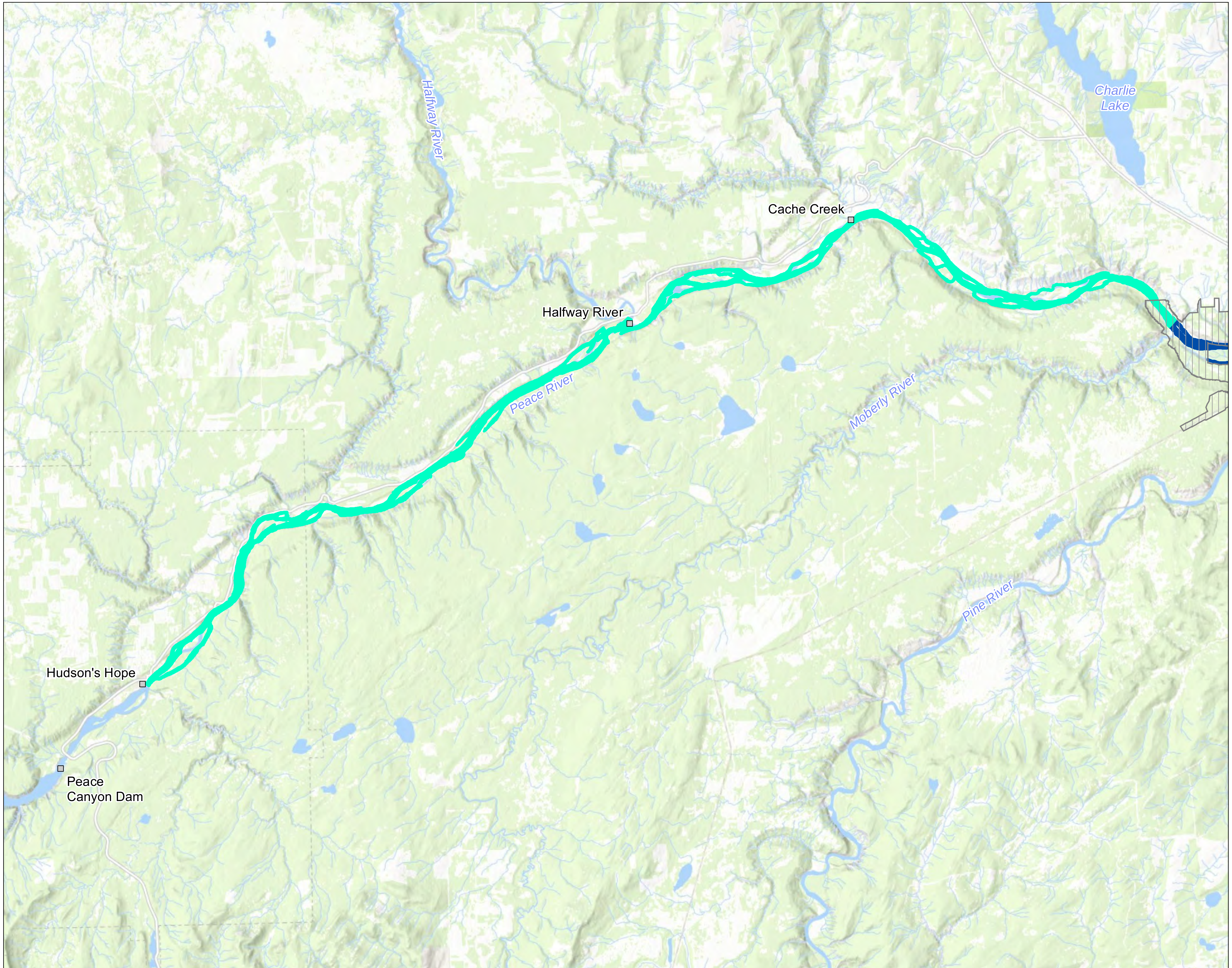
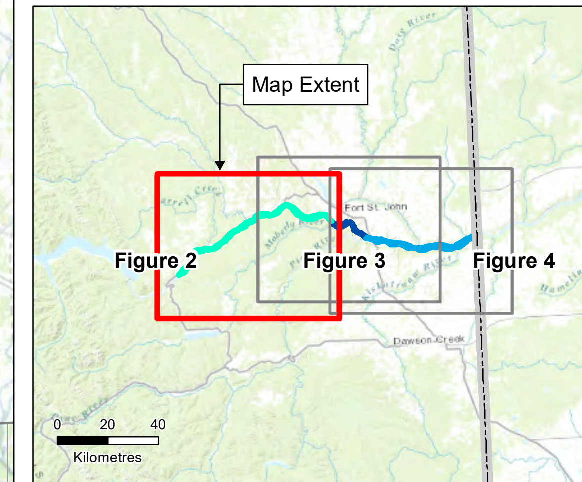
Figure 2 - Inundation Impact Area on the Peace River





Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area
- Proposed Dam Site

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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Migratory Waterbird Follow-up Monitoring Program
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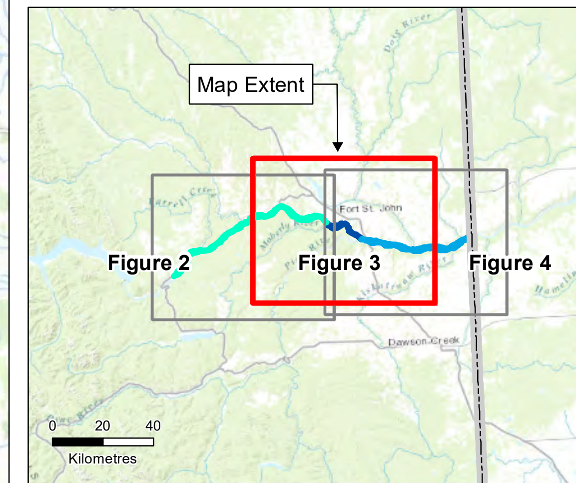
Figure 3 - Flow Regime Change Impact Area on the Peace River



Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area
- Proposed Dam Site

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.

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Migratory Waterbird Follow-up Monitoring Program
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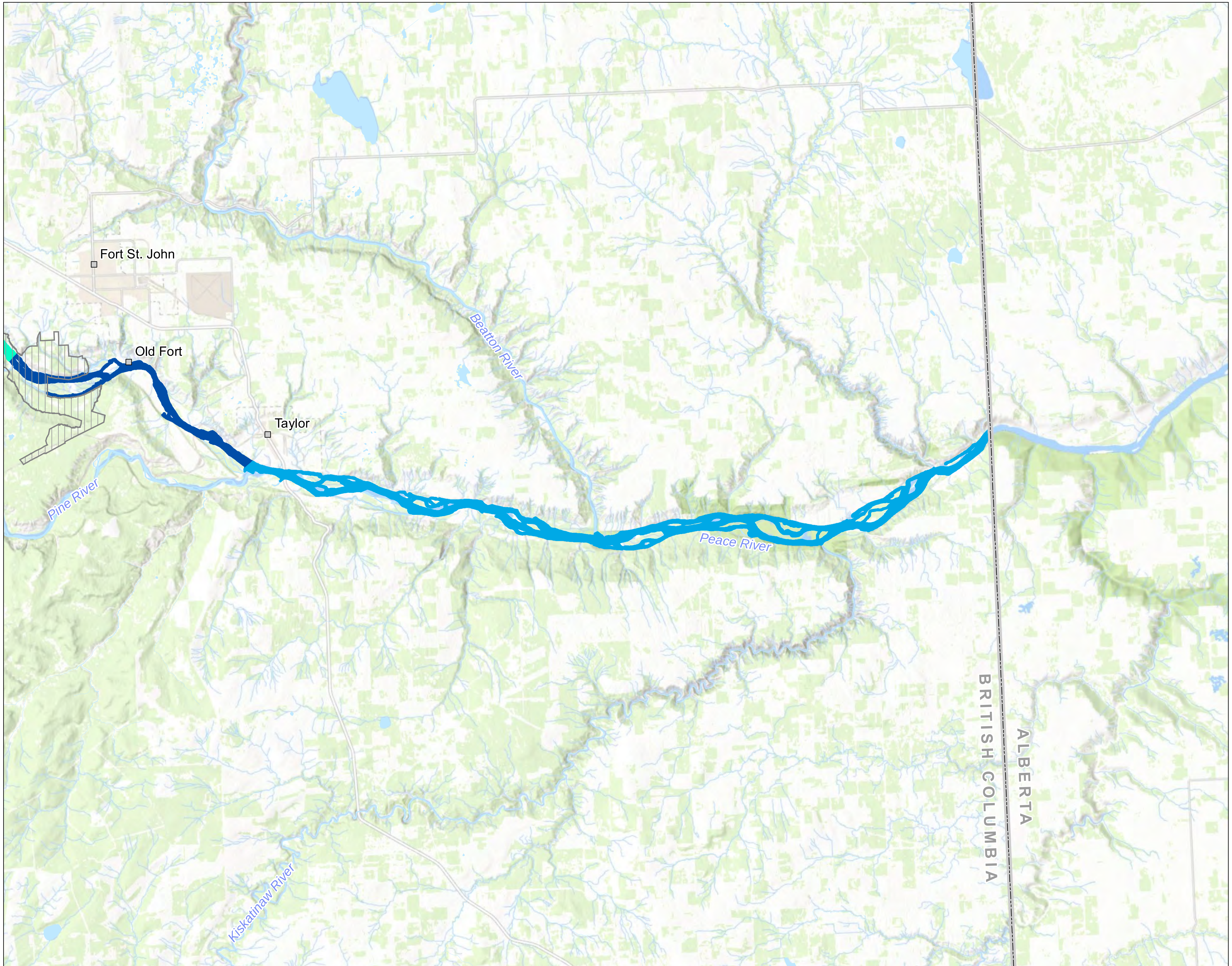
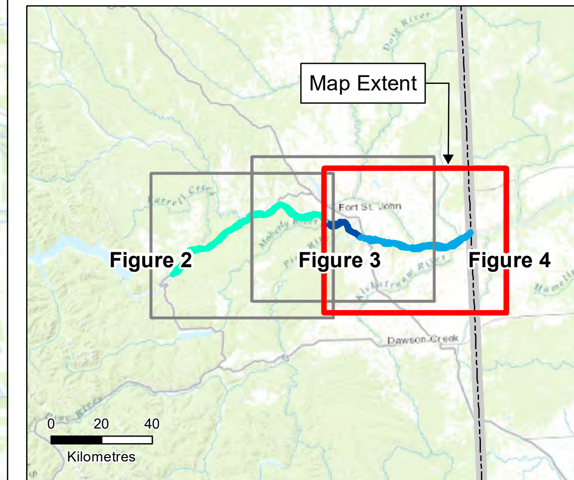
Figure 4 - Control Area on the Peace River





Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area
- Proposed Dam Site

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.

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2.1.2 Survey Methods

Boat surveys, following a modified version of the “Floating Rivers in Rafts or Kayaks” methods described in Inventory Methods for Riverine Birds (RIC 1998) and Inventory Methods for Waterfowl and Allied Species (RIC 1999), provided visual coverage throughout most of the Peace River study area from Hudson’s Hope to the Alberta border (**Figure 1**). Boat surveys provided clear lines of sight of open water habitat as well as shoreline, nearshore areas, exposed sandbanks, gravel bars, and mudbanks/flats along the mainstem of the river, side channels, and many backchannels.

Survey routes circled around islands and side channels and extended up backchannels wherever water levels allowed. Areas where water levels were too low for boat access, or the entrance to backchannels or side channels was obstructed by debris, were not surveyed. Boat surveys were conducted at speeds of 30 to 40 km/h, except where shallow waters required faster speeds to prevent the boat from grounding on the riverbed. Also, speeds were slowed for 1 to 2 minutes to improve the accuracy of species identification and abundance estimates when large or multiple flocks of waterbirds were observed. Surveys usually required 2 days to provide coverage of the complete length of river from Hudson’s Hope to the Alberta border (i.e., 2 days per survey round). Surveys took place in daylight hours (h) between 07:00 and 18:00. During a typical survey round, portions of the Peace River study area upstream of the Project dam site were surveyed during the first day and portions of the study area downstream of the dam site were surveyed during the second day. Surveys were conducted by biologists trained in waterbird identification and survey protocols. During boat surveys, 2 observers focused their respective survey efforts on opposite shores to the centre of the river and communicated bird movements to prevent double counting birds. The observers scanned the river from the front of the boat using the naked eye to detect birds and used binoculars for species identification. Data were recorded using electronic data forms immediately following each observation using map-based spatial software. Only one surveyor entered data at any given time so at least one observer was available to search.

Surveys were not conducted during sustained inclement weather conditions that would result in a reduced ability to detect waterbirds. Weather was judged inclement when wave conditions were associated with a sea state greater than 3 on the Beaufort scale as per provincial standards (RIC 1999). Weather was also deemed inclement when rain or fog resulted in poorvisibility within 1 km. Wave conditions reflecting a sea state greater than 3 on the Beaufort scale means frequent whitecaps, and waves higher than 1.5 m. Surveys were conducted up to wind speeds of 38 km/h (Beaufort 5) unless frequent whitecaps and wave heights reduced visibility at lower wind speeds.

Field crews recorded the following information during each survey day:

- Survey date
- Start and end time
- Proportion of backchannels surveyed by boat and visible with binoculars if not surveyed by boat
- Global positioning system (GPS) track of the survey transect line
- Weather conditions at the start of surveys and any notable changes in weather
- Survey crew (including a third observer if present).

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, open river, riverbank, terrestrial)
- Distance to disturbance (Not disturbed, less than [<] 50 m, 50 m to <100 m, 100 m to <200 m, 200 m to 400 m, greater than [>] 400 m).

Waterbirds were identified to the most specific taxonomic classification possible. When species identification was not possible, birds were identified by genus or foraging guild. Only those birds that could not be identified at any of these levels were classified as “unidentified waterbird”. Two methods were employed to provide the data necessary to account for birds that were present during surveys but not detected by observers (i.e., incomplete detection). Distance sampling using line transect methods (Buckland et al. 2015) was applied starting in the fall of 2018 (and continuing throughout 2019, 2020, and 2021) by recording a track of each survey using a handheld GPS, from which distance can be calculated between the transect and each georeferenced waterbird record. Through data analysis, abundance and density estimates can be adjusted to account for birds not detected due to their distance from the survey transect based on the relationship between distance to birds from the path of the survey vessel (i.e., transect line) and the number of birds detected within various distance categories. Additionally, a subset of Peace River surveys have included a third observer to provide data that can be used to test assumptions of distance sampling (e.g., 100% detection along the transect line) and to specify the direction (i.e., positive versus negative) and magnitude of any resulting biases.

2.2 Transmission Line Wetland Surveys

Surveys of wetlands were designed and conducted to assess the abundance and diversity of waterbirds using wetland habitats along the transmission line ROW (i.e., transmission line wetlands) as per study objectives to document baseline conditions and to assess potential Project-related change from those conditions. The approach by which Project-related change will be assessed, as per Condition 11.4.3 of the FDS, is presented in **Section 2.2.1**. The specific methods applied during transmission line wetland surveys are detailed in **Section 2.2.2**.

2.2.1 Approach to Evaluating Change

The survey methods applied to the study were selected to provide habitat-specific estimates of waterbird density and diversity in order to assess impacts to waterbirds associated with the Site C transmission line and reservoir inundation. Density estimates, derived from relative abundance and detection rates or distance sampling data to account for incomplete detection, can be multiplied by the area of impacted habitat to estimate the abundance and species of birds (i.e., diversity) impacted by habitat changes within the transmission line footprint. Additionally, relative abundance and diversity metrics can be compared over time (e.g., before versus after reservoir inundation) to assess potential changes to wetland habitat use due to other impacts of the Project. Such impacts could include potential displacement of waterbirds from inundated river valley habitat into adjacent wetlands. The study provides data to compare abundances of waterbirds for habitat types surveyed before relative to after reservoir inundation (i.e., using a before-after analysis framework to assess change). A BACI study design framework will not be applied to assess change in the wetlands study area as there is no clear before period prior to which a transmission line was in place (due to a pre-existing transmission line), and there is no clear distinction between wetlands on the Moberly Plateau that would be affected by reservoir filling versus not, as required to define impact and control areas.

2.2.2 Survey Methods

Wetland survey stations assessed during surveys in 2021 and prior years contained one or more focal habitat type. Each wetland habitat type within a station was surveyed separately such that multiple surveys were often conducted at a single station in a single survey day or survey round. Three unique survey methods were applied across wetland habitat types. The methods applied were selected to minimize detection constraints specific to each habitat type and maximize the amount of information obtained on waterbirds:

- Fixed-length transects of vegetated habitat with water depths less than 50 cm, traversed on foot
- Stationary standwatch surveys of open water and flooded wetland habitat
- Bioacoustics monitoring using autonomous recording units (ARUs) of vegetated wetlands as well as transition zones between vegetated wetlands other habitat types (e.g., open water, forests).

2.2.2.1 Transect and Standwatch Surveys

Wetland survey effort was standardized either by length (100 metre [m] transects) or time (20-minute standwatch surveys). Transect surveys were conducted in 2021 within sedge and willow-sedge habitats along the transmission line ROW. This method was considered appropriate given that vegetation obstructed lines of sight within these habitat types, thereby preventing detection through stationary survey methods. Also, vegetated habitat with water levels below 50 cm could be safely traversed on foot, which allowed close visual inspection of the surveyed area and increased detection by flushing birds hidden amongst vegetation. Stationary standwatch surveys were conducted in areas with open water habitat and flooded wetlands, including areas with open water interspersed with vegetation where open water comprised an area of at least 0.25 hectares. Standwatch surveys are the most appropriate method for these habitats because visual lines of sight from ground level, or from a slightly elevated perspective, provide efficient visual detection of waterbirds on the water's surface across large areas.

Where necessary, the 20-minute standwatch survey was divided into two 10-minute segments at 2 vantage points, while being cautious to avoid double-counting birds. The same vantage points were used to survey open-water wetland stations during each survey round. Transects could not always be completed in a consistent time due to differences in conditions between stations and seasons such as variable terrain, vegetation, and water depth. However, transect surveys were targeted for completion within 5 to 10 minutes, and the time taken was recorded to account for differences in waterbird detections per transect due to differences in survey time and distance, if required. Wetland habitats at each station were surveyed once over a 2 to 3-day period (i.e., survey round). Two crews, each consisting of a biologist and a field assistant, completed wetland surveys during daylight hours between 07:00 and 18:00. The biologists were experienced in visual and vocalization identification of wetland bird species and were trained in survey protocols as well as wetland habitat characterization (i.e., identification of habitat types). Sedge and willow-sedge wetlands with water levels less than 50 cm were surveyed with at least one, and a maximum of 3 transects at each wetland station. Where multiple wetland types were present within wetland stations, transects were conducted within distinct habitat types to provide data specific to each type. Transects were generally straight but followed meandering routes where necessary to stay within target habitat types or safe terrain. Transect surveys targeted vegetated wetlands with a minimum width of 5 m of the target habitat type (e.g., sedge and/or willow-sedge habitat) and a minimum of 2 m of such habitat on either side of the transect line.

Surveys were not conducted during sustained inclement weather such as high winds (i.e., >5 on the Beaufort scale) or moderate to heavy precipitation that would impede visibility within 1 km. As stated above, to align with provincial survey standards, surveys were not conducted under conditions that would compromise detection of waterbirds (e.g., frequent whitecaps or large waves).

The following information was recorded at each wetland survey station:

- Wetland station ID
- Date and time
- Survey lead and field assistant names
- Weather data (temp, cloud cover, wind, precipitation) recorded within the hour
- Extent (percent) of each habitat type within the wetland or survey station (e.g., percent open water)
- Estimated average water depth within sedge and willow-sedge habitat types in survey area.

The following information was recorded for each survey:

- Start and end time of survey
- Start and end UTM coordinates
- Survey method (transect, standwatch) and ID (transect 1, transect 2)
- Area of habitat surveyed (area of open water, width of contiguous habitat along transect)
- Extent (percent) of each habitat type present within the surveyed area
- Estimated water depth for each habitat type within the area surveyed
- Estimate of average vegetation height (measure of detection constraint)
- Extent (percent) of vegetation present within open water areas (for standwatch surveys).

The following information was recorded for each 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
- Estimated water depth (dry, >0 cm to 10 cm, 10 cm to 50 cm, >50 cm) where flock was observed
- Primary behavior
- Detection type (e.g., detected while flushing, flying, not disturbed)
- Distance from the observer and transect (for transect surveys).

The methods of taxonomic classification and species identification applied for wetlands surveys were the same as described for surveys of the Peace River in **Section 2.1.2**. As detailed above, habitat data were collected at 3 scales (i.e., waterbird records, survey, wetland station) for each bird or flock observed and at 2 scales for each survey (i.e., survey and station). This approach was taken to provide habitat association data for each waterbird record and to ensure that the size of wetland habitat patches and the habitat present within surrounding areas could be accounted for if either are found to be a factor affecting the abundance and/or diversity of waterbirds.

Wetland surveys were repeated within a subset of open water and flooded areas surveyed by standwatch methods to obtain a measure of the number of birds not detected during a typical survey (i.e., to inform detection rates). Transect surveys typically disturbed waterbirds, causing them to flush and leave the area, thereby altering abundances and leading to reduced numbers during repeated surveys. Consequently, repeated transect surveys were not informative of detection rates. Instead, distance to disturbance and from the transect was recorded during surveys of vegetated wetland habitat types to provide the data necessary to account for incomplete detection with distance sampling.

2.2.2.2 Bioacoustics Monitoring

Marsh bird species that can easily go undetected during standwatch and transect surveys (e.g., yellow rail [*Coturnicops noveboracensis*], American bittern [*Botaurus lentiginosus*]) were assessed with passive acoustic monitoring using ARUs (Song Meter 3 and Song Meter 4, Wildlife Acoustics Inc. Maynard, Massachusetts, USA). Passive acoustic monitoring using ARUs is particularly useful for detecting rail and bittern species as they have known call signatures but are rarely observed during time-constrained, daytime surveys due to scarcity on the landscape, cryptic appearance and behavior, and limited diurnal activity. Acoustic data from ARU deployments 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. ARUs are designed to record acoustic data (e.g., calls and songs of birds) at specified time intervals over a period of days, weeks, or months. ARUs were programmed to record acoustic data between dusk and dawn during the peak vocalization period for rails and American bittern (i.e., from May through July [Conway 2011]).

In 2021, bioacoustics monitoring with ARUs was primarily focused on habitat types in which yellow rail had been recorded most consistently in prior years (sedge-dominated habitats) because this was the only species recorded with ARUs and not by other survey methods in the previous 4 years of monitoring. Consequently, bioacoustic monitoring in 2021 primarily targeted sedge-dominated habitats. ARUs were also deployed in sedge-dominated habitat adjacent to open water, as this habitat type was only surveyed via bioacoustics monitoring at two locations in prior years. As in previous years, ARUs were deployed at multiple locations and most were moved acrouss multiple locations over the course of the survey period (mid-May through mid-August) to increase the number of locations and habitat types surveyed. However, one ARU was left in the same location throughout the entire survey period to provide information regarding temporal variability of detections within locations. The location selected for assessment of temporal variability was one where yellow rail had been detected in previously.

All ARUs were fitted with omnidirectional SMM-A1 microphones recording at a sample rate of 16 kHz and gain of 0 dB. The microphones were installed approximately 2 m above ground and were set up to record acoustic data from 30 minutes before dusk to 30 minutes after dawn. Dusk and dawn recording times are recognized automatically by the internal GPS and clock of the ARU, which accurately detects the time zone where the ARU is recording. ARUs were deployed and recorded data for a minimum of one week (i.e., 7 nights) at each site.

2.3 Habitat Assessment

Habitat types within the Peace River and wetland study areas were summarized in 2017 from existing TEM data using ArcGIS Desktop (v.10.5.1) software (Hemmera 2018). The TEM data were complimented with satellite imagery and observations from the field to refine wetland and river habitat type designations within study areas.

2.3.1 Peace River

Within the Peace River, waterbird habitat was classified into 4 types based on connectivity to the river and associated water flow rates and depths: Mainstem, Moderate Flow, Limited Connectivity, and Minimal Connectivity. Polygons of these habitat types were delineated across the study area using satellite imagery and notes regarding water depth collected during 2017 through 2021. Characteristics for each habitat type are detailed in **Table 1**. Habitat characteristics associated with flow rate and connectivity to the Peace River were considered relevant to waterbirds because they correspond with substrate type, the amount and type of aquatic vegetation available as a foraging resource for waterbirds (e.g., dabbling ducks, large dabblers), and the abundance and availability of other waterbird prey (e.g., fish and invertebrates). Additionally, water depth is known to influence habitat selection and species composition, with dabbling ducks selecting habitat along a depth gradient relevant to their morphology, and piscivorous as well as benthic feeding divers typically preferring deeper water (Baschuk et al. 2012; Colwell and Taft 2000).

Portions of the river classified as Minimal Connectivity habitat were not accessible by boat and therefore were not surveyed in 2020 and 2021. Limited Connectivity habitat was also inaccessible by boat in a small proportion of areas (**Table 2**) and more broadly when river levels and associated flow rates were low. Despite these constraints on river boat survey methods, the power analysis conducted using data collected from 2017 through 2019 specified that surveys of areas accessible by boat would provide sufficient power to detect changes in waterbird abundance for all foraging guilds (**Appendix A**).

A photograph showing an example of the Mainstem river habitat type within the Peace River is presented in **Photo 1**, with a photograph of Moderate Flow and Limited Connectivity river habitat types in **Photo 2**.

Table 1 Characteristics of River Habitat Types Used to Delineate Polygons along the Peace River

River Habitat Type	Characteristics
Minimal Connectivity	Minimal or no connectivity to the river (e.g., lentic water features) except during extreme high water or flooding events with minimal or no flow and silty or otherwise fine-grained substrates and mostly shallow, including ephemeral ponds. Both emergent and submergent aquatic vegetation proliferates in these habitats.
Limited Connectivity	Limited connectivity to the river (e.g., backchannels primarily connected to the river at the downstream end) with relatively low flow rate and volumes, fine substrates (e.g., silts and sands) and many shallow areas only inundated when river levels are high. Submergent aquatic vegetation occurs along the shoreline in these habitats.
Moderate Flow	Consistently connected to the river (e.g., side channels connected on up- and downstream ends) with relatively moderate flows, moderately sized substrates (e.g., sand, gravel) and shallow waters typically inundatating most of the river bed. Aquatic vegetation is sparse.
Mainstem	Main channel of the river where water flow rates, depths, and substrate size (e.g., gravel, cobble) are greatest. Permananently inundated with aquatic vegetation sparse or absent.

Photo 1 Example of the Mainstem River Habitat Type.

Photo 2 Example of the Moderate Flow (center/right) and Limited Connectivity (left) River Habitat Types.

The total length of river within the study area is 142.5 km; 78.1 km in the Inundation Impact area (**Figure 2**), 18.0 km in the Flow Impact area (**Figure 3**), and 46.5 km in the Control area (**Figure 4**). The total river area assessed in this study, including side channels and wetted backchannels, varies depending on water levels associated with discharge rates from the Peace Canyon dam and tributaries to the Peace River. The total mapped area of the Peace River as defined within TEM data is 56.78 square kilometres (km^2), with 27.98 km^2 in the Inundation Impact area, 5.98 km^2 in the Flow Impact area, and 22.77 km^2 in the Control area (**Table 2**). These statistics represent wetted areas under typical water levels. The actual wetted area in each treatment area varies from day to day and across survey rounds in association with precipitation rates, snow melt, and other factors.

All 4 river habitat types described in **Table 1** are present within the Inundation Impact and Control treatment areas (**Table 2**), and all habitat types but Minimal Connectivity are present and accessible by boat within the Flow Impact area. Mainstem habitat comprises the vast majority (77%) of the area of the Peace River, followed by Moderate Flow habitat (13%). Minimal and Limited Connectivity habitat comprise 4% and 6% of the total study area, respectively.

Table 2 Area of River Habitat Types, as Defined by Flow Volume and Connectivity, within the Peace River Study Area by Treatment Areas

Treatment Area	River Habitat Type Areas (km^2)				Total (km^2)	Boat Access (km^2)
	Minimal Connectivity (Boat Access)	Limited Connectivity (Boat Access)	Moderate Flow	Mainstem		
Control	0.93 (0.00)	1.14 (1.08)	4.23	16.47	**22.77**	**21.78**
Flow Impact	0.05 (0.00)	0.35 (0.35)	0.32	5.31	**6.03**	**5.98**
Inundation Impact	1.42 (0.00)	1.89 (1.83)	2.93	21.73	**27.98**	**26.48**
Total	**2.40 (0.00)**	**3.39 (3.25)**	**7.47**	**43.51**	**56.78**	**54.24**

Note: Minimal Connectivity habitat and some Limited Connectivity habitat were not accessible for boat surveys. The areas accessible by boat for these habitat types are provided in parentheses next to their total areas.

Water flow and depth are known to influence the abundance, distribution, and species composition of waterbirds within wetland systems (Colwell and Taft 2000; Baschuk et al. 2012). These factors are particularly important to consider on the Peace River given the pronounced fluctuations in flow associated with hydroelectric dams and the presence of the Peace Canyon dam immediately upstream of the study area. Flow data were obtained from monitoring stations within each treatment area (Inundation Impact, Flow Impact, Control), since flows in each of these areas are uniquely influenced by inputs from tributaries along the course of the Peace River. Hourly flow data were summarized using SigmaPlot (v.12.5) to illustrate the frequency of flow rates within each treatment area. To determine if surveys were conducted under representative flow conditions, frequency distributions of hourly river flow rates throughout the spring and fall of 2017 through 2021 were compared to frequency distributions from hours during which surveys were conducted in those years. Following subsequent years of data collection, flow rate data can also be used as a habitat variable in models describing waterbird distribution within the Inundation Impact area prior to inundation and within the Flow Impact and Control areas before and after inundation. After inundation, reservoir water level changes within the Inundation Impact area are expected to be minimal, with the exception of short duration changes due to relatively rare, extreme events.

2.3.2 Transmission Line Wetlands

The terrestrial ecosystem mapping (TEM) data developed for the Peace River Terrestrial Ecosystem Mapping Project (Keystone Wildlife Research Ltd. 2012) was also used to identify 6 habitat types with potential to be used by waterbirds across the wetlands study area (**Table 3**). Wetland surveys within Labrador tea-sedge and Tamarack-sedge were discontinued as of 2019 due to a lack of observed use by waterbirds (**Table 3**). Consequently, wetland waterbird surveys in 2021 were focused on survey stations encompassing open water, sedge, and willow-sedge habitats.

Table 3 Wetland Habitat Types Adjacent to the Project Transmission Line ROW and Observed Presence

Wetland Habitat Type	Characteristics	Consistent Waterbird Observations in 2017 and 2018?
Open water (OW)	Open water with no (or limited) emergent vegetation, including shallow open water (less than 2 m depth), as well as ponds, and lakes transitioning or connected to wetlands	Yes
Tamarack-sedge (TS)	Fen with tamarack-dominated overstorey	No
Sedge (SE)	Uniform sedge (*Carex* sp) flat low area with less than 10% willow – birch. Typically wetted and often with standing water.	Yes
Labrador tea-sedge (BT)	Labrador tea-dominated peat bogs, often with black spruce overstory	No
Willow-sedge (WS)	Sedge (*Carex* sp.) meadow with scattered (>10%) willows/scrub birch. Often bordering sedge habitat in slightly elevated and areas with less standing water than sedge habitat	Yes
Cultivated field (CF)	Only considered if wetted and/or water source or wetland occurs within 100 m	No

Wetland habitat area has not changed appreciably since 2017, such that the proportional extent of habitat types is expected to have remained unchanged through 2021. According to the TEM data, the most widespread wetland habitat types in the study area are Labrador tea-sedge and tamarack-sedge (**Table 4**, **Figure 5**). Sedge and open water are less widespread, and willow-sedge is the least common wetland habitat type. Habitat data was collected with waterbird observations as described above in **Sections 2.1** and **2.2** for each survey method.

Table 4 Area of Wetland Habitat Types in the Peace River Valley and Moberly Plateau Study Area

Wetland Habitat Type	Area (ha)
Labrador tea-sedge	7,243
Tamarack-sedge	4,749
Cultivated field	3,845
Sedge	1,782
Open water	1,535
Willow-sedge	720
Non-forested floodplain wetlands	440

Note: Habitat areas presented here are derived from TEM data developed for the Peace River Terrestrial Ecosystem Mapping Project (Keystone Wildlife Research Ltd. 2012).

Photographs showing examples of standwatch and transect surveys and habitats surveyed by the respective methods are provided in **Photo 3**, **Photo 4** and **Photo 5**. An example of a waterbird observation within open water habitat is provided in **Photo 6**.

Photo 3 Example of a wetland standwatch survey of open water habitat within station OW-06.

Photo 4 Example of a transect survey of sedge-dominated wetland within station SE-04.

Photo 5 Example of a transect survey within a willow-sedge and scrub birch-dominated wetland within station WS-03.

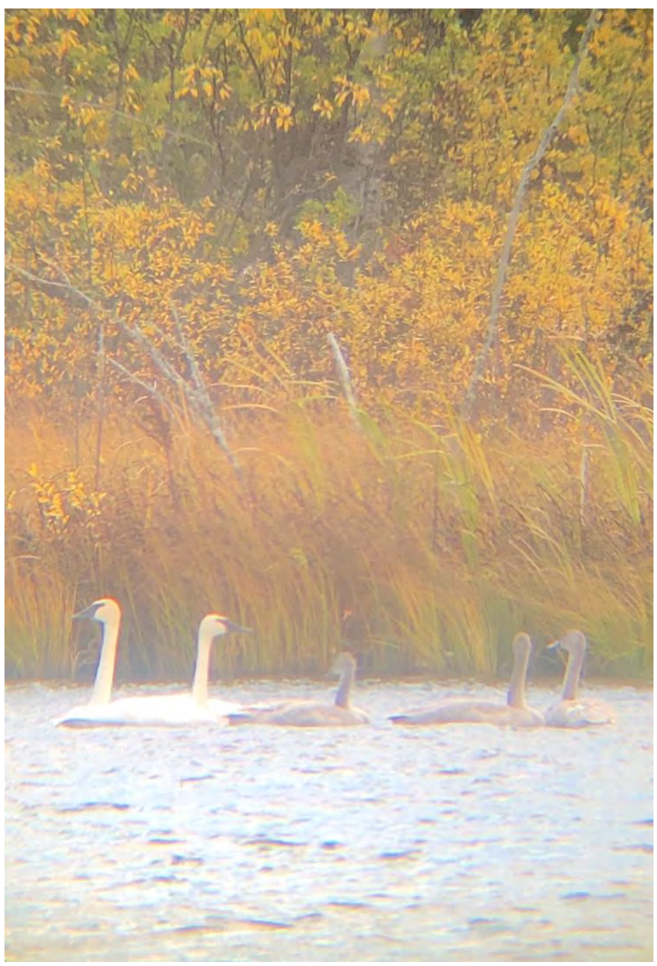
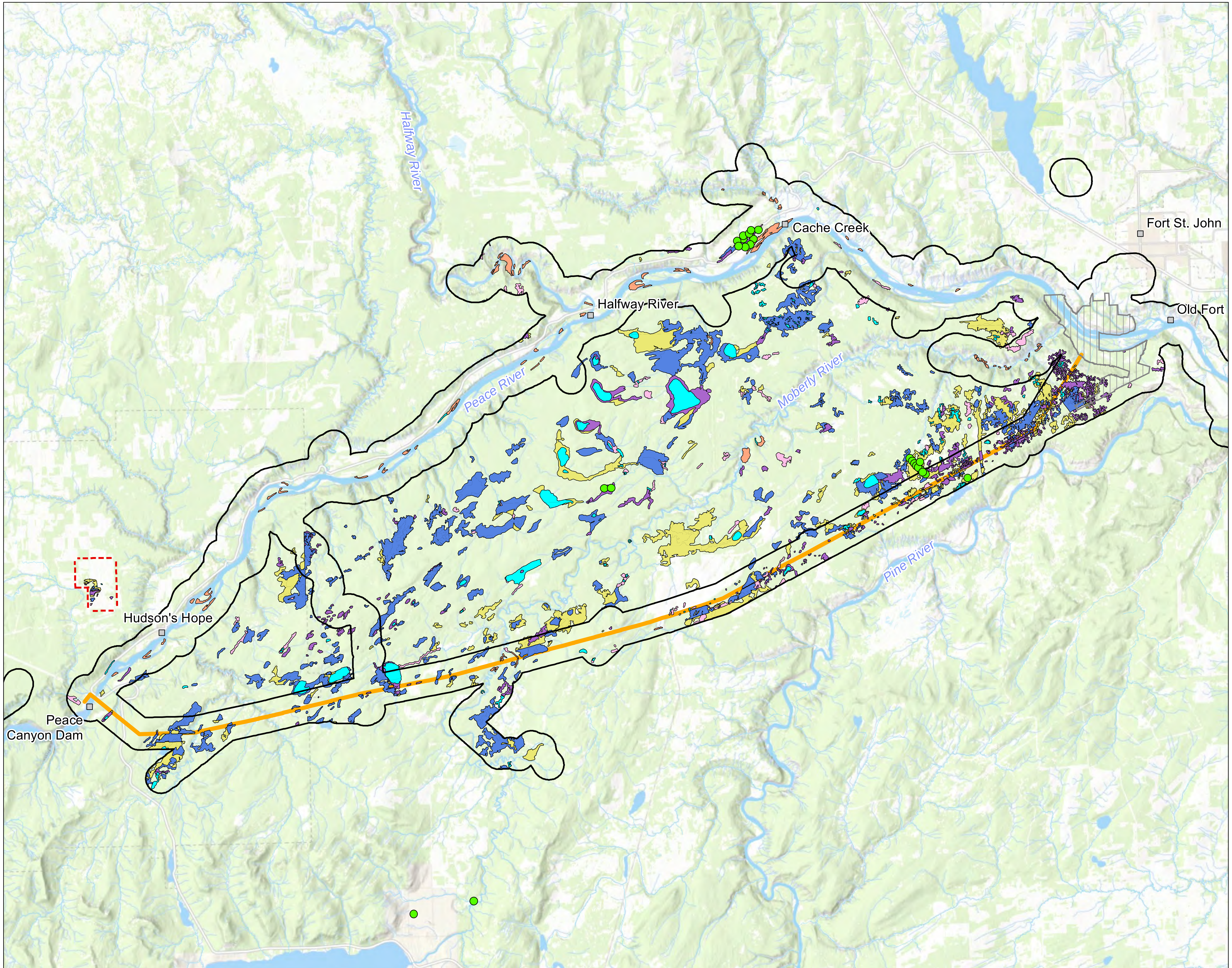


Photo 6 Trumpeter swan (*Cygnus buccinator*) adults and juveniles using open water wetland habitat within station OW-06

Migratory Waterbird Follow-up Monitoring Program
2021 Report
Site C, Peace River, BC

Figure 5 - Wetland Habitat Types and Historic Yellow Rail Detections in and Adjacent to the Peace River Valley and Transmission Line Route



Legend

- Site C LAA
- Proposed Dam Site
- Marl Fen Property - BC Hydro Wetland Compensation Site
- Transmission Line Right-of-Way
- Historic YERA records (prior to 2017) from eBird and Baseline Studies

Wetland Types

- Labrador-tea – sedge (BT)
- Non-forested floodplain wetland (WH)
- Sedge (SE)
- Open water (OW)
- Tamarack-sedge (TS)
- Willow sedge (WS)

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.
3. 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.

Sources

- Basemap: ESRI World Topographic Base

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3.0 DATA MANAGEMENT AND ANALYSIS

This section details the methods applied for data management (e.g., QA/QC and compilation) as well as calculation of summary statistics for waterbird abundance and diversity by season, survey period, and habitat type for Peace River and wetlands study areas as well as by treatment area for the Peace River study area.

3.1 Data Management

Waterbird records from 2021 surveys were screened and vetted for accuracy. Any outlying records (e.g., high counts, rare species) were verified by confirming with field staff and, where possible, by reviewing data sources such as hardcopy data forms, survey notes, and ARU recordings. Once these quality assurance (QA) measures were applied to identify anomalous species or counts, data from the current year were appended to a relational database management system (Microsoft Access) holding data from previous survey years.

3.2 Data Analysis

As in previous years, the scope of this annual report is limited to descriptive statistics (e.g., ranges, means, and variability around means). These statistics are presented to demonstrate that survey methods are capturing the targeted foraging guilds across all study areas and treatment areas within relevant time periods and habitat types, as required to meet the study objectives. Metrics of waterbird diversity and relative abundance are reported for each foraging guild within study areas, treatment areas, seasons, survey periods, and habitat types. A full list of species observed and the guilds to which they are assigned is presented in **Appendix B-1**.

Measures of abundances in this report are presented in terms of relative abundance because they represent the number of waterbirds detected, rather than absolute abundances. Measures of the proportion of birds not detected were obtained during surveys and are available to provide estimates of absolute abundance in future analyses of Project-related effects following data collection from the operations period. More specifically, distance and repeated survey data were collected (as described in **Section 2.1.2** and **2.2.2.1**) to provide measures of detectability and allow for estimates of absolute abundance in future analyses to assess the magnitude and significance of Project-related change. Throughout the remainder of this report, the terms abundance and density refer to relative abundance and relative density, as summary statistics are not corrected for detection rate via distance sampling or other means. Relative abundance refers to a measure, or index, of abundance that can reveal changes over time (e.g., between baseline conditions and Project operations conditions). While relative abundance does not necessarily reflect the true and exact number of individuals, generally referred to as absolute abundance, it is a standard measure recognized as appropriate in British Columbia (BC) for monitoring studies assessing change (RIC 1998). Measures of relative abundance are reported in terms of density per unit of survey area or transect length except in cases where abundances are reported for an entire study area (e.g., the Peace River study area) in which case the relevant area is known and is specified within the results (see **Section 4.1.2**).

Waterbird diversity is presented for each survey period, with averages calculated as means across years, in terms of species richness (i.e., the number of species) and species evenness (i.e., the degree of similarity in abundance of each species) using Pielou's evenness index. Additionally, a full list of the species observed was developed including the cumulative number of each species recorded across all study years and during 2021 monitoring. The equation for calculating Pielou's evenness index is reported by MacDonald et al. (2017):

$$Species\ evenness = \frac{(-\sum_{i=1}^{s}(p_i \times \ln p_i))}{(\ln S)}$$

Where *S* is the number of species (i.e., species richness), p_i is the proportion of all sampled waterbirds represented by species *i,* and *ln* is the natural logarithm. MacDonald et al. (2017) generally recommend against using indices that combine measures of species richness and evenness (e.g., Shannon-Wiener index) for measuring changes in biodiversity because of the subjective nature of weighting diversity by evenness and outputs (e.g., indices) that are difficult to meaningfully interpret.

3.2.1 Peace River Waterbird Surveys

Waterbird data from Peace River surveys were summarized to provide mean measures of abundance and diversity across survey periods and seasons, and mean measures of density and abundance by habitat type and treatment area for each foraging guild. To calculate mean abundance and diversity measures for each survey period, density estimates were averaged first across survey rounds within survey periods of each year, then averaged across across years. To compare the number of waterbirds observed across habitat types and treatment areas, density measures were calculated in addition to abundances to provide a measure that accounts for the variable size of habitat types and treatment areas. To account for variable survey timing across years (e.g., some survey periods were not surveyed in all years), mean measures of density and abundance for each habitat types and treatment areas were calculated each survey period in each year, then averaged across years to provide average measures for each survey round across years, and averaged across survey rounds to provide average measures for each season.

To calculate measures of abundance and density, survey data were initially summarized in terms of the number of birds/ha within polygons of distinct habitat types in each study area. Each waterbird detection was assigned to the habitat polygon in which the bird was recorded in or closest to (i.e., birds within the polygon, on the shoreline, or within 100 m of the polygon) and dividing cumulative counts from all combinations of habitat type and treatment area (**Table 1**) by the area of those factors that was surveyed during each survey round. Abundance data were summarized for each treatment area and habitat type by multiplying these density estimates (birds/km^2) by the total area within each treatment area and by the total area of each river habitat type within the study area as a whole for each survey round. Determining densities based on assigning waterbird records to habitat polygons is a method that has been applied to other monitoring studies of wetland and riverine systems in British Columbia (Gill and Craig 2020). This method provides improved resolution for density determinations compared to estimates based on river length (e.g., birds/km), as it allows for separate estimates of density in unique habitats that occur within each of the treatment areas. Additionally, the use of density by area estimates is aligned with the statistical power analyses that informed the level and timing of survey effort in 2020, in which measures of survey effort used to generate estimates of statistical power were adjusted based on the area covered during each round of surveys (**Appendix A**).

To provide comparabale measures of diversity based on equivalent survey effort across surveys rounds, diversity statistics were derived from data collected in areas that were surveyed consistently in all completed survey rounds. Consequently, diversity estimates were derived from survey data collected from Mainstem and Moderate Flow habitat types, as these areas were accessible by boat during both low and high river flow conditions. These habitat types comprise the vast majority (approximately 90%) of the study area (**Table 2**). While some species that forage predominantly in shallow and low flow habitats may be missed by these limited summaries of diversity, subsequent analyses of Project-related effects can apply more sophisticated analytical methods (e.g., species rarefaction / accumulation curves) to account for variable survey effort. A complete list of the species and numbers of individual waterbirds observed is presented within **Appendix B** of the report.

Data from surveys that did not cover the entire study area due to logistical constraints or inappropriate survey conditions were excluded from calculations of abundance and diversity. However, these data will be maintained within the monitoring program database and can be incorporated into more sophisticated analyses of Project-related effects in future years. Such analyses were considered beyond the scope of annual baseline monitoring reporting.

3.2.2 Transmission Line Wetland Surveys

Data from surveys conducted annually from 2017 through 2021 were summarized to provide estimates of average (mean) density and diversity for both standwatch and vegetated transect surveys. For transect surveys, the number of birds of each foraging guild observed in sedge and willow-sedge habitat were determined for each 100 m transect survey conducted. The mean number of birds observed per transect was calculated and extrapolated to an estimate of density per kilometre of transect by multiplying survey results by a factor of 10 (i.e., 10 x 100 m = 1 km). Data collected from standwatch surveys were used to provide estimates of density at stations with open water, and an average estimate of density was calculated across all these stations for each foraging guild based on the area of open water (i.e., total number of birds observed divided by total area surveyed). Summarization of diversity statistics from wetland waterbird surveys was completed to provide estimates of mean diversity for each survey period, averaged across survey periods within years and then across years. Cumulative species richness for each foraging guild was also calculated for habitats surveyed by both standwarch and transect methods and the proportion of species within each foraging guild was determined.

Acoustic data were downloaded and analyzed using a cluster analysis method in Kaleidoscope Pro V.5.1.9 (Wildlife Acoustics, Inc.), followed by manual verification. Cluster analysis groups bird songs with similar parameters such as minimum and maximum frequency range of the song, duration of the song and inter-syllable gap. Reference songs of sora, yellow rail, and American bittern were obtained from the Cornell Laboratory of Ornithology (Macauley Library), and Xeno-canto (www.xeno-canto.org) and characteristics for several songs from each of these species were matched to the groups of songs from the cluster analysis. Recorded songs suspected to be of sora, yellow rail or American bittern were aurally verified and checked against the reference calls from the Macaulay Library. Although the Peace Region is outside of the recognized range of Virginia rail (*Rallus limicola*) (Conway 2021), an incidental observation of this species at Watson Slough in 2019 prompted a review of recent species records in the region, which revealed multiple records in 2019 and 2020 (eBird 2021). Consequently, bioacoustics data recorded from ARU deployments in 2020 and 2021 were also analyzed to identify vocalizations of Virginia rail, also using the methods described above.

The number of nights that ARUs were deployed was recorded at each site and the results of acoustic data analyses were assessed as present or not detected for American bittern, sora, Virginia rail, and yellow rail at each monitoring station. Bioacoustics data cannot easily distinguish between individual birds to provide estimates of density at ARU monitoring sites. However, estimates of density for sora are provided from standwatch and transect surveys and all audio data has been archived for more detailed analyses if they are deemed necessary at a later date.

4.0 RESULTS

Results for the monitoring program from 2017 through 2021 provide an overview of habitat data as well as estimates of waterbird relative abundance and diversity metrics within habitat types, seasons, and, where possible, survey periods. Results are summarized together for all years of monitoring and are also presented separately for this year's (i.e., 2021) surveys.

4.1 Peace River Waterbird Surveys

This section describes the results of the Peace River component of the monitoring program including the temporal and spatial scope of surveys attained relative to survey objectives (**Sections 4.1.1** and **4.1.2**).

4.1.1 Survey Effort and Timing

In 2017, 2018, and 2019 the Peace River study area was surveyed during 5 survey rounds in the spring and 6 survey rounds in the fall (**Table 5**). Survey effort and timing in 2020 and 2021 was adjusted in accordance with a power analysis of the first 3 years of data (**Appendix A**), resulting in 2 surveys in spring and 3 surveys in fall (**Table 5**). In 2021, boat-based surveys were conducted on the Peace River during spring (April 6 to April 13, 2021) and fall (August 11 to October 6, 2021) waterbird migrations. Over the course of these first 5 years of the monitoring program, 45 survey rounds were attempted and a total of 41 surveys of the full length of the Peace River study area were completed (**Table 5**). Details are provided below regarding issues preventing completion of the other 4 surveys and a required third day for completion of 2 survey rounds.

Table 5 Peace River Survey Timing During 2017 Through 2021 Annual Waterbird Migration Monitoring

Survey Period	2017 Survey Dates	2018 Survey Dates	2019 Survey Dates	2020 Survey Dates	2021 Survey Dates
Spring					
Early (Apr 1 to Apr 14)	Apr 5, 6 Apr 12[2]	Apr 13, 14	Apr 3, 4, 8[1] Apr 11, 12	Apr 7, 8 Apr 13, 14	Apr 6, 7 Apr 12,13
Middle (Apr 15 to May 6)	Apr 26, 27 May 3, 4	Apr 25, 26, May 1[1] May 5, 6	Apr 19, 24[2] May 1, 2	Apr 23, 24[2]	No surveys
Late (May 7 to May 30)	May 10, 11 May 14, 15	May 10, 11 May 18, 19	May 9, 10	No surveys	No surveys
Fall					
Early (Aug 1 to Aug 14)	Aug 8, 9 Aug 14, 15	Aug 4, 5	Aug 7, 9	Aug 5, 6	Aug 9, 10
Early-Middle (Aug 15 to Sep 14)	Aug 22, 23 Aug 28, 29	Aug 20, 21 Sep 4, 5	Aug 19, 20 Sept 4, 5[2]	Aug 31, Sep 1	Aug 27, 28
Late-Middle (Sep 15 to Oct 14)	Sep 21, 22 Sep 27, 28	Sep 20, 21 Oct 4, 05	Sep 16, 17 Sep 30, Oct 1	Sep 29, Sep 30	Sep 27, 28
Late (Oct 15 to Oct 30)	No surveys	Oct 15, 16	Oct 16, 17	No surveys	No surveys

Note: When multiple survey rounds were completed within a survey period, survey dates from each round are presented on separate lines. [1]Two (2) days were typically required to complete surveys; however, inclement weather (e.g., heavy rain, snow, high winds), unsafe river conditions (e.g., release of ice-break up from tributaries into the Peace River), or logistical constraints (e.g., mechanical issues with boat) occasionally required a third day for surveys. [2]In other cases, survey conditions and logistical constraints did not allow for complete coverage of the study area within a week and resulted in an incomplete survey.

Incomplete surveys and surveys requiring a third day were typically the result of poor survey conditions or mechanical issues with the boat. Due to rain and wind speeds that exceeded survey standards (**Section 2.1.2**), the Control area was not surveyed during the second survey round of the early spring period in 2017. The first survey of middle spring 2018 and early spring 2019 were not completed within the usual 2 days because ice from the Pine River entered the Peace River and a third survey day was required to complete these survey rounds. In 2019, the first round of middle spring surveys was not completed due to mechanical issues with the river boat and a lack of alternative options within the survey window (**Table 5**). Finally, a survey round in the middle period of spring 2020 (conducted prior to finalization of the power analysis) was cut short at the confluence with the Beatton River due to release of an ice break-up preventing access to areas of the Peace River downstream of that tributary. All survey rounds in 2021 were completed successfully within two days each.

4.1.2 Habitat Assessment

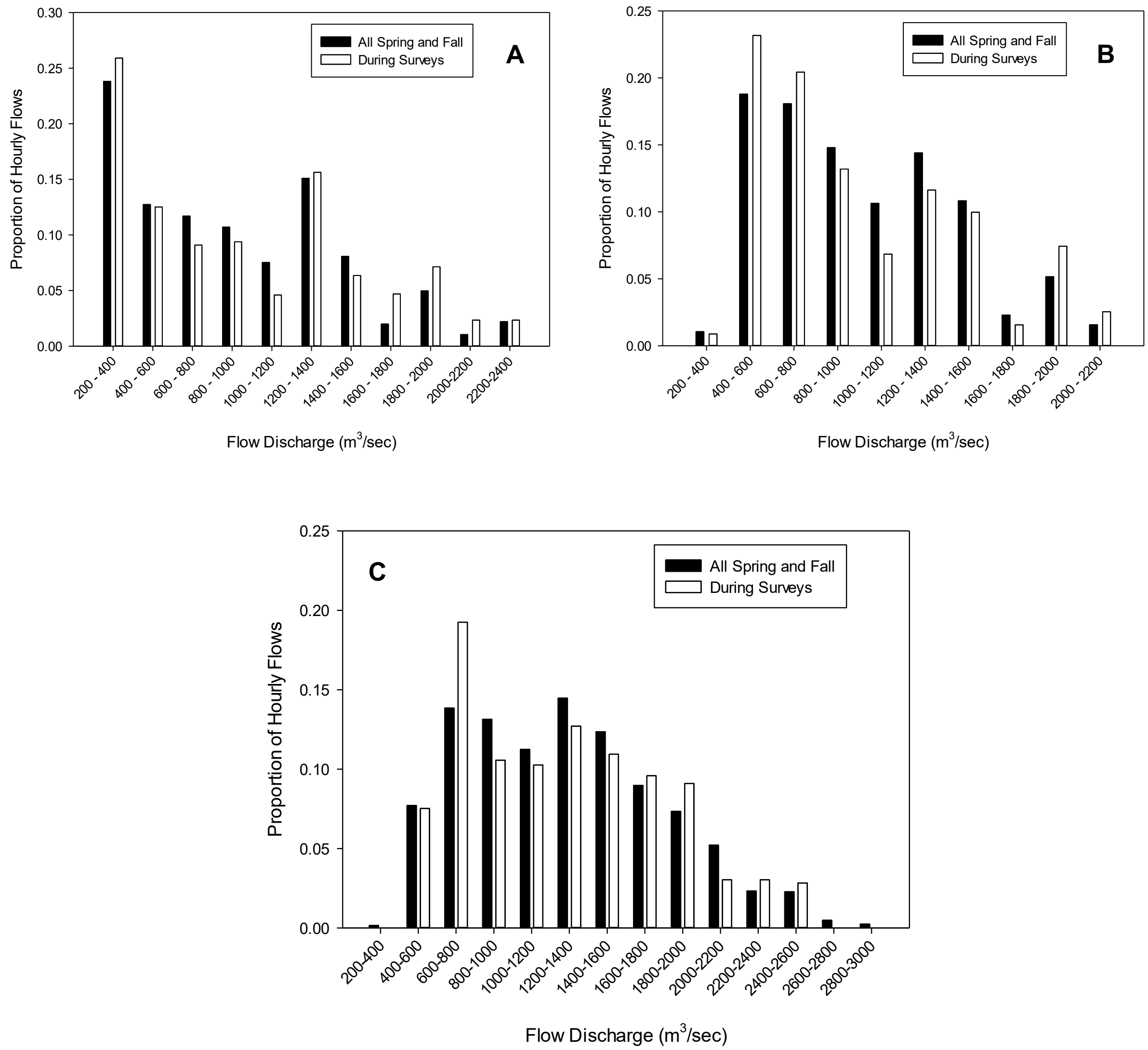
Locations with active hydrological monitoring gauges from which water flow data were obtained were as follows: Inundation Impact area - Hudson's Hope (2017, 2018)[1] and Peace Canyon Dam (2019, 2020, 2021); Flow Impact area - Old Fort (all years); Control area – Taylor (all years). The hydrological gauges are located within or adjacent to the towns they are named after in **Figure 1**. Water flow data from these monitoring stations during the spring and fall migrations of 2017 through 2021 are summarized across years, seasons, and treatment areas in **Table 6** and frequency distributions illustrating the flow regime throughout the spring and fall migration within each treatment area relative to flows during surveys are presented in **Figure 6**. Mean flow rates varied substantially across years and seasons, ranging from a low of 602 m^3/sec during the spring of 2019 to a high of 1,956 m^3/sec during spring 2021. Frequency distribution plots of flow rate data illustrated in **Figure 6** provide evidence that, across the 5 survey years, flow rates were similarly distributed and, thus, representative of flow rates throughout the spring and fall migration periods in all treatment areas. Similar figures are presented for 2021 flow rates during surveys relative to throughout spring and fall migration in **Appendix F**.

1 The Hudsons' Hope gauge was discontinued in 2019 to facilitate the placement of rip-rap for Site C reservoir shoreline erosion protection. Thus, in 2019, 2020, and 2021, flow data for the Inundation Impact area was collected from a gauge immediately downstream of the Peace Canyon Dam.

Table 6 Mean Hourly Water Flow Rates on the Peace River During Waterbird Surveys Across Years, Seasons, and Treatment Areas in 2017 Through 2021

Season	Year	Water Flow (m^3/sec) within Treatment Areas			
		Inundation Impact	Flow Impact	Control	Mean
Spring	2017	650	909	1,412	**991**
	2018	594	862	1,626	**1,027**
	2019	520	559	725	**602**
	2020	1,383	1,364	1,492	**1,413**
	2021	1,943	1,953	1,972	**1,956**
Fall	2017	1,409	1,363	1,445	**1,406**
	2018	1,086	1,129	1,232	**1,149**
	2019	847	787	982	**872**
	2020	1,565	1,687	1,869	**1,707**
	2021	711	693	806	**737**

Note: Flow discharge rate data for the Inundation Area were collected from Hudson's Hope in 2017 and 2018 and from Peace Canyon Dam in 2019, 2020, and 2021. Data for the Flow Impact and Control area were collected from Old Fort and Taylor (downstream of the Pine River confluence), respectively. Data includes hourly flow rates during the day (0600 to 1800 hours) from the dates when Peace River waterbird surveys were conducted (**see Table 5**).



Note: Flow discharge data in the Inundation Area were collected from Hudson's Hope in 2017 and 2018 and from Peace Canyon Dam in 2019, 2020, and 2021, during April 1 to May 31 (spring migration) and August 1 to October 31 (fall migration). Data for the Flow Impact and Control area were collected from Old Fort and Taylor (downstream of the Pine River confluence), respectively, during the same dates.

Figure 6 Distribution of hourly flow rates (shown as proportion of total) in the Inundation Impact (A), Flow Impact (B), and Control (C) treatment areas during surveys relative to across spring and fall migrations in 2017 through 2021.

4.1.3 Abundance and Density

As in previous years, waterbirds were observed along the entirety of the Peace River study area in spring and fall of 2021 (see waterbird location figures in **Appendix C: Figures C-1 to C-4**). There were a total of 76,197 individual waterbirds observed during Peace River boat surveys in 2017 through 2021 of which 93% were identified to species (**Appendix B-1**). In 2021, a total of 13,086 waterbirds were observed during Peace River boat surveys, of which 88% were identified to species (**Appendix B-2**).

Across all survey years, the highest mean waterbird abundances during spring were observed in the early survey period and, during fall, were found in the early-middle survey period (**Table 7**). Large dabblers, primarily Canada goose (*Branta canadensis*) (**Appendix B-1**), were the most abundant waterbirds overall, with the highest abundances observed during the early spring (more than 3 fold abundances observed during other survey periods). Dabbling ducks and gulls were the next most adundant guilds (**Table 7**). Estimates of foraging guild abundances specific to survey periods in 2021 are presented in **Table 8**, and estimates of interannual variability are presented in **Appendix E** (**Table E-7**).

Table 7 Mean Abundance Estimates (birds/survey round) of Waterbird Foraging Guilds within the Peace River During Spring and Fall of 2017 Through 2021

Foraging Guild	Spring Survey Periods			Fall Survey Periods				Average of Survey Period Means
	Early	Middle	Late	Early	Early-Middle	Late-Middle	Late	
Benthic Feeding Divers	169	168	23	2	21	14	5	**57**
Dabbling Ducks	1,006	661	489	102	308	345	51	**423**
Gulls	2	69	32	776	697	314	102	**284**
Large Dabblers	2,280	502	538	233	455	738	623	**767**
Piscivorous Divers	311	95	51	44	33	21	12	**81**
Shorebirds	1	6	115	216	130	4	0	**67**
Unknown Waterbirds	92	128	59	18	7	20	13	**48**
Total (All Waterbirds)	**3,861**	**1,629**	**1,308**	**1,391**	**1,652**	**1,455**	**805**	

Note: Mean abundances reflect relative rather than absolute abundances as they do not account for incomplete detection. Abundances within each survey round were calculated by extrapolating density estimates observed within each habitat across the entire study area to account for the areas not accessible by boat, which varied across survey rounds depending on water levels and boat access. Mean abundances were then calculated within each habitat type across survey rounds first within periods of each year, and then averaged across years.

Table 8 Mean Abundance Estimates (birds/survey round) of Waterbird Foraging Guilds within the Peace River During Spring and Fall of 2021

Foraging Guild	Spring Survey Periods			Fall Survey Periods				Average of Survey Period Means
	Early	Middle	Late	Early	Early-Middle	Late-Middle	Late	
Benthic Feeding Divers	152	-	-	2	1	6	-	**40**
Dabbling Ducks	2,422	-	-	64	689	31	-	**801**
Gulls	1	-	-	334	206	35	-	**144**
Large Dabblers	2,213	-	-	338	1,085	808	-	**1,111**
Piscivorous Divers	324	-	-	16	36	23	-	**100**
Shorebirds	0	-	-	224	206	3	-	**108**
Unknown Waterbirds	28	-	-	16	1	1	-	**11**
Total (All Waterbirds)	**5,139**	**-**	**-**	**993**	**2,224**	**907**	**-**	

Note: Mean abundances reflect relative rather than absolute abundances as they do not account for incomplete detection. Abundances within each survey round were calculated by extrapolating density estimates observed within each habitat across the entire study area to account for the areas not accessible by boat, which varied across survey rounds depending on water levels and boat access. Mean abundances were then calculated within each habitat type across survey rounds first within periods of each year, and then averaged across years. Dashes reflect no data collected during some survey periods as recommended by power analyses.

Totals of mean densities of waterbird foraging guilds determined for 2017 through 2021 varied across river habitat types, primarily reflecting the distribution of the most abundant guilds (i.e., large dabblers and dabbling ducks in spring [**Table 9**], gulls and large dabblers in fall [**Table 11**]). The highest mean densities of waterbirds observed across seasons and habitat types were in the spring within Limited Connectivity habitat. During spring, mean densities summed across foraging guilds were more than 10 times higher within Limited Connectivity habitat than in Mainstem habitat and approximately 4 times higher within Limited Connectivity habitat than in Moderate Flow habitat (**Table 9**, **Figure 7**, **Figure 8**, **Figure 9**). During fall, total waterbird densities across survey years were again greatest within Limited Connectivity habitat (**Table 11**). Mean densities during fall were higher in the Flow Impact area compared to other treatment areas (**Table 11**, **Figure 10**, **Figure 11**, **Figure 12**). Survey results specific to 2021 are presented in **Table 10** for spring surveys and **Table 12** for fall surveys. Variability statistics across years are provided for spring and fall in **Appendix E** in **Table E-9** and **E-11**, respectively.

Table 9 Mean 2017 Through 2021 Spring Densities (birds/km^2/survey round) and Estimated Abundances of Migrant Waterbirds by River Habitat Type and Treatment Area During

Foraging Guild	Density by River Habitat Type			Density by Treatment Area		
	Limited Connectivity	Moderate Flow	Mainstem	Inundation Impact	Flow Impact	Control
Benthic Feeding Divers	17.6	3.0	1.5	2.7	6.2	1.7
Dabbling Ducks	108.6	29.6	8.8	9.1	36.2	23.0
Gulls	0.0	<0.1	0.5	0.3	1.7	0.1
Large Dabblers	210.9	47.6	17.5	32.1	19.9	38.3
Piscivorous Divers	17.9	7.3	2.8	7.0	2.5	1.5
Shorebirds	3.4	1.1	0.2	0.6	0.6	0.4
Unknown Waterbirds	6.1	2.1	1.0	1.8	1.0	1.1
Total (All Waterbirds)	**364.7**	**90.8**	**32.2**	**53.5**	**68.1**	**66.2**
Estimated Abundance	**1,187**	**679**	**1,400**	**1,417**	**407**	**1,441**

Note: Mean densities reflect relative rather than absolute densities as they do not account for incomplete detection. Means were calculated by averaging density estimates (birds/km^2/survey) within each habitat type across survey rounds first within periods of each year, and then across years so that differences in sampling effort did not bias means towards results from years with more survey rounds. Total mean density is the sum of all foraging guild and unknown waterbird densities. Abundances calculated as density multiplied by area.

Table 10 Mean 2021 Spring Densities (birds/km^2/survey round) and Estimated Abundances of Migrant Waterbirds by River Habitat Type and Treatment Area

Foraging Guild	Density by River Habitat Type			Density by Treatment Area		
	Limited Connectivity	Moderate Flow	Mainstem	Inundation Impact	Flow Impact	Control
Benthic Feeding Divers	18.1	4.0	1.5	2.1	8.2	2.2
Dabbling Ducks	255.0	86.3	21.8	14.0	103.4	65.8
Gulls	0.0	0.0	<0.1	<0.1	0.0	0.0
Large Dabblers	245.6	71.2	20.3	47.7	24.2	36.9
Piscivorous Divers	20.7	12.9	3.7	9.9	1.3	2.5
Shorebirds	0.0	0.0	0.0	0.0	0.0	0.0
Unknown Waterbirds	0.0	0.5	0.6	0.8	0.0	0.3
Total (All Waterbirds)	**539.5**	**175.0**	**47.7**	**74.5**	**137.1**	**107.8**
Estimated Abundance	**1,756**	**1,307**	**2,077**	**1,972**	**820**	**2,347**

Note: Mean densities reflect relative rather than absolute densities as they do not account for incomplete detection. Means were calculated by averaging density estimates (birds/km^2/survey) within each habitat type across survey rounds first within periods of each year, and then across years so that differences in sampling effort did not bias means towards results from years with more survey rounds. Total mean density is the sum of all foraging guild and unknown waterbird densities. Abundances calculated as density multiplied by area.

Table 11 Mean 2017 Through 2021 Fall Densities (birds/km^2/survey round) of Migrant Waterbirds by River Habitat Type and Treatment Area

Foraging Guild	Density by River Habitat Type			Density by Treatment Area		
	Limited Connectivity	Moderate Flow	Mainstem	Inundation Impact	Flow Impact	Control
Benthic Feeding Divers	0.4	<0.1	0.2	0.3	0.3	0.1
Dabbling Ducks	38.6	6.5	1.0	5.0	10.4	1.1
Gulls	2.3	0.9	11.8	8.3	50.9	0.2
Large Dabblers	51.9	9.4	5.4	7.6	12.1	9.1
Piscivorous Divers	3.1	0.8	0.3	0.7	0.3	0.4
Shorebirds	8.6	3.7	1.0	1.7	0.9	2.2
Unknown Waterbirds	3.0	0.2	0.1	0.3	0.7	<0.1
Total (All Waterbirds)	**107.9**	**21.5**	**19.8**	**23.9**	**75.5**	**13.1**
Estimated Abundance	**351**	**160**	**860**	**634**	**452**	**285**

Note: Mean densities reflect relative rather than absolute densities as they do not account for incomplete detection. Means were calculated by averaging density estimates (birds/km^2/survey) within each habitat type across survey rounds first within periods of each year, and then across years so that differences in sampling effort did not bias means towards results from years with more survey rounds. Total mean density is the sum of all foraging guilds and unknown waterbird densities. Abundances calculated as density multiplied by area.

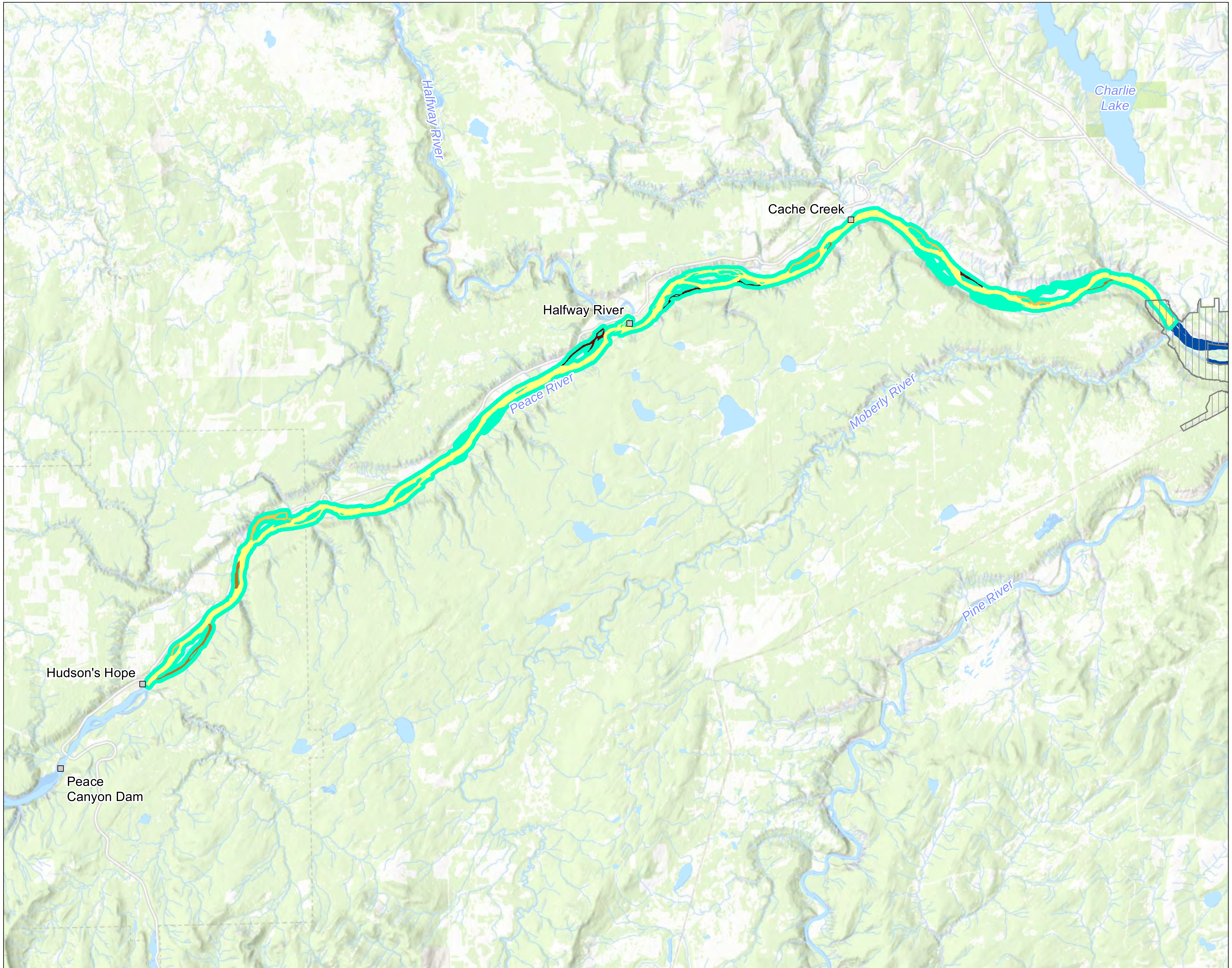
Table 12 Mean 2021 Fall Densities (birds/km^2/survey round) of Migrant Waterbirds by River Habitat Type and Treatment Area

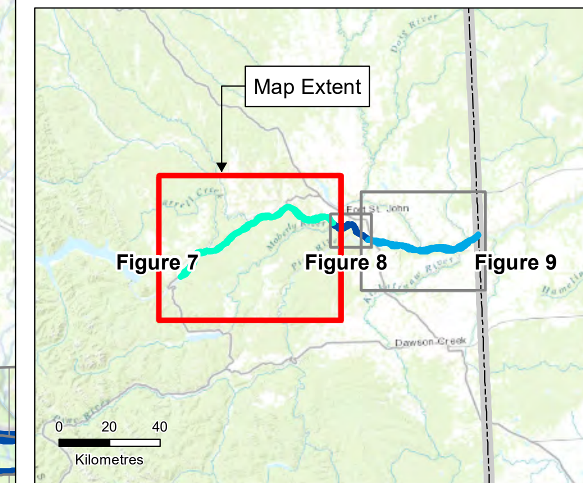
Foraging Guild	Density by River Habitat Type			Density by Treatment Area		
	Limited Connectivity	Moderate Flow	Mainstem	Inundation Impact	Flow Impact	Control
Benthic Feeding Divers	0.1	0.0	0.1	0.1	0.0	0.0
Dabbling Ducks	5.6	30.6	0.3	9.4	1.3	0.2
Gulls	0.4	1.3	4.1	6.5	2.6	0.2
Large Dabblers	78.2	21.3	7.6	13.2	14.1	14.2
Piscivorous Divers	0.5	0.6	0.4	0.7	0.4	0.2
Shorebirds	12.2	6.2	1.3	3.3	1.0	2.3
Unknown Waterbirds	1.3	0.2	<0.1	0.2	0.2	<0.1
Total (All Waterbirds)	**98.3**	**60.2**	**13.9**	**33.4**	**19.6**	**17.1**
Estimated Abundance	**320**	**450**	**605**	**886**	**117**	**372**

Note: Mean densities reflect relative rather than absolute densities as they do not account for incomplete detection. Means were calculated by averaging density estimates (birds/km^2/survey) within each habitat type across survey rounds first within periods of each year, and then across years so that differences in sampling effort did not bias means towards results from years with more survey rounds. Total mean density is the sum of all foraging guilds and unknown waterbird densities. Abundances calculated as density multiplied by area.

Migratory Waterbird Follow-up Monitoring Program
2021 Report
Site C, Peace River, BC

Fig. 7 - Mean Density (birds/km^2/survey round) of Spring Migrant Waterbirds within Inundation Impact Area Habitat Polygons from 2017 through 2021





Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area
- Proposed Dam Site

Waterbird densities (birds/km^2/survey round) by quartile [3]

- 0.09 - 0.63
- 0.64 - 0.79
- 0.80 - 2.33
- 2.34 - 7.96

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.
3. Waterbird density values were classified using approximate Quantile Breaks.

Sources

- Basemap: ESRI World Topographic Base

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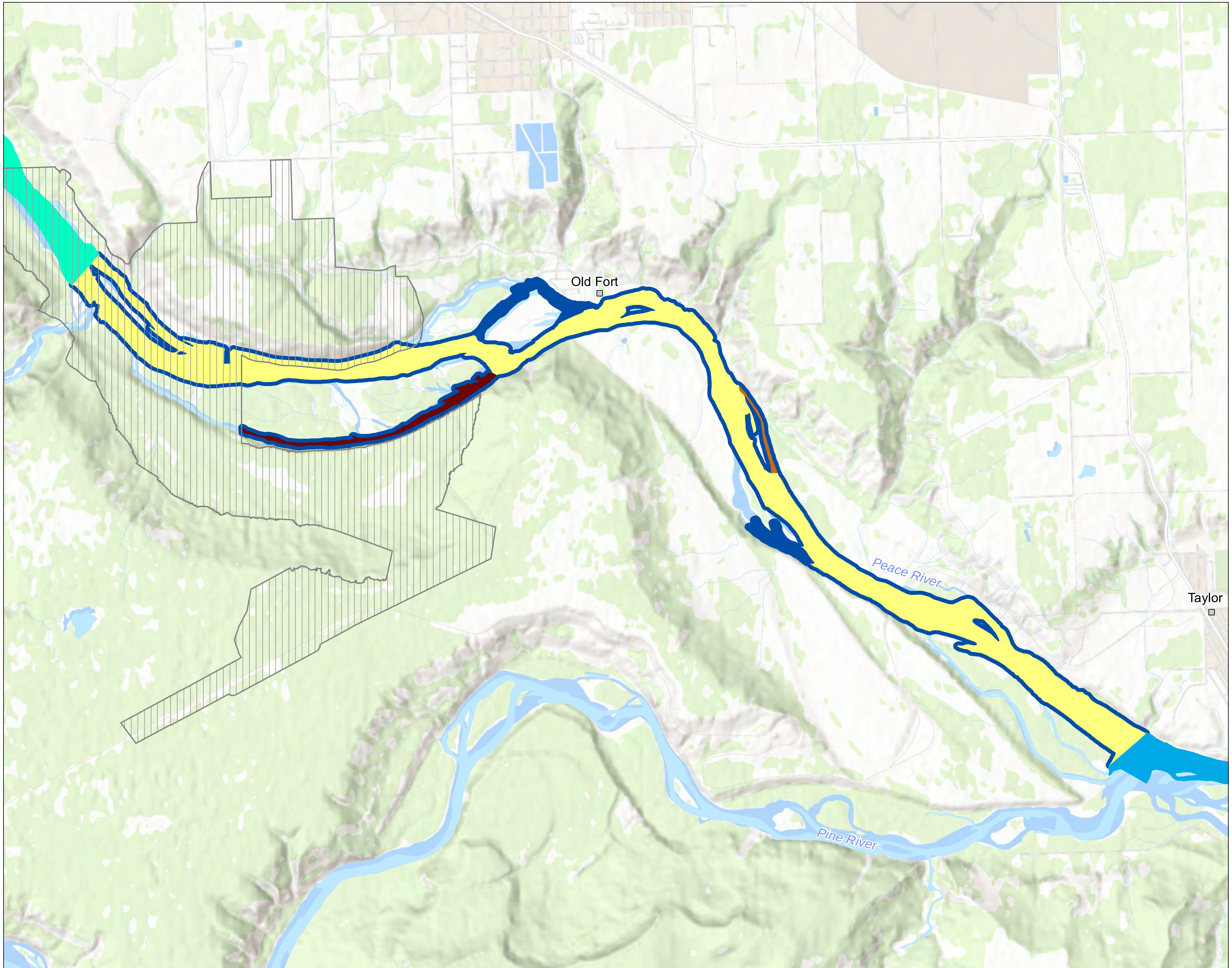
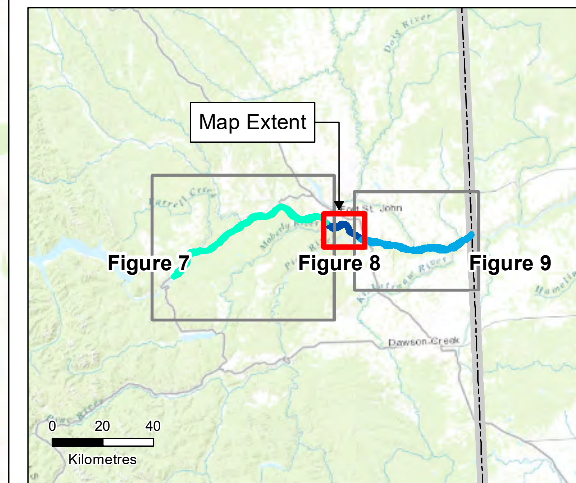
989619-07	Production Date: Jan 14, 2022	Figure 7

Hemmera An Ausenco Company BC hydro

Migratory Waterbird Follow-up Monitoring Program
2021 Report
Site C, Peace River, BC

Fig. 8 - Mean Density (birds/km²/survey round) of Spring Migrant Waterbirds within Flow Regime Impact Area Habitat Polygons from 2017 through 2021





Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area
- Proposed Dam Site

Waterbird densities (birds/km²/survey round) by quartile [3]

- 0.09 - 0.63
- 0.64 - 0.79
- 0.80 - 2.33
- 2.34 - 7.96

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Sources

- Basemap: ESRI World Topographic Base

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Hemmera An Ausenco Company

BC hydro

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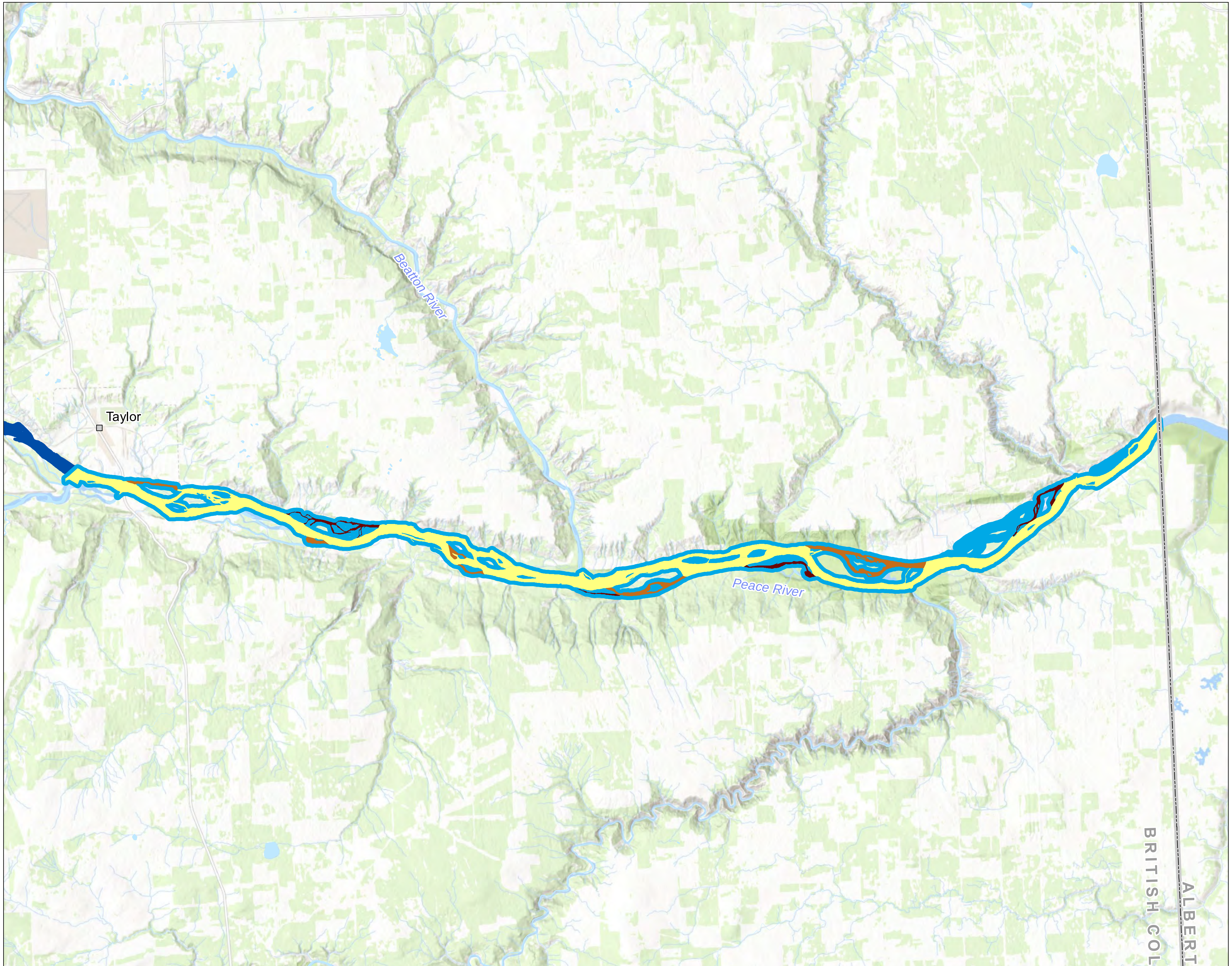
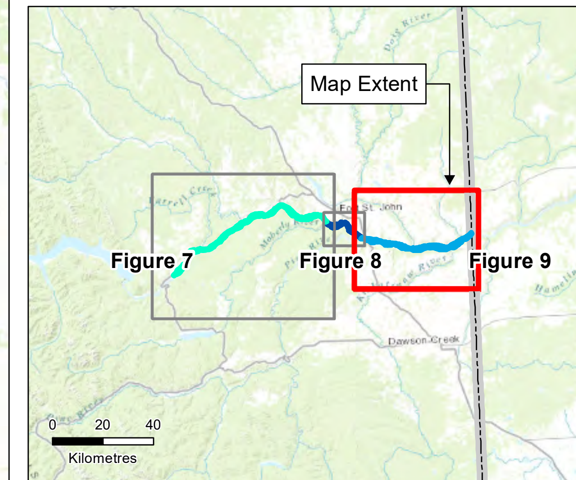


Migratory Waterbird Follow-up Monitoring Program
2021 Report
Site C, Peace River, BC

Fig. 9 - Mean Density (birds/km^2/survey round) of Spring Migrant Waterbirds within Control Area Habitat Polygons from 2017 through 2021



Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area

Waterbird densities (birds/km^2/survey round) by quartile [3]

- 0.09 - 0.63
- 0.64 - 0.79
- 0.80 - 2.33
- 2.34 - 7.96

Notes

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3. Waterbird density values were classified using approximate Quantile Breaks.

Sources

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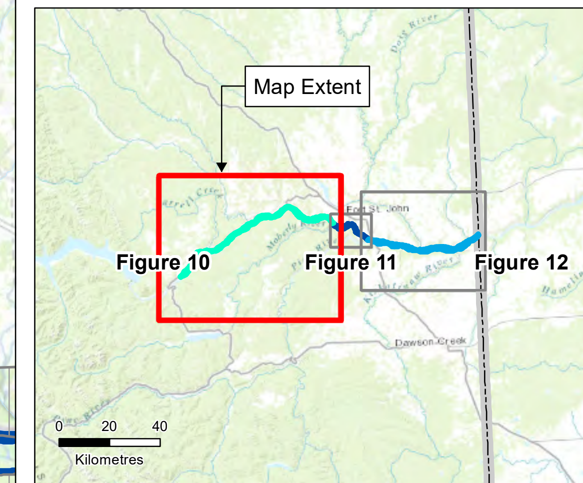
989619-07	Production Date: Jan 14, 2022	Figure 9

Hemmera An Ausenco Company

BC hydro

Migratory Waterbird Follow-up Monitoring Program
2021 Report
Site C, Peace River, BC

Fig. 10 - Mean Density (birds/km^2/survey round) of Fall Migrant Waterbirds within Inundation Impact Area Habitat Polygons from 2017 through 2021



Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area
- Proposed Dam Site

Waterbird densities (birds/km^2/survey round) by quartile [3]

- 0.08 - 0.14
- 0.15 - 0.23
- 0.24 - 1.10
- 1.11 - 3.13

Notes

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3. Waterbird density values were classified using approximate Quantile Breaks.

Sources

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989619-07	Production Date: Jan 14, 2022	Figure 10

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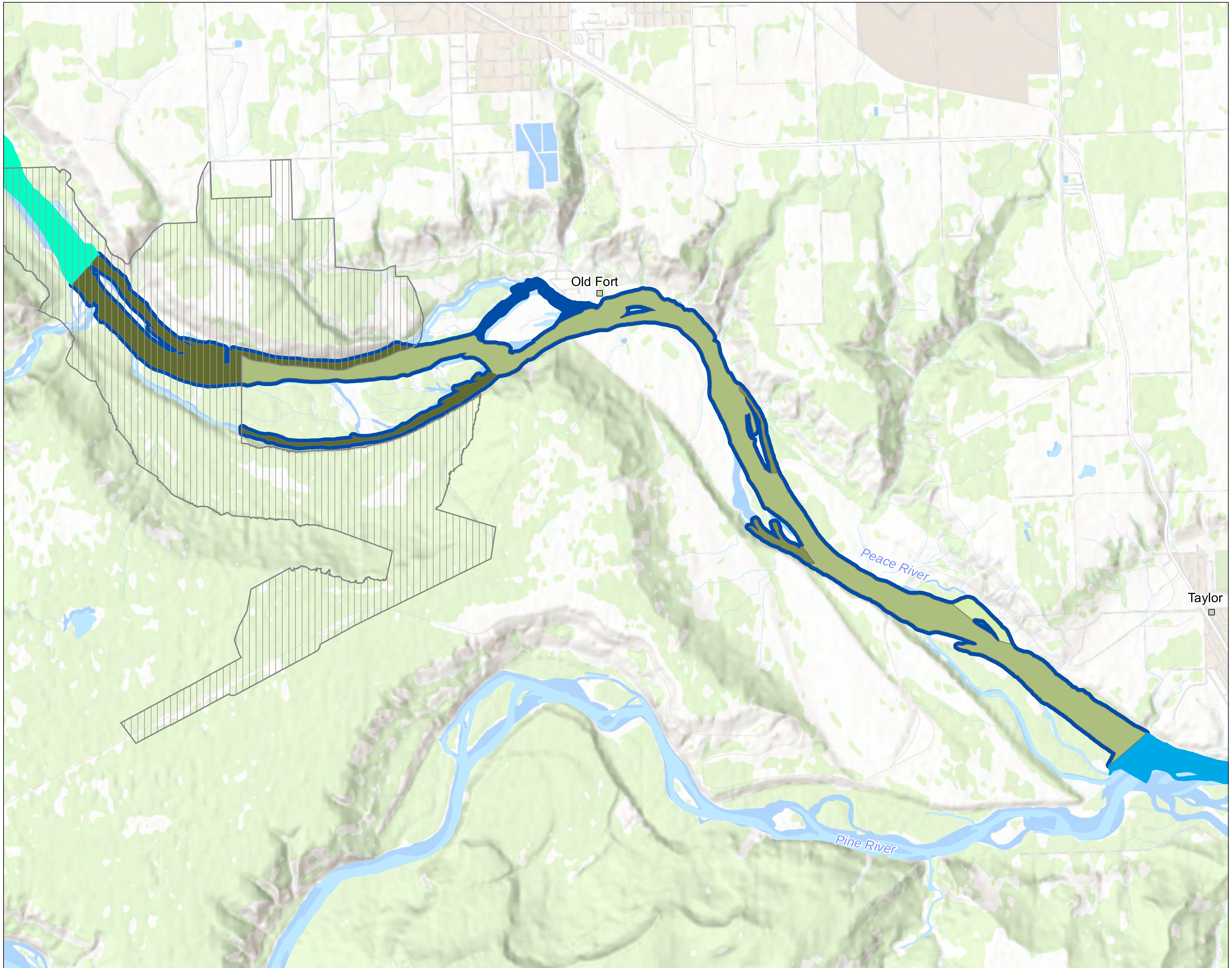
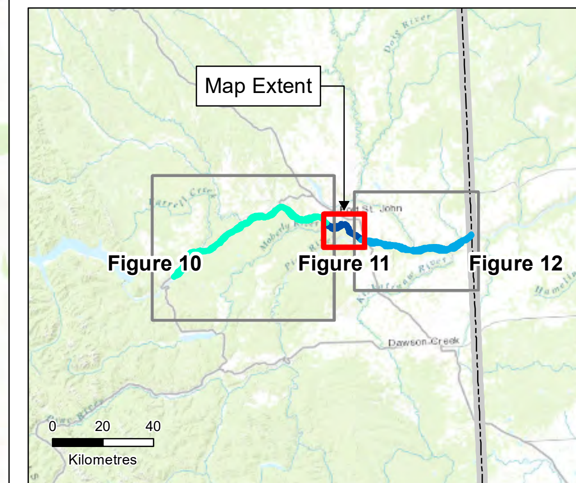
Migratory Waterbird Follow-up Monitoring Program
2021 Report
Site C, Peace River, BC

Fig. 11 - Mean Density (birds/km^2/survey round) of Fall Migrant Waterbirds within Flow Regime Impact Area Habitat Polygons from 2017 through 2021





Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area
- Proposed Dam Site

Waterbird densities (birds/km^2/survey round) by quartile [3]

- 0.08 - 0.14
- 0.15 - 0.23
- 0.24 - 1.10
- 1.11 - 3.13

Notes

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3. Waterbird density values were classified using approximate Quantile Breaks.

Sources

- Basemap: ESRI World Topographic Base

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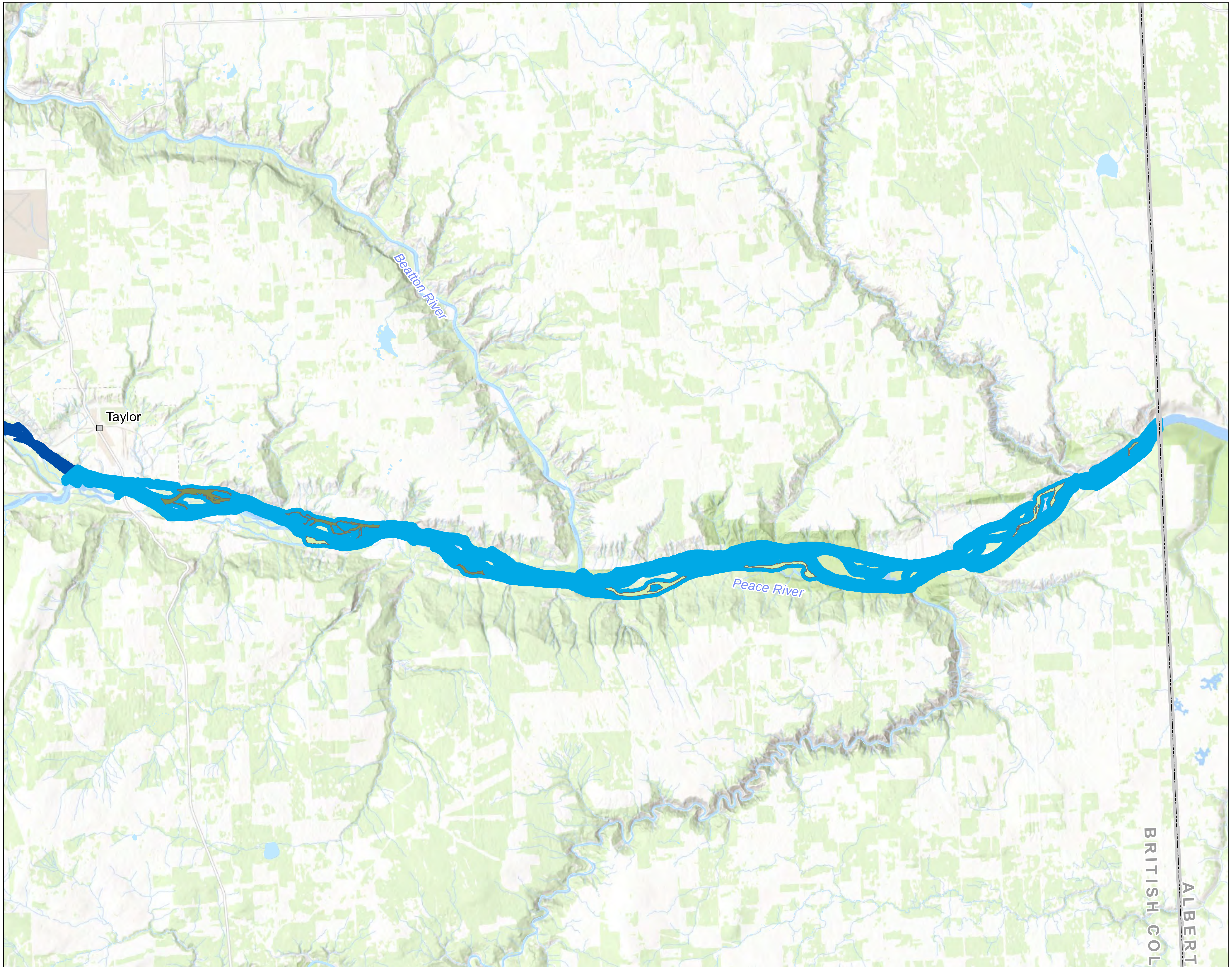
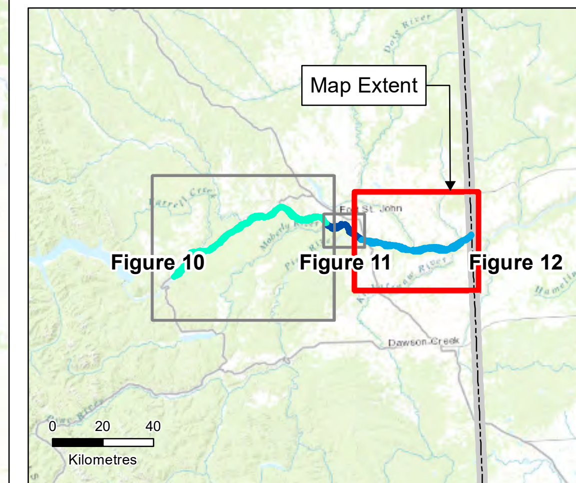
989619-07	Production Date: Jan 14, 2022	Figure 11

Hemmera An Ausenco Company
BC hydro



Migratory Waterbird Follow-up Monitoring Program
2021 Report
Site C, Peace River, BC

Fig. 12 - Mean Density (birds/km²/survey round) of Fall Migrant Waterbirds within Control Area Habitat Polygons from 2017 through 2021



Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area

Waterbird densities (birds/km²/survey round) by quartile [3]

- 0.08 - 0.14
- 0.15 - 0.23
- 0.24 - 1.10
- 1.11 - 3.13

Notes

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3. Waterbird density values were classified using approximate Quantile Breaks.

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989619-07	Production Date: Jan 14, 2022	Figure 12

Hemmera An Ausenco Company

BC hydro

4.1.4 Diversity

A total of 64 waterbird species were detected across boat surveys of the Peace River conducted annually from 2017 through 2021 (**Appendix B-1**), including 36 species from 2021 surveys (**Appendix B-2**). Dabbling ducks (15 species) were the most species rich foraging guild observed, followed by piscivorous divers (14 species) and shorebirds (10 species) over the 5 years of monitoring that has been conducted (**Appendix B-1**). Mean annual species richness within Mainstem and Moderate Flow river habitats ranged from less than 1 to 7 species across foraging guilds and survey periods (**Table 13**). During spring, average species richness was generally higher for dabbling ducks than for other foraging guilds, particularly in the middle and late spring, and lowest for shorebirds (**Table 13**). During fall, the most species rich foraging guild was gulls, particularly in early fall, while species richness was lowest for benthic feeding divers. In 2017 through 2021, mean species evenness ranged from values of 0.4 to 0.6 across survey periods (**Table 13**). Survey results specific to 2021 are presented in **Table 14**. Variability in diversity metrics across years are presented in **Appendix E** (**Table E-13**).

Table 13 Mean 2017 Through 2021 Diversity Metrics for Waterbird Foraging Guilds on the Peace River Across Seasons and Survey Periods

Foraging Guild	Spring Species Richness			Spring Mean	Fall Species Richness				Fall Mean
	Early	Middle	Late		Early	Early-Middle	Late-Middle	Late	
Benthic Feeding Divers	2.3	2.8	3.7	**2.8**	0.6	0.5	1.0	0.0	**0.7**
Dabbling Ducks	4.8	6.3	7.0	**5.7**	2.3	3.3	2.4	1.5	**2.5**
Gulls	0.4	1.8	3.3	**1.4**	4.5	3.6	3.1	3.5	**3.7**
Large Dabblers	2.2	2.0	1.3	**1.9**	1.1	1.6	1.7	2.0	**1.5**
Piscivorous Divers	1.6	2.5	3.5	**2.3**	1.9	2.7	3.0	1.5	**2.4**
Shorebirds	0.6	0.5	1.2	**0.6**	2.6	1.2	1.0	0.0	**1.4**
Total Species Richness	**11.9**	**16.0**	**20.0**	**14.8**	**13.0**	**12.9**	**12.2**	**8.5**	**12.2**
Species Evenness	**0.5**	**0.6**	**0.6**	**0.5**	**0.6**	**0.5**	**0.5**	**0.4**	**0.5**

Note: Mean species richness was calculated by averaging species richness across survey rounds first within periods each year, and then across years so that differences in sampling effort did not bias means towards diversity observed in years with more survey rounds. Data from Minimal and Limited Connectivity habitat are excluded due to inconsistent survey effort within these habitats due to variable access with fluctuations in water levels. Individual birds not identified to species are excluded from species richness totals and diversity calculations.

Table 14 Mean 2021 Diversity Metrics for Waterbird Foraging Guilds on the Peace River Across Seasons and Survey Periods

Foraging Guild	Spring Species Richness			Spring Mean	Fall Species Richness				Fall Mean
	Early	Middle	Late		Early	Early-Middle	Late-Middle	Late	
Benthic Feeding Divers	3.0	-	-	**3.0**	1.0	1.0	1.0	-	**1.0**
Dabbling Ducks	5.5	-	-	**5.5**	3.0	6.0	2.0	-	**3.7**
Gulls	0.5	-	-	**0.5**	6.0	5.0	3.0	-	**4.7**
Large Dabblers	2.0	-	-	**2.0**	1.0	1.0	1.0	-	**1.0**
Piscivorous Divers	2.0	-	-	**2.0**	2.0	4.0	5.0	-	**3.7**
Shorebirds	0.0	-	-	**0.0**	2.0	1.0	1.0	-	**1.3**
Total Species Richness	**13.0**	**-**	**-**	**13.0**	**15.0**	**18.0**	**13.0**	**-**	**15.3**
Species Evenness	**0.5**	**-**	**-**	**0.5**	**0.7**	**0.6**	**0.2**	**-**	**0.5**

Note: Mean species richness was calculated by averaging species richness across survey rounds first within periods each year, and then across years so that differences in sampling effort did not bias means towards diversity observed in years with more survey rounds. Data from Minimal and Limited Connectivity habitat are excluded due to inconsistent survey effort within these habitats due to variable access with fluctuations in water levels. Individual birds not identified to species are excluded from species richness totals and diversity calculations. Dashes reflect no data collected during some survey periods as recommended by power analyses (**Appendix A**).

Due to unequal areas of the river habitat types and treatment areas (i.e., unequal survey effort and sample sizes; see **Table 2**), diversity statistics are not directly compared across habitat types or treatment areas.

4.1.5 Waterbird Species at Risk

The following species designated as at risk as per provincial, *Species at Risk Act* (SARA), or Committee on the Status of Endangered Wildlife in Canada (COSEWIC) rankings, were observed during Peace River surveys from 2017 through 2021:

- Double-crested cormorant (*Nannopterum auritum*), BC listing (Blue)
- California gull (*Larus californicus),* BC listing (Blue)
- Eared grebe (*Podiceps nigricollis*), BC listing (Blue)
- Great blue heron (*Ardea herodias herodias*), BC listing (Blue)[2]
- Horned grebe (*Podiceps auratus*), COSEWIC (special concern [SC]), SARA (SC)
- Long-tailed duck (*Clangula hyemalis*), BC listing (Blue)
- Red-necked phalarope (*Phalaropus lobatus*), BC listing (Blue)
- Surf scoter (*Melanitta perspicillata*), BC listing (Blue)
- Tundra swan (*Cygnus columbianus*), BC listing (Blue)
- Western grebe (*Aechmophorus occidentalis*), BC listing (Red), COSEWIC (SC), SARA (SC).

[2] Great blue heron was not a target species and is not included in estimates of relative abundance or diversity due to its rarity in the region and unique foraging strategy compared to the species guilds assessed in this study.

Records of waterbird species at risk were generally few (i.e., 6 or less per species in total across years), with the exception of surf scoter (206 individuals), California gull (35 individuals), and red-necked phalarope (11) (**Appendix B-1**). Three at risk species were observed during 2021 surveys (**Appendix B-2**):

- Double-crested cormorant (not observed during previous study years)
- California gull
- Surf scoter.

4.2 Transmission Line Wetland Surveys

This section describes the results of the transmission line ROW wetland survey component of the monitoring program, including the temporal and spatial scope of surveys (**Sections 4.2.1** and **4.2.2**) relative to survey objectives. Estimates of mean abundance and diversity across years are summarized for each foraging guild by season, survey period, and habitat type. Diversity statistics are also summarized by foraging guild with means averaged across years provided for each survey period. Results are summarized together for all years of monitoring and are also presented independently for this year's (i.e., 2021) surveys.

4.2.1 Survey Effort and Timing

In 2021, transect and standwatch surveys were conducted on the Moberly Plateau and adjacent to the Site C transmission line ROW during spring (May 3 to May 16, 2021) and fall (August 11 to October 6, 2021) waterbird migration periods (**Table 15**). Surveys in 2021 were conducted during 2 survey periods in spring and 3 survey periods in fall over a total of 18 days (7 days in spring and 11 days in fall). No wetland surveys were conducted in the early spring survey because wetlands were frozen and unavailable for waterbird foraging during that time (**Table 15**). Bioacoustics monitoring for marsh birds in 2021 was conducted from May 14 through August 19, 2021 (**Table 22**).

Table 15 Wetland Survey Timing During 2017 Through 2021 Annual Waterbird Migration Monitoring

Survey Period	2017 Survey Dates	2018 Survey Dates	2019 Survey Dates	2020 Survey Dates	2021 Survey Dates
Spring					
Early (Apr 1 to Apr 14)	Wetlands Frozen	Wetlands Frozen	Wetlands Frozen	Wetlands Frozen	Wetlands Frozen
Middle (Apr 15 to May 6)	Apr 29, 30; May 1, 2	Apr 27, 28, 29 May 2, 3, 4	Apr 21, 22, 23 May 3, 4, 5	May 4, 5, 6	May 3, 4, 5, 6
Late (May 7 to May 30)	May 16, 17; May 18, 19, May 25, 26; May 27, 28	May 7, 8, 9 May 15, 16, 17	May 11, 12, 13 May 22, 23, 24	May 24, 25, 26, 27	May 14, 15, 16
Fall					
Early (Aug 1 to Aug 14)	Aug 10, 11; 12, 13	Aug 6, 7, 8	Aug 10, 11, 12	Aug 7, 8, 9	Aug 11, 12, 13
Early-Middle (Aug 15 to Sep 14)	Aug 24, 25; 26, 27	Aug 22, 23, 24, Sep 6, 7, 10	Aug 21, 22, 23 Sep 10, 11	Sep 2, 3, 4	Aug 26, 29, 30
Late-Middle (Sep 15 to Oct 14)	Sep 23, 24; 25, 26	Sep 17, 18, 19 Oct 1, 2, 3	Sep 18, 19, 20 Oct 2, 3	Sep 28, Oct 1, 2	Sep 29, 30, Oct 1, 2, 6
Late (Oct 15 to Oct 30)	No surveys	Oct 17, 18, 19	Oct 18, 19	No surveys	No surveys

4.2.1.1 Transect and Standwatch Surveys

In 2021, waterbird surveys were conducted within 22 wetland stations (**Figure 13**, **Figure 14**, **Figure 15**, **Table 16**). As described in **Section 2.2.2**, each wetland station included one or more habitat types in which waterbird surveys were conducted. Within the 22 stations, 15 areas of open water habitat were surveyed by standwatch methods, 11 areas with willow-sedge habitat were surveyed by transect methods, and 12 areas with sedge habitat were also surveyed by transect methods. Standwatch surveys were conducted at 4 open water wetlands clear of vegetation (i.e., lakes), which provided unobstructed lines of sight, and 12 areas of open water interspersed with emergent or flooded vegetation. Photos of stations showing aerial views or representative habitat are provided in **Appendix D**.

Table 16 Survey Methods and Wetland Habitat Types Survey within Wetland Stations

Wetland Station ID	Bioacoustics (ARU) Surveys	Transect Surveys[1]	Standwatch Surveys[2]
	Sedge, Open Water, Willow-Sedge	Sedge, Willow-Sedge	Open Water
OW-01	2021	2020, 2021	2017, 2018, 2019, 2020, 2021
OW-02	-	-	2017, 2018, 2019, 2020, 2021
OW-04	-	-	2017, 2018, 2019, 2020, 2021
OW-06	2020	2020, 2021	2017, 2018, 2019, 2020, 2021
OW-07	-	-	2020, 2021
OW-09	-	-	2017, 2018, 2019, 2020, 2021
OW-10	-	-	2017, 2018, 2019, 2020, 2021
OW-11	-	-	2017, 2018, 2019, 2020, 2021
SE-01[3]	-	2018, 2019	-
SE-02	2021	2018, 2019, 2020, 2021	2020, 2021
SE-03	2021	2018, 2019, 2020, 2021	2020, 2021
SE-04	2018, 2019, 2020, 2021	2018, 2019, 2020, 2021	2020
SE-05	2017, 2019, 2020, 2021	2018, 2019, 2020, 2021	-
SE-06	2017, 2019, 2020	2018, 2019	2020, 2021
SE-07	-	2018, 2019, 2020, 2021	2020, 2021
SE-09	2020	2018, 2019, 2020, 2021	2020, 2021
SE-10	2017, 2019	2018, 2019, 2020, 2021	-
SE-11	2020, 2021	2018, 2019, 2020, 2021	-
SE-12	-	2018, 2019	2020, 2021
SE-14	-	2018, 2019, 2020, 2021	2020, 2021
WS-01	2019	2018, 2019, 2020, 2021	-
WS-02	-	2018, 2019, 2020, 2021	-
WS-03	2021	2018, 2019, 2020, 2021	-

Notes: Dashes indicate no surveys conducted

1. Surveys conducted with water depths of 0.5 m or less
2. Surveys conducted in areas of 0.25 ha or more of open water. Stations only surveyed in 2020 were surveyed using remotely piloted aircraft systems in 2018 and 2019
3. Discontinued after 2019. Replaced with more easily accessed habitat adjacent to OW-01

Within the wetland survey stations listed above, a total of 243 standwatch surveys of open water and 508 transect surveys of sedge and willow-sedge habitat were conducted under appropriate survey conditions during the spring and fall of 2017 through 2021 (**Table 17**). Of the total 751 surveys conducted across all years, 278 and 473 surveys were conducted during spring and fall, respectively, and 138 were conducted during 2021.

Table 17 Number of Unique Wetland Surveys for Migrating Waterbirds Conducted by Standwatch and Transect Methods by Survey Period During 2017 Through 2021

Survey Method	Year	Spring			Fall				Total
		Early[1]	Middle	Late	Early	Middle-Early	Middle-Late	Late[1]	
Standwatch (OW)	2017	-	2	8	6	5	6	0	27
	2018	-	9	14	6	11	12	6	58
	2019	-	11	13	6	13	12	3	58
	2020	-	11	12	11	11	9	0	54
	2021	-	6	14	8	10	8	0	46
Total		**-**	**39**	**61**	**37**	**50**	**47**	**9**	**243**
Transect (WS,SE)	2017	-	-	-	-	-	-	-	-
	2018	-	11	32	20	27	37	21	148
	2019	-	26	36	20	37	37	6	162
	2020	-	20	22	21	23	20	0	106
	2021	-	19	12	22	21	18	0	92
Total		**-**	**76**	**102**	**83**	**108**	**112**	**27**	**508**
Grand Total		**-**	**115**	**163**	**120**	**158**	**159**	**36**	**751**

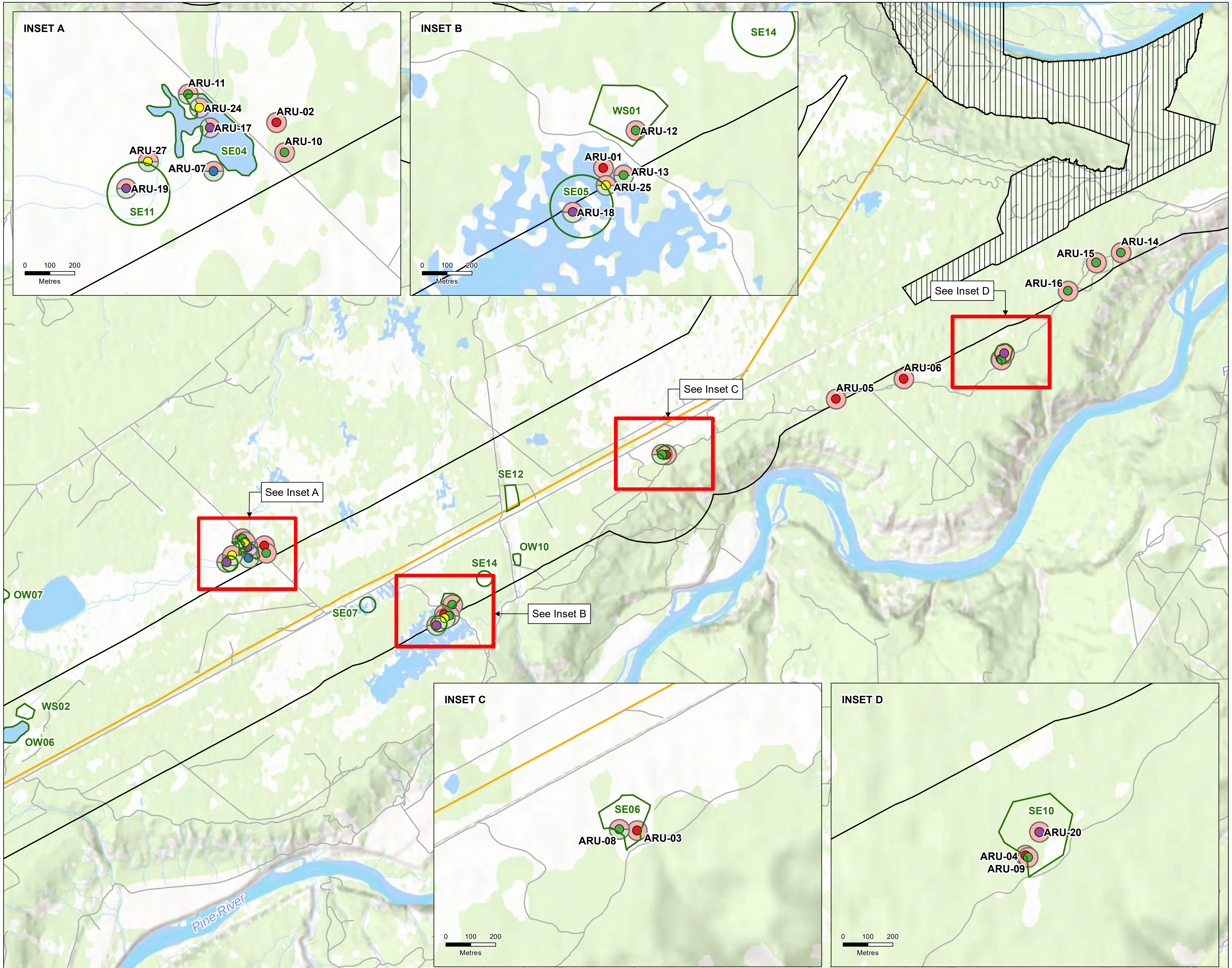
Note: Multiple transects conducted within the same habitat type counted as a single unique survey. Dashes indicate no surveys conducted during some years and survey periods. [1]No surveys were conducted during early spring and few surveys were conducted during late fall due to snow and ice cover of wetlands which restricted access and has also been found to be associated with limited use by waterbirds relative to warmer conditions.

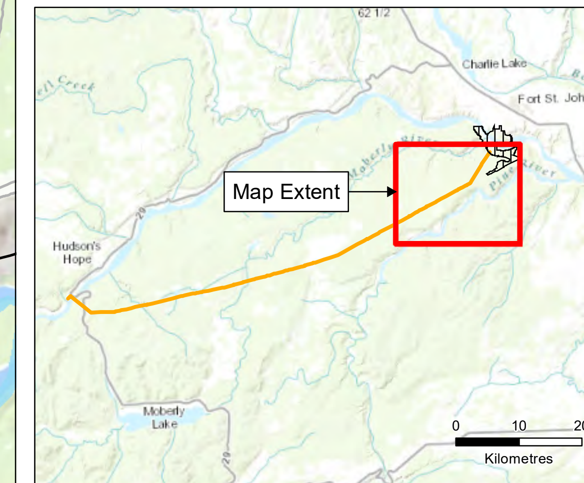
4.2.1.2 Bioacoustics Monitoring

Bioacoustics monitoring during 2017 through 2021 was conducted with ARU deployments at 12 wetland survey stations and 6 other locations (**Figure 13**) over a cumulative total of 547 nights including 257 nights from 7 locations in 2021 (**Table 22**). ARU surveys were conducted at 7 stations in 2021; at 3 stations where marsh bird surveys using ARUs were conducted in previous years and at 4 stations not surveyed previously.

Migratory Waterbird Follow-up Monitoring Program
2021 Report
Site C, Peace River, BC

Figure 13 - Wetland Survey Stations and ARU Monitoring Locations on the Transmission Line Route (East)





Legend

- Site C LAA
- Proposed Dam Site
- Wetland Survey Station
- Access / Service Road
- Transmission Line Right-of-Way

Positive Detections of Targeted Species

- SORA
- VIRA
- YERA

ARU Deployment Year

- 2017
- 2018
- 2019
- 2020
- 2021

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.
3. 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.

Sources

- Basemap: ESRI World Topographic Base

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Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

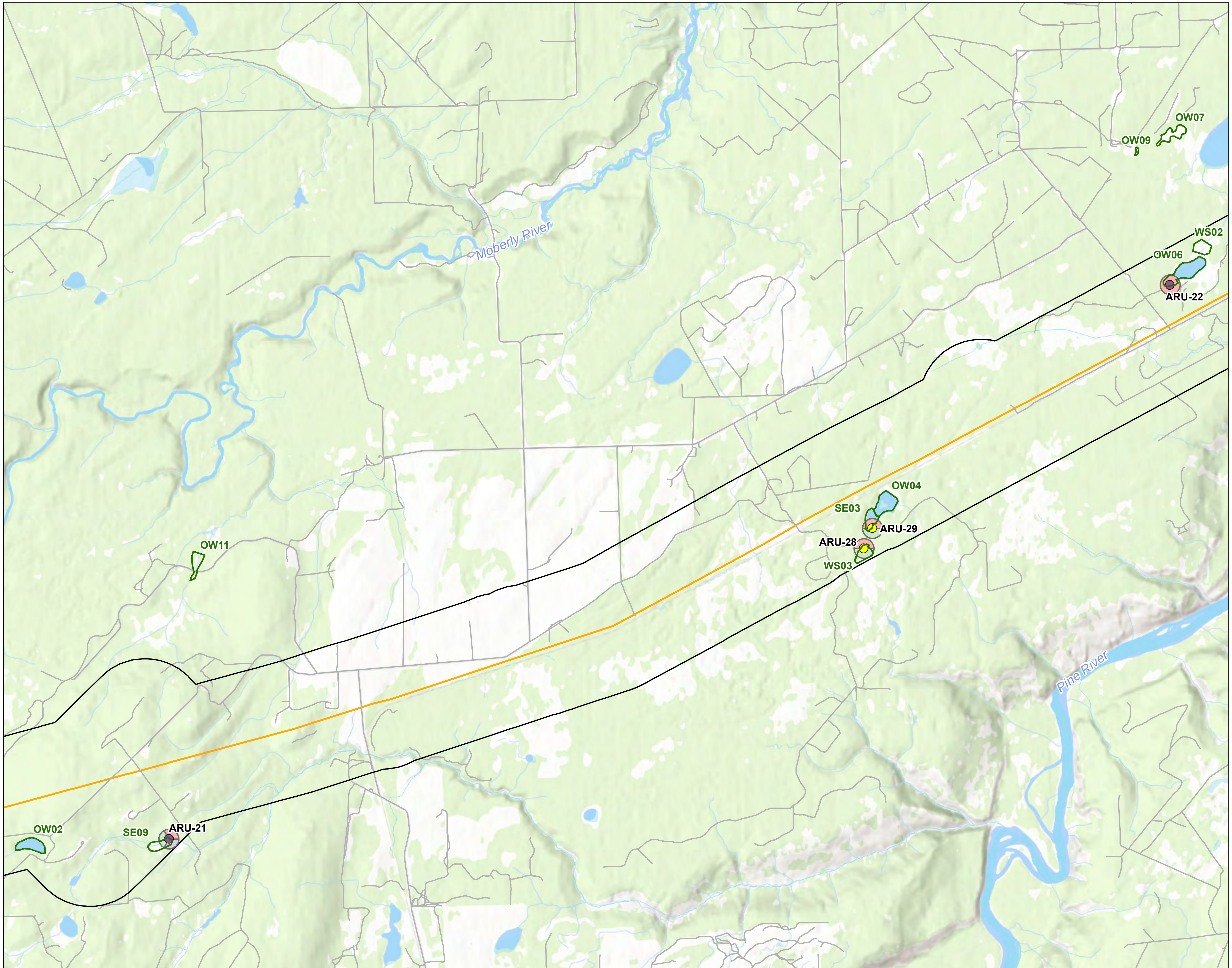
989619-07	Production Date: Jan 14, 2022	Figure 13

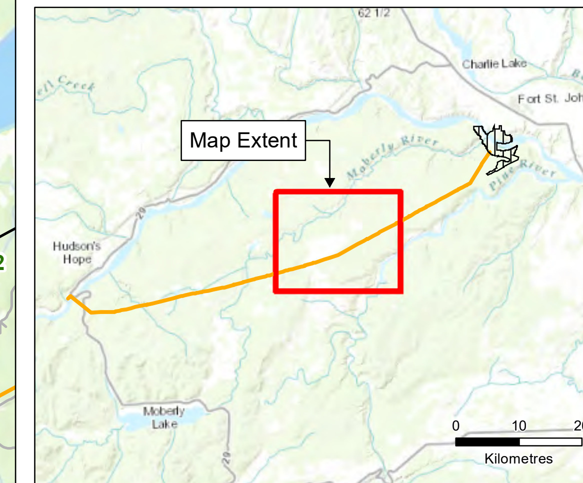
Hemmera An Ausenco Company
BC hydro

Path: S:\Geomatics\Projects\989619\07_waterfowl\mxd\MonitoringProgram2021\Fig13_989619_07_Waterbirds_Wetland_Survey_Stations_East_220114.mxd

Migratory Waterbird Follow-up Monitoring Program
2021 Report
Site C, Peace River, BC

Figure 14 - Wetland Survey Stations Locations on the Transmission Line Route (Central)





Legend

Site C LAA
Wetland Survey Station
Access / Service Road
Transmission Line Right-of-Way

ARU Deployment Year

2020
2021

Positive Detections of Targeted Species

SORA
VIRA
YERA

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.
3. 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.

Sources

- Basemap: ESRI World Topographic Base

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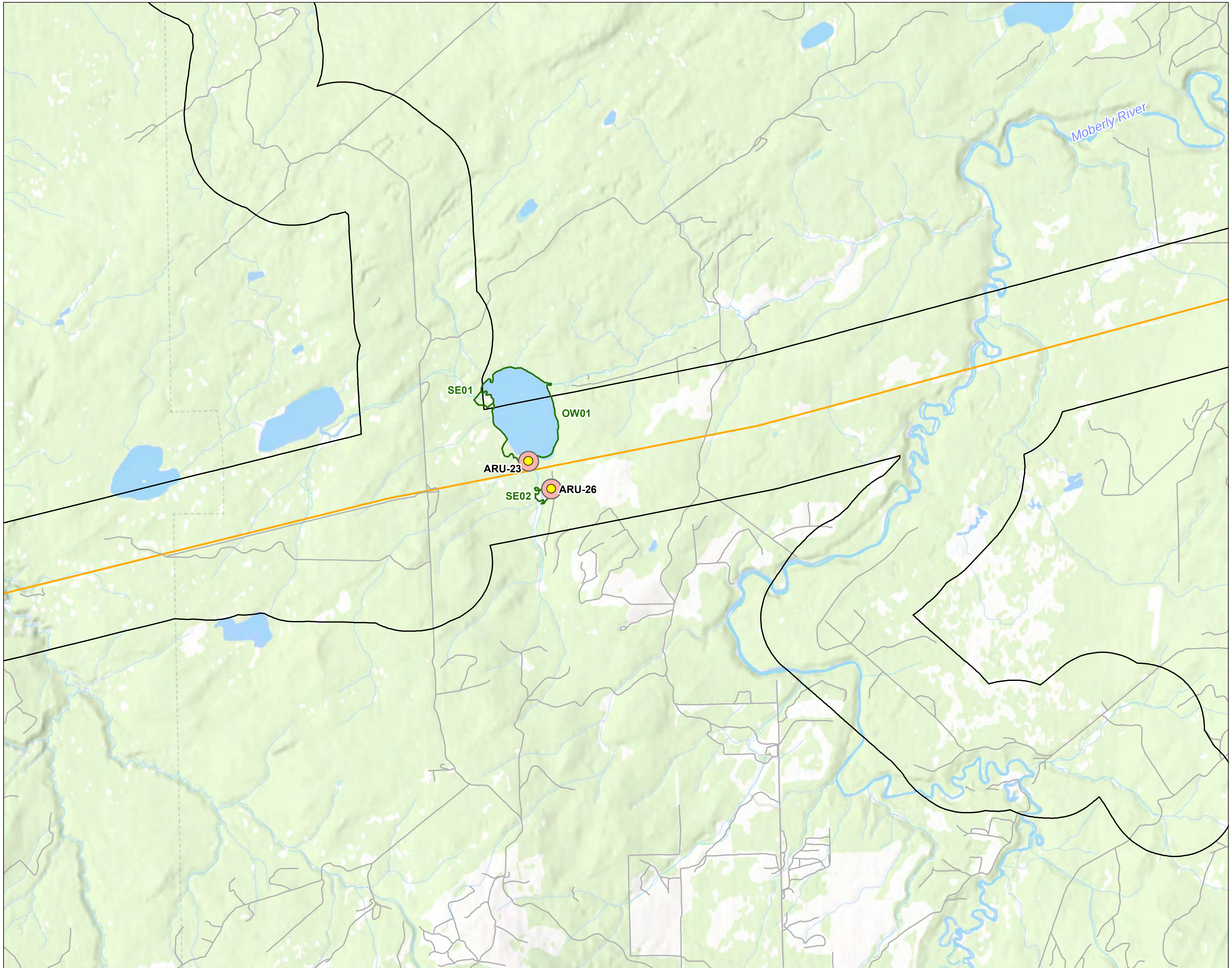
989619-07	Production Date: Jan 14, 2022	Figure 14

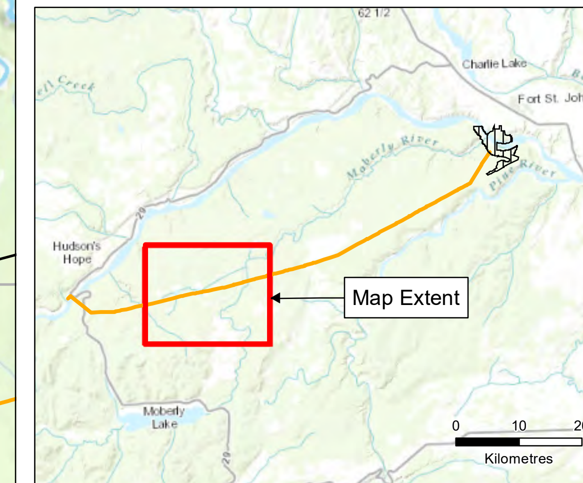
Hemmera
An Ausenco Company

BC hydro

Migratory Waterbird Follow-up Monitoring Program
2021 Report
Site C, Peace River, BC

Figure 15 - Wetland Survey Stations Locations on the Transmission Line Route (West)





Legend

- Site C LAA
- Wetland Survey Station
- Access / Service Road
- Transmission Line Right-of-Way

ARU Deployment Year

- 2021

Positive Detections of Targeted Species

- SORA

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.
3. 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.

Sources

- Basemap: ESRI World Topographic Base

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Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

989619-07	Production Date: Jan 14, 2022	Figure 15

Hemmera An Ausenco Company
BC hydro

4.2.2 Abundance and Density

Summaries of waterbird obervations are presented below for habitat types surveyed by transect and standwatch methods. For the purposes of annual reporting, waterbird observation data are summarized primarily in terms of density by area of open water for standwatch surveys of open water habitat including permanent water features (e.g., lakes), as well as inundated sedge and willow-sedge habitats (**Table 18**, **Table 19**), and as mean density per 1 km of transect length within sedge and willow-sedge habitats with water levels less than 50 cm (**Table 20**, **Table 21**). The results of bioacoustics monitoring are described in terms of the proportion of monitoring locations where species were confirmed to be present, based on presence/not detected results for target species from each monitoring location (**Table 22**).

4.2.2.1 Transect and Standwatch Surveys

Standwatch surveys detected 8,184 waterbirds from 2017 through 2021 (**Appendix B-1**), including 1,821 individuals in 2021, of which 97% were identified to species (**Appendix B-2**). Across years, mean densities of waterbirds recorded during the late fall period were less than one third of any other period during spring or fall. Waterbirds observed during standwatch surveys were primarily comprised of dabbling ducks and benthic feeding divers (**Table 18**). Estimates of foraging guild densities within open water habitats specific to survey periods in 2021 are presented in **Table 19**, and estimates of interannual variability are presented in **Appendix E** (**Table E-18**).

Table 18 Mean 2017 Through 2021 Waterbird Densities (birds/km^2/survey) within Open Water Habitat Reported by Foraging Guild from Standwatch Surveys

Foraging Guild	Spring		Fall			
	Middle	Late	Early	Early-Middle	Late-Middle	Late
Benthic Feeding Divers	143.0	131.3	227.6	181.0	151.8	41.2
Dabbling Ducks	530.5	596.5	694.8	631.6	489.0	96.2
Gulls	1.9	6.0	1.3	0.0	0.0	0.0
Large Dabblers	67.5	55.3	16.0	23.8	7.0	0.8
Marsh Birds	1.1	28.2	1.4	14.9	0.0	0.0
Piscivorous Divers	4.1	21.8	28.5	42.5	24.9	23.8
Shorebirds	19.5	91.1	107.4	12.4	0.0	0.0
Unknown Waterbirds	0.1	18.6	26.2	5.2	41.7	26.3
Total (All Waterbirds)	**767.7**	**949.1**	**1,103.1**	**911.3**	**714.4**	**188.4**

Note: Mean densities reflect relative rather than absolute densities as they do not account for incomplete detection. Mean relative densities were calculated by averaging relative density across survey rounds first within each period per year, and then across years to avoid bias associated with uneven sampling effort in some periods and years. Results include survey data from permanent open water habitat, flooded vegetated wetlands, and open water areas with interspersed vegetation such as rushes and sedge.

Table 19 Mean 2021 Waterbird Densities (birds/km^2/survey) within Open Water Habitat Reported by Foraging Guild from Standwatch Surveys

Foraging Guild	Spring		Fall			
	Middle	Late	Early	Early-Middle	Late-Middle	Late
Benthic Feeding Divers	25.0	138.3	104.3	51.5	49.2	-
Dabbling Ducks	104.1	1,042.7	761.2	1,135.5	1,114.9	-
Gulls	0.0	6.2	4.4	0.0	0.0	-
Large Dabblers	0.0	79.2	55.5	35.5	68.4	-
Marsh Birds	0.0	7.0	4.9	0.0	1.4	-
Piscivorous Divers	0.0	33.5	23.5	52.5	123.0	-
Shorebirds	15.3	110.2	81.7	0.4	6.4	-
Unknown Waterbirds	0.0	0.0	0.0	15.4	0.0	-
Total (All Waterbirds)	**144.4**	**1,417.3**	**1,035.4**	**1,290.9**	**1,363.4**	**-**

Note: Mean densities reflect relative rather than absolute densities as they do not account for incomplete detection. Mean relative densities were calculated by averaging relative density across survey rounds first within each period per year, and then across years to avoid bias associated with uneven sampling effort in some periods and years. Results include survey data from permanent open water habitat, flooded vegetated wetlands, and open water areas with interspersed vegetation such as rushes and sedge. Dashes indicate no surveys conducted during some survey periods.

Transect surveys of vegetated wetlands with low water levels detected 347 waterbirds within sedge and willow-sedge habitat across 2018 through 2021 (**Appendix B-1**)**,** including 44 individuals during surveys conducted in 2021 (**Appendix B-2**). Due to the close proximity of observations, 100% of waterbird individuals were identified to species in 2021. Mean densities observed within vegetated habitats were highest during late spring, with dabbling ducks the most densely occurring forgaging guild across seasons and survey periods (**Table 20**). In contrast, no waterbirds were detected during transect surveys on the Moberly Plateau and adjacent to the Site C transmission line ROW during surveys conducted in late fall during 2018 and 2019 (**Table 20**). Due to the lack of observations in these years, no transect surveys were conducted during late fall in 2020 or 2021. As mentioned previously, no surveys were conducted in the early spring because wetlands are largely covered in ice and snow during that time and are therefore unavailable to waterbirds as foraging habitat. Estimates of foraging guild densities within open water habitats specific to survey periods in 2021 are presented in **Table 21**, and estimates of interannual variability are presented in **Appendix E** (**Table E-20**)**.**

Table 20 Mean 2018 through 2021 Waterbird Densities (birds/km/survey) within Vegetated Wetland (sedge, willow-sedge) Habitat Reported by Foraging Guild from Transect Surveys

Foraging Guild	Spring		Fall			
	Middle	Late	Early	Early-Middle	Late-Middle	Late
Benthic Feeding Divers	0.00	0.00	0.00	0.00	0.00	0.00
Dabbling Ducks	1.72	5.32	0.09	0.73	1.71	0.00
Gulls	0.00	0.00	0.00	0.00	0.00	0.00
Large Dabblers	0.33	0.10	0.00	0.00	0.00	0.00
Marsh Birds	0.74	3.09	1.32	1.49	0.26	0.00
Piscivorous Divers	0.00	0.11	0.00	0.00	0.00	0.00
Shorebirds	0.68	1.56	0.00	0.00	0.00	0.00
Unknown Waterbirds	0.00	0.00	0.00	0.00	0.00	0.00
Total (All Waterbirds)	**3.48**	**10.18**	**1.41**	**2.22**	**1.97**	**0.00**

Note: Mean densities reflect relative rather than absolute densities as they do not account for incomplete detection. Mean relative densities were calculated by averaging relative density across survey rounds first within each period per year, and then across years to avoid bias associated with variable survey effort across survey periods and years.

Table 21 Mean 2021 Waterbird Densities (birds/km/survey) within Vegetated Wetland (sedge, willow-sedge) Habitat Reported by Foraging Guild from Transect Surveys

Foraging Guild	Spring		Fall			
	Middle	Late	Early	Early-Middle	Late-Middle	Late
Benthic Feeding Divers	0.00	0.00	0.00	0.00	0.00	-
Dabbling Ducks	0.23	0.50	0.00	0.09	0.68	-
Gulls	0.00	0.00	0.00	0.00	0.00	-
Large Dabblers	0.05	0.00	0.00	0.00	0.00	-
Marsh Birds	0.05	0.10	0.06	0.13	0.13	-
Piscivorous Divers	0.00	0.00	0.00	0.00	0.00	-
Shorebirds	0.05	0.00	0.00	0.00	0.00	-
Unknown Waterbirds	0.00	0.00	0.00	0.00	0.00	-
Total (All Waterbirds)	**0.36**	**0.60**	**0.13**	**0.22**	**0.74**	**-**

Note: Mean densities reflect relative rather than absolute densities as they do not account for incomplete detection. Mean relative densities were calculated by averaging relative density across survey rounds within each period. Dashes indicate no surveys conducted during some survey periods.

4.2.2.2 Bioacoustics Monitoring

Sora were detected at all locations monitored in 2017 through 2021 and no American bittern vocalizations were recorded at any location. Yellow rail was detected at 12 of 29 bioacoustics monitoring locations across years, and at 4 of 7 locations in 2021 (**Table 22**). Analysis of bioacoustics data for Virginia rail identified the species at 3 of 13 locations where ARUs were deployed across years (2020 and 2021) including at 1 of 7 locations in 2021 (**Table 22**). All species, when detected, were detected within the first 2 nights of ARU deployments and confirmed on subsequent nights.

Table 22 Bioacoustics Monitoring Locations, Habitat Description, Survey Effort, and Confirmed Detections of Target Species

ARU Survey ID	Latitude	Longitude	Habitat type	Wetland Survey Station	Dates of Acoustic Monitoring	Number of nights	SORA	YERA	AMBI	VIRA[3]
ARU-01	56.104658	-121.044231	Sedge and willow-sedge	SE-05[2]	May 16 to May 28, 2017	13	Yes	No	No	N/A
ARU-02	56.115311	-121.090337	Sedge and upland forested	N/A	May 16 to May 28, 2017	13	Yes	No	No	N/A
ARU-03	56.126825	-120.985543	Sedge and edge of open water	SE-10	May 28 to Jun 12, 2017	16	Yes	No	No	N/A
ARU-04	56.139182	-120.898154	Sedge and upland forested	SE-06	May 28 to Jun 12, 2017	16	Yes	No	No	N/A
ARU-05	56.134144	-120.941172	Sedge	N/A	Jun 12 to Jun 27, 2017	16	Yes	No	No	N/A
ARU-06	56.136775	-120.923437	Sedge	N/A	Jun 12 to Jun 24, 2017	13	Yes	No	No	N/A
ARU-07	56.113610	-121.094496	Sedge	SE-04	Jul 4 to Jul 23, 2018	20	Yes	Yes	No	N/A
ARU-08	56.126888	-120.986697	Sedge, willow-sedge, upland forested	SE-06	May 17 to May 24, 2019	8	Yes	Yes	No	N/A
ARU-09	56.139104	-120.897989	Open water, upland forested	SE-10	May 17 to May 24, 2019	8	Yes	No	No	N/A
ARU-10	56.114216	-121.08986	Open water, sedge, upland forested	SE-04[2]	May 17 to May 24, 2019	8	Yes	No	No	N/A
ARU-11	56.116424	-121.096006	Sedge, willow-sedge, upland forested	SE-04	May 24 to Jun 14, 2019	22	Yes	Yes	No	N/A
ARU-12	56.105986	-121.042059	Sedge, willow-sedge, upland forested	WS-01	May 24 to Jun 14, 2019	22	Yes	No	No	N/A
ARU-13	56.104382	-121.042940	Sedge, willow-sedge, upland forested	SE-05[2]	May 24 to Jun 14, 2019	22	Yes	Yes	No	N/A
ARU-14	56.154077	-120.866156	Sedge, willow-sedge, upland forested	N/A	Jul 22 to Aug 1, 2019	11	Yes	No	No	N/A
ARU-15	56.152748	-120.872644	Sedge	N/A	Jul 22 to Aug 1, 2019	11	Yes	No	No	N/A
ARU-16	56.148765	-120.880178	Sedge	N/A	Jul 22 to Aug 1, 2019	11	Yes	No	No	N/A
ARU-17	56.11519	-121.09466	Sedge, willow-sedge, upland forested	SE-04	May 6 to May 15, 2020	10	Yes	Yes	No	Yes

ARU Survey ID	Latitude	Longitude	Habitat type	Wetland Survey Station	Dates of Acoustic Monitoring	Number of nights	SORA	YERA	AMBI	VIRA[3]
ARU-18	56.10309	-121.04630	Sedge, upland forested, willow-sedge, open water	SE-05	May 6 to May 16, 2020	11	Yes	Yes	No	No
ARU-19	56.11307	-121.10017	Sedge and willow-sedge	SE-11	May 26 to June 5, 2020	10	Yes	Yes	No	No
ARU-20	56.14001	-120.89719	Sedge, upland forested, open water	SE-06	May 26 to June 4, 2020	9	Yes	No	No	No
ARU-21	56.01027	-121.42445	Sedge, upland forested, open water, willow-sedge	SE-09	June 16 to June 26, 2020	10	Yes	Yes	No	Yes
ARU-22	56.08691	-121.16201	Sedge, upland forested, willow-sedge, open water	OW-06	June 16 to June 26, 2020	10	Yes	No	No	No
ARU-23	55.99180	-121.66468	Open water, sedge, willow sedge	OW-01	May 16 to June 13, 2021	29	Yes	No	No	No
ARU-24	56.11592	-121.09529	Sedge, willow-sedge, upland forested	SE-04	May 14 to May 25, 2021	12	Yes	Yes	No	Yes
ARU-25a	56.10403	-121.04410	Sedge, upland forested, willow-sedge, open water	SE-05	May 14 to Jun 21, 2021	38	Yes	No	No	No
ARU-25b	56.10403	-121.04410	Sedge, upland forested, willow-sedge, open water	SE-05	Jun 24 to July 16 Aug 19, 2021	25	Yes	No	No	No
ARU-25c	56.10403	-121.04410	Sedge, upland forested, willow-sedge, open water	SE-05	July 16 to Aug 19, 2021	36	Yes	No	No	No
ARU-26	55.98771	-121.65892	Sedge, willow sedge, open water, upland forested	SE-02	Jun 21 to Jul 16, 2021	36	Yes	No	No	No
ARU-27	56.11402	-121.09871	Sedge, willow sedge	SE-11	Jun 21 to Jul 14, 2021	24	Yes	Yes	No	No
ARU-28	56.04991	-121.24299	Willow sedge, sedge, upland forested	WS-03	Jul 16 to Aug 13, 2021	29	Yes	Yes	No	No
ARU-29	56.05278	-121.24065	Open water, sedge, upland forested	SE-03	Jul 16 to Aug 13, 2021	29	Yes	Yes	No	No
					Totals	**547**	**29/29**	**12/29**	**0/29**	**3/13**

Notes:

1. Days ARU recorded acoustic data.
2. Adjacent to wetland station.
3. ARU data only reviewed for VIRA in 2020 and 2021 as the study area was considered outside of the species' range in prior years.

4.2.3 Diversity

Standwatch surveys detected 44 waterbird species during the spring and fall of 2017 through 2021 (**Table 23**), including 31 species in 2021 (**Appendix B-2**). Transect surveys detected 19 species during 2018, 2019, 2020, and 2021 (**Table 23**), 9 of which were observed in 2021 (**Appendix B-2**).

The most diverse foraging guilds observed during standwatch surveys of open water and flooded wetlands were dabbling ducks followed by piscivorous divers with 13 and 10 species observed, respectively, from 2017 through 2021 (**Table 23**). During transect surveys of vegetated wetlands, dabbling ducks were the most species rich guild observed, with 8 species. No more than 4 species of any other guild were observed during transect surveys and gulls were entirely absent from transect survey records.

Table 23 Cumulative 2017 Through 2021 Species Richness of Waterbird Foraging Guilds Observed During Transect and Standwatch Surveys of Wetland Habitats

Foraging Guild	Transect Surveys 2018 to 2021		Standwatch Surveys 2017 to 2021	
	Number of Species	Proportion of Species	Number of Species	Proportion of Species
Benthic Feeding Divers	1	0.05	7	0.16
Dabbling Ducks	8	0.42	13	0.30
Gulls	0	0.00	4	0.09
Large Dabblers	2	0.11	2	0.05
Marsh Birds	3	0.16	2	0.05
Piscivorous Divers	1	0.05	10	0.23
Shorebirds	4	0.21	6	0.14
Total	**19**		**44**	

Average species richness and evenness were calculated across years for each foraging guild in each survey period for standwatch surveys of open water habitat (**Table 24**) and transect surveys of vegetated habitat (**Table 26**). Diversity metrics within open water and vegetated habitats along the transmission line ROW were generally highest in the late spring (**Table 24**, **Table 26**). Species richness and evenness statistics are also provided for the current reporting year (**Table 25**, **Table 27**) and statistics describing interannual variability are available in **Appendix E** for open water and vegetated wetland habitats within **Table E-24** and **Table E-26**, respectively.

Table 24 Average 2017 Through 2021 Species Richness of Waterbird Foraging Guilds within Open Water Wetland Habitat By Survey Period Observed during Standwatch Surveys

Foraging Guild	Spring			Fall			
	Early	Middle	Late	Early	Early-Middle	Late-Middle	Late
Benthic Feeding Divers	-	2.6	3.1	1.8	1.9	2.2	2.0
Dabbling Ducks	-	5.6	7.2	5.3	6.3	4.6	4.0
Gulls	-	0.2	0.8	0.6	0.0	0.0	0.0
Large Dabblers	-	1.4	1.8	0.8	1.2	0.9	1.0
Marsh Birds	-	0.5	0.7	0.3	0.8	0.0	0.0
Piscivorous Divers	-	1.4	2.8	3.0	3.0	2.6	2.0
Shorebirds	-	0.8	2.2	1.4	0.4	0.0	0.0
Total Species Richness	**-**	**11.9**	**18.7**	**12.8**	**13.1**	**10.3**	**9.0**
Species Evenness	**-**	**0.8**	**0.8**	**0.8**	**0.8**	**0.7**	**0.7**

Note: Average diversity statistics were determined by calculating mean richness and evenness across survey rounds first within each period per year, and then across years to avoid bias associated with variable survey effort across survey periods and years. Dashes indicate no surveys conducted during some survey periods or insufficient data for summary statistic calculations.

Table 25 Species Richness in 2021 for Waterbird Foraging Guilds within Open Water Wetland Habitat By Survey Period Observed during Standwatch Surveys

Foraging Guild	Spring Survey Periods			Fall Survey Periods			
	Early	Middle	Late	Early	Early-Middle	Late-Middle	Late*
Benthic Feeding Divers	-	2.0	3.0	3.0	1.0	3.0	-
Dabbling Ducks	-	3.0	9.0	9.0	9.0	6.0	-
Gulls	-	0.0	2.0	0.0	0.0	0.0	-
Large Dabblers	-	0.0	2.0	1.0	1.0	1.0	-
Marsh Birds	-	0.0	1.0	0.0	1.0	0.0	-
Piscivorous Divers	-	0.0	3.0	5.0	4.0	7.0	-
Shorebirds	-	0.0	3.0	1.0	1.0	0.0	-
Total Species Richness	**-**	**5.0**	**23.0**	**19.0**	**17.0**	**17.0**	**-**
Species Evenness	**-**	**1.0**	**0.6**	**0.7**	**0.7**	**0.5**	**-**

Note: Dashes indicate no surveys conducted during some survey periods or insufficient data for summary statistic calculations.

Table 26 Average 2018 Through 2021 Species Richness of Waterbird Foraging Guilds within Sedge and Willows-sedge Wetland Habitat By Survey Period Observed during Transect Surveys

Foraging Guild	Spring			Fall			
	Early	Middle	Late	Early	Early-Middle	Late-Middle	Late
Benthic Feeding Divers	-	0.0	0.1	0.0	0.0	0.0	0.0
Dabbling Ducks	-	1.4	2.9	1.0	0.6	0.4	0.0
Gulls	-	0.0	0.0	0.0	0.0	0.0	0.0
Large Dabblers	-	0.6	0.1	0.0	0.0	0.0	0.0
Marsh Birds	-	1.3	1.9	1.5	1.4	0.5	0.0
Piscivorous Divers	-	0.0	0.3	0.0	0.0	0.0	0.0
Shorebirds	-	1.3	1.0	0.0	0.0	0.0	0.0
Total Species Richness	**-**	**4.4**	**6.3**	**2.8**	**1.5**	**0.9**	**0.0**
Species Evenness	**-**	**0.7**	**0.8**	**0.8**	**0.9**	**0.4**	**-**

Note: Average diversity statistics were determined by calculating mean richness and evenness across survey rounds first within each period per year, and then across years to avoid bias associated with variable survey effort across survey periods and years. Dashes indicate no surveys conducted during some survey periods, or insufficient data for summary statistic calculations.

Table 27 Species Richness in 2021 for Waterbird Foraging Guilds within Sedge and Willows-sedge Wetland Habitat By Survey Period Observed during Transect Surveys

Foraging Guild	Spring			Fall			
	Early	Middle	Late	Early	Early-Middle	Late-Middle	Late*
Benthic Feeding Divers	-	0.0	0.0	0.0	0.0	0.0	-
Dabbling Ducks	-	2.0	2.0	1.0	1.0	1.0	-
Gulls	-	0.0	0.0	0.0	0.0	0.0	-
Large Dabblers	-	1.0	0.0	0.0	0.0	0.0	-
Marsh Birds	-	2.0	1.0	2.0	2.0	1.0	-
Piscivorous Divers	-	0.0	0.0	0.0	0.0	0.0	-
Shorebirds	-	2.0	0.0	0.0	0.0	0.0	-
Total Species Richness	**-**	**7.0**	**3.0**	**3.0**	**3.0**	**2.0**	**-**
Species Evenness	**-**	**0.9**	**0.7**	**0.9**	**1.0**	**0.4**	**-**

Note: Dashes indicate no surveys conducted during some survey periods or insufficient data for summary statistic calculations.

4.2.4 Waterbird Species at Risk

The following species designated as at risk, as per provincial, *Species at Risk Act* (SARA), or Committee on the Status of Endangered Wildlife in Canada (COSEWIC) rankings, were observed during 2017 through 2021 transmission line wetland surveys:

- Eared grebe (*Podiceps nigricollis*), BC listing (Blue)
- Horned grebe (*Podiceps auratus*), COSEWIC (SC), SARA (SC)
- Long-tailed duck (*Clangula hyemalis*), BC listing (Blue)
- Red-necked phalarope (*Phalaropus lobatus*), BC listing (Blue)
- Surf scoter (*Melanitta perspicillata*), BC listing (Blue)
- Western grebe (*Aechmophorus occidentalis*), BC listing (Red), COSEWIC (SC), SARA (SC)
- Yellow rail (*Coturnicops noveboracensis*), BC listing (Red), COSEWIC (SC), SARA (SC).

Across years, the most commonly observed waterbird species at risk within wetlands was surf scoter (111 individuals). Horned grebes (83 individuals) and eared grebes (78 individuals) were also regularly recorded. Fewer than 30 individuals of other species at risk were recorded within wetalnds across the 5 survey years (**Appendix B-1**). Except for long-tailed duck, all of these species were observed during surveys of wetlands conducted in 2021 and red-necked phalarope was observed for the first time during transmission line wetland surveys in 2021 (**Appendix B-2**).

5.0 DISCUSSION AND RECOMMENDATIONS

As per the objectives described in **Section 1.2**, the monitoring program has improved understanding of baseline conditions for waterbirds, including assessment of habitat and documentation of habitat-specific measures of relative abundance and diversity for waterbird species groups. The results obtained are discussed below within the context of these monitoring objectives and prior understanding regarding baseline conditions for waterbirds and their habitat within the Peace River Valley and wetlands on the Moberly Plateau.

5.1 Habitat Assessment

Waterbird habitat associations (e.g., river and wetland habitat types) and habitat characteristic data (e.g., TEM mapping and Peace River flow rates) collected during 2017 through 2021 improve understanding of baseline conditions and factors influencing the distribution and abundance of waterbirds. Waterbird location and habitat association data collected during this monitoring program improve on the data available prior to 2017, in which bird observations were recorded within 5 km segments without habitat characteristics. While TEM-based mapping provides informative wetland habitat data, it does not include landform information pertinent to waterbird presence on the Peace River, where river dynamics can change habitat from year to year. However, re-characterization of habitat types along the Peace River following Project commissioning will provide comparisons of habitat availability relative to Project-related changes to impact treatment areas. LIDAR data of the Peace River Valley may also be considered in future analyses (e.g., BACI models) to assess the influence of topographic features such as water depth on waterbirds. Similarly, river levels may influence waterbird abundances and / or diversity and can be considered in models assessing the magnitude and significance of Project-related changes to the abundance and diversity of waterbirds. Consideration of flow rate as a co-variate within future BACI models should account for the influence of river levels on waterbird abundance or density, including potential bias from surveys conducted under atypical conditions. For example, high river levels could result in a re-distribution of dabbling waterbirds from Mainstem and Moderate Flow habitats to more shallow areas such as Minimal and Limited Connectivity habitat types where suitable foraging depths persist. Inclusion of flow rate as a co-variate in analyses could account for such variation and increase power to detect change.

Once the Site C reservoir begins to fill (currently anticipated during fall 2023), the Inundation Impact area will be buffered from the effects of river flow rates, at which point waterbird abundance and diversity metrics in that area will no longer be influenced by this factor. Reservoir levels can be recorded during this period and may also help to explain variations in the abundance and diversity of waterbirds, although fluctuations in reservoir water levels sufficient to affect waterbird distribution are expected to be rare.

5.2 Peace River Waterbird Surveys

Boat surveys of the Peace River in 2017 through 2021 have provided estimates of relative abundance and diversity throughout the spring and fall migrations to meet the waterbird monitoring program objectives (**Section 4.1**). All target taxa, including shorebirds, were observed during boat surveys. Results from Peace River observations in 2017 through 2021 identified 93% of birds at the species level and 97% of records to the foraging guild level at which Project-related effects are to be assessed (**Appendix B-1**). This represents a substantial improvement over survey methods applied prior to 2017, which were unable to detect shorebirds and had species identification rates under 80% (Hemmera 2017). Results of Peace River surveys are discussed below, first summarizing the relative abundance of foraging guilds and highlighting the most abundant species, then discussing patterns of abundance and diversity across survey periods in relation to the allocation of effort prescribed by power analyses that informed the design of the study. The relative abundance of foraging guilds across habitat types is also discussed along with the distribution of waterbirds across treatment areas and implications for assessing Project-related change.

The most abundant foraging guilds observed in the study area were large dabblers followed by dabbling ducks and gulls, while benthic feeding divers, piscivorous divers, and shorebirds were the least-abundant waterbird guilds observed on the Peace River. At the species level, the most numerous waterbird observed on the Peace River across all years was Canada goose, followed by mallard, Bonaparte's gull (*Chroicocephalus philadelphia*), and Franklin's gull (*Leucophaeus pipixcan*) (**Appendix B-1**). Surveys in 1996 and 1999 resulted in similarly high abundances of Canada goose relative to other speices, which made up over 50% of the observed waterbirds (Robertson 1999; Robertson and Hawkes 2000; Hawkes et al. 2006).

Peace River waterbird surveys from the spring of 2017 through 2021 found the highest mean abundance and densities in early spring. Higher waterbird numbers in the early spring are likely driven by the lack of available wetland habitat on the plateau, which is typically frozen during this time, leaving few open water habitat alternatives other than the Peace River. Wetlands on the plateau typically thaw by late April, allowing waterbirds to disperse more broadly across open water habitat during the later spring survey periods. During the middle spring period, early and late migrant waterbirds use the river as a migratory stopover and for breeding. Consistent with results reported in previous years, 2021 analyses of diversity within Mainstem and Moderate Flow habitats found lower species diversity in the early spring (April 1 to April 14) relative to middle and late spring periods (April 15 through May 30). These results remain consistent with the findings of other researchers who found mid-May to be the peak of the spring migration (Siddle 2010).

Data collected in 2017 through 2021 show that all habitats in the Peace River are used by waterbirds, with variations in timing, distribution and abundance for each foraging guild. The greatest densities of waterbirds were consistently observed within Limited Connectivity habitat, such as backchannels with little to no flow, silty sediments, and relatively abundant aquatic vegatation. Higher densities of dabbling ducks and large dabblers within more shallow habitats (e.g., Limited Connectivity and Moderate Flow habitats) align with findings from other studies assessing waterbirds associations with wetlands of various water depths (Colwell and Taft 2000; Baschuk et al. 2012). In contrast with findings from these prior studies, benthic feeding and piscivorous divers were also observed in higher densities within shallow as compared to deeper waters within Mainstem habitat of the Peace River. This result suggests that prey availability for diving birds is greater within shallow habitat, but may also reflect higher use of these more sheltered habitats to reduce exposure to predators or to rest away from higher energy flows within Mainstem habitat. Despite higher densities within Limited Connectivity habitat, more birds were observed within the Mainstem of the Peace River than in any other habitat type because Mainstem habitat comprised the greatest area and proportion of the study area.

While overall densities of waterbirds observed across Peace River habitat types were highest in Limited Connectivity habitat regardless of season, densities varied between Mainstem and Moderate Flow habitats between seasons. In spring, waterbirds used Moderate Flow habitat more than Mainstem, whereas that pattern was reversed in fall. This finding appears to be driven by relatively low densities of dabbling ducks and large dabblers (e.g., Canada goose) within Moderate Flow habitat in spring, and higher abundances of gulls in the fall, which were primarily recorded in Mainstem habitat in both seasons.

Differences in detection rates across habitat types may contribute to higher apparent abundances of some species within Limited Connectivity and Moderate Flow relative to Mainstem habitats given that the distance to detection is typically smaller within shallower habitats and birds are more readily flushed and detected in these circumstances. Thus, it is likely that detection rates of small birds (e.g., benthic feeding divers, shorebirds, dabbling ducks) was greater within Limited Connectivity and Moderate Flow as compared to Mainstem habitats. Such potential biases related to distance to detection can be accounted for in analyses of Project-related effects through the application of distance sampling (Buckland et al. 2015), for which distance to detection measures have been recorded during surveys. Waterbird records are not tied to the river habitat categories applied in the summary statistics of this report. Thus, habitat types and assignments can be refined or re-classifed to account for other factors if they are found to explain variation in waterbird abundance better than the habitat types proposed here.

Surf scoter was the only species at risk regularly observed during Peace River surveys, with a total of 206 individuals observed across years, including 12 during monitoring in 2021. California gull and tundra swan are similar in appearance to other species, so their numbers may have been underestimated. Some California gull individuals may have been recorded as unknown gull species. Similarly, some tundra swan individuals may have been recorded as unknown swan species or pooled with records of trumpeter swan (*Cygnus buccinator*).

The summary of data within treatment areas found that waterbird densities were similar within the Control and impact areas. All foraging guilds occurring within the impact areas were also found to be present within the Control area in both spring and fall, therefore meeting a standard assumption for BACI study design and data analysis. However, the numbers and densities of benthic feeding divers and gulls observed within the control area are low relative to the impact areas. The high numbers of gulls in the Flow Impact area and within Confluence river reaches, particularly during fall, explain some of the divergence in gull densities across treatment areas. As described above, most gulls are concentrated around disturbed habitat at the Project construction site and close to the local landfill. While benthic feeding divers are found in low densities within the Control relative to other treatment areas, they are present and will still provide some indication of background variations in density under baseline and post-construction conditions.

5.3 Transmission Line Wetland Surveys

Wetland surveys along the transmission line successfully provided estimates of spring and fall relative abundance and diversity of waterbirds in suitable wetland habitat types. Survey results provide the data required to meet the study's monitoring objectives (**Section 4.2**). A representative suite of sampling stations has been established, and consistent monitoring of these has been conducted in 2018 through 2021. Additionally, 5 consecutive years of monitoring have been conducted within open water wetland habitats surveyed by standwatch methods. Taken together, these methods provide density and relative abundance data for all wetland habitats where waterbirds have been found to regularly occur and are sufficient to characterize the relative abundance and diversity of waterbirds during spring and fall migration, which is briefly summarized below.

The dabbling duck foraging guild, encompassing small species of duck that primarily forage on aquatic vegetation, were the most commonly recorded foraging guild in open water and flooded sedge and willow-sedge wetlands surveyed by standwatch. Ring-necked duck (*Aythya collaris*), American wigeon (*Mareca americana*), scaup species (*Aythya* spp.), green-winged teal (*Anas crecca*) and mallards were among the most-numerous species observed. Vegetated wetland surveys conducted by walking transects found dabbling ducks (e.g., mallards, green- and blue-winged teal [*Spatula discors*], and northern shoveler [*Spatula clypeata*]) and marsh birds (e.g., Wilson's snipe [*Gallinago delicata*], and sora [*Porzana carolina*]) were most abundant, with 171 and 117 records across years, respectively (**Appendix B-1**). Shorebirds (e.g., spotted sandpiper) were the next most abundant with 51 records. Results from wetland transect and standwatch surveys 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) and are aligned with prior reports from this monitoring program (Hemmera 2018, 2019, 2020). 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 through 2008 studies in the transmission line ROW area (EIS, appendix R, part 4) and 2017 (Hemmera 2018). While fewer waterbirds were observed within sedge and willow-sedge habitats surveyed by transect methods, these surveys documented abundances of sora and wilson's snipe (*Gallinago gallinago*), which seldom use flooded habitat and, consequently, are not seldom observed during standwatch survey methods.

The timing of peak waterbird abundance and diversity is likely linked to spring thaw and the open water habitats on the Moberly Plateau becoming available. This coincides with reduced numbers of waterbirds on the Peace River, as waterbirds appear to relocate from river to upland wetlands in middle to late spring. Across survey periods, mean densities of waterbird foraging guilds were lowest in the late fall (i.e., after October 15). This likely reflects the increasingly cold conditions in mid-October and southward migration of some species. The absence of waterbirds observed from transect surveys of vegetated sedge and willow-sedge wetlands during the late fall survey periods suggests reduced vocalizations and/or presence of marsh birds and re-distribution of dabbling ducks into other habitat types during October. The lack of waterbird observations from transect surveys during late fall of 2017 through 2019 supports the discontinuation of transect surveys during this period in 2020 and 2021 and as planned in subsequent years.

Survey efforts within the wetland study area were not entirely consistent across years due to weather and access constraints. Measures of diversity will ultimately be refined by accounting for variation in survey effort in all survey years to provide cleaner comparisons across years when assessing Project-related change to waterbird diversity. Similarly, while estimates of density per kilometre of transect are considered sufficient for the purposes of documenting annual data collection in this report and for documenting change over time, future analyses considering transect width and distance sampling will be required to provide more accurate estimates of density.

Another challenge encountered during the 2021 monitoring program was changes to habitat within the wetland study area. During 2021, wetland survey stations SE-12 and OW-10 were drained of water, apparently due to the installation or modification of culverts on the southern edge of these survey station polygons. Consequently, these areas were only surveyed on the rare occasions when water was present within them this year. Additional habitat will be identified for surveys in subsequent years to replace these stations if they continue to be drained of water, as they would no longer represent suitable foraging habitat for waterbirds.

With regard to bioacoustics monitoring, ARU survey results are satisfying monitoring objectives to document trends in the presence of yellow rail, American bittern, and sora. In 2020 and 2021, ARUs were also used to document the presence of Virginia rail, which will continue through future monitoring. Observations of crepuscular marsh birds have been consistent across the wetlands during the 5 study years, indicating that sora is common, yellow rail is uncommon but regularly occurs within relatively large areas of non-flooded sedge habitat, and American bittern is rare. Since no records of American bittern were confirmed during 5 years of monitoring or as part of any other Site C wildlife studies, it is unlikely that bioacoustics monitoring will yield meaningful estimates of density or distribution beyond what is already known: the species is rare and typically absent or undetected within suitable habitat in the region. In contrast, sora have been detected consistently at every deployment conducted to date, including in all wetland and mixed habitat types surveyed and all portions of the bioacoustics monitoring period (**Table 22**). Furthermore, sora are often detected during wetland transect and standwatch surveys, providing robust data from multiple survey methods throughout the wetland study area. ARU bioacoustics monitoring confirms previous reports of yellow rail from call-playback and point-count surveys (Hilton et al. 2013) EIS, appendix R, part 4). Furthermore, ARU deployments in 2021 re-detected yellow rail at 3 sites (ARU deployments within sedge habitat at wetland stations SE-04, SE-05 and SE-11), indicating that the species occurs consistently across years within the study area in sedge-dominated wetlands. The detection of yellow rail at two new locations, within wetland stations WS-03 and SE-03, indicates that this species also inhabits mixed habitat or smaller areas of sedge habitat than reported up to this point. Additional monitoring will help to determine the frequency of yellow rail occurrence in mixed habitat where sedge habitat is present but not dominant. During bioacoustics monitoring in 2020 and 2021, Virginia rail was detected during May and June at locations surrounded by sedge, willow-sedge, and upland forested habitats (**Table 22**). Monitoring in 2022 will target similar locations and habitats during July and August to inform on whether Virginia rail is present and vocally active within the study area during the latter half of the monitoring period.

6.0 CLOSING

This Work was performed in accordance with Contract No. 95055-05 between Hemmera Envirochem Inc. (Hemmera), a wholly owned subsidiary of Ausenco Engineering Canada Inc. (Ausenco), and BC Hydro (Client), dated September 28, 2016 (Contract). 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.

We sincerely appreciate the opportunity to have assisted BC Hydro with this project and if there are any questions, please do not hesitate to contact the undersigned by phone or email.

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7.0 REFERENCES

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APPENDIX A

Ducks Unlimited / Native Plant Solutions Technical Memo: Waterbird Program Analysis: Statistical Analysis of Survey Effort and Timing, Combined 2017, 2018 and 2019 Peace River Waterbird Data

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ATTENTION: Brock Simons

RE: Waterbird Program Analysis:
Statistical Analysis of Survey Effort and Timing,
Combined 2017, 2018 and 2019 Peace River Waterbird Data

Overview

BC Hydro has requested Native Plant Solutions (NPS)/Ducks Unlimited Canada (DUC) to repeat statistical analyses performed in December 2019 on the Peace River Waterbird data, now with combined 2017, 2018 and 2019 data. The intent of this technical memo is to outline the results of the analysis, as part of preparation for the 2020 waterbird monitoring field season. Specifically, DUC reviewed survey effort and survey timing in 2017, 2018 and 2019, based on the data provided by Hemmera on November 19th, 2019 and December 18th, 2019. The review focused on the 2017-2019 River Transect Waterbird data, including statistical analyses of the difference in density observed during survey periods (Statistical Analysis #1) and the sampling effort required to detect change (Statistical Analysis #2). The analysis also determines what effect dropping the UAV portion of the survey program will have on the overall survey effort required.

Background to monitoring methodology

Statistical analysis was conducted on the combined 2017-2019 unmanned aerial vehicle (UAV) and river boat survey data. During each season of migration, the season was split into several periods (spring: early, mid, late; and fall: early, early-mid, late-mid and late). Survey effort in 2019 was kept the same as in 2018 with the goal of better capturing and defining optimal survey periods for each foraging group and determining if the late fall survey period added in 2018 improved detection of Benthic Divers. Table 1 lists the survey periods and dates for each field season.

Within most survey periods, two replicate surveys were conducted, with each survey taking two days to complete. There was an exception in 2018 where three days were required due to ice washing down the Peace River on April 26 in the middle of the survey. There was also an exception in 2019 where three days were required to complete the first survey of the season (April 3, 4, 8). Note that in spring 2017, one survey day was dropped from statistical analysis (April 12), due to poor weather and therefore low bird counts. Survey dates in 2017-2019 were as described in Table 1.

Table 1. Survey periods and dates in 2017, 2018 and 2019.

Period	2017 Dates	2018 Dates	2019 Dates
Spring_Early	Apr. 5, 6	Apr. 13, 14	Apr. 3, 4, 8; Apr. 11, 12
Spring_Mid	Apr. 26, 27; May 3, 4	Apr. 25, 26 & May 1; May 5, 6	Apr. 19, 24; May 1, 2
Spring_Late	May 10, 11; May 14, 15	May 10, 11; May 18, 19	May 9, 10
Fall_Early	Aug. 8, 9; Aug. 14, 15	Aug. 4, 5	Aug. 7, 9
Fall_Early-Mid	Aug. 22, 23; Aug. 28, 29	Aug. 20, 21; Sep. 4, 5	Aug. 19, 20; Sep. 4, 5
Fall_Late-Mid	Sep. 21, 22; Sep. 27, 28	Sep. 20, 21; Oct. 4, 5	Sep. 16, 17; Sep. 30, Oct. 1
Fall_Late	none	Oct. 15, 16	Oct. 16, 17

In this technical memo, the following terminology is used when referring to the waterbird monitoring program:

- **Survey period:** A survey period is the timing of when a survey happens within a season (i.e., spring or fall) to document migrants, including early, early-mid, mid, late-mid and late. The original study design of the Waterbird Migration Follow-up Monitoring Program (BC Hydro 2018) was structured to have two surveys within each period acting as replicates to provide measures of uncertainty around estimates of relative abundance and diversity. For example, late spring is a survey period, containing two surveys.
- **Survey:** A survey is the census of waterbirds over the length of the Peace River, from the Peace Canyon Dam (Hudson's Hope) to the Alberta border (BC Hydro 2018). A survey typically takes two survey days to complete. For example, April 5 and 6 in spring 2017 is an early survey. Survey effort is quantified as the total length (km) of the river impact and control areas surveyed over the course of a survey.
- **Survey day:** A survey takes two survey days (noting the above-mentioned exceptions) to complete, with half of the river study area being surveyed each day and, in most cases, the whole river being surveyed in consecutive days. Each day is referred to in this technical memo as a survey day. For example, 12 survey days were conducted in fall of 2017 (e.g., August 8, 9, 14, 15, 22, 23, 28 and 29, and September 21, 22, 27 and 28).
- **Survey Area:** A survey area is a portion of the river labelled as one of control, flow impact, and inundation impact. For the remainder of this technical memo, flow and inundation impacts will be treated together as the "impact" area.

Statistical Analysis #1 - Statistical analysis of differences in density observed during survey periods (i.e., early, mid and late) in spring and fall

Statistical Analysis #1 tests for differences among early, mid and late periods in both spring and fall survey periods. Based on the results of Statistical Analysis #1, the biological inference that can be made from this is to assess if the timing and number of survey periods in spring and fall of 2017, 2018 and 2019 were capturing peaks in abundance during migration and the specific survey timing recommended for capturing any peaks.

The spring and fall survey periods were analysed separately, fit with foraging group-specific negative binomial regression models, with total bird counts per complete river survey (normally completed over two consecutive days) as the response and survey period (Spring: early vs. mid vs. late; and Fall: early vs. early-mid vs. late-mid vs. late), study area (control vs flow and inundation impact) and year as predictors. The natural log of surveyed river length by study area (km) was used as an offset variable to scale total bird counts for differing effort across surveys. Survey period and study area were treated as additive predictors in the foraging group model since preliminary analyses suggested similar patterns in waterbird abundance peaks across the control and impact areas.

A complete list of species observed during spring and fall surveys in 2017, 2018 and 2019 is provided in Appendix A. Some species and foraging groups (e.g., bald eagles) were not included in the combined analysis due to the low densities observed. Differences in density among survey periods were also analyzed at a foraging group level. The allocation of species to each foraging group is also listed in Appendix A. Discussion of the 2017-2019 data is focused at the foraging group level because of the greater strength of inference analysis at the foraging group level allows (see NPS 2018 technical memo).

During spring migration surveys (Table 2), at a foraging group level, the early period yielded the highest counts for Large Dabblers and Piscivorous Divers and lowest counts for Surface Feeding Terns/Gulls. Late spring surveys yielded the highest counts for Shorebirds, Surface Feeding Terns/Gulls, with lowest counts for Benthic-Feeding Divers and Piscivorous Divers.

During fall migration surveys (Table 3), at a foraging group level, the early survey period yielded the highest counts for Shorebirds and lowest counts for Large Dabblers. Late-mid and late fall surveys yielded the highest counts for Large Dabblers.

Table 2. Spring survey periods results.

Forage Group	Differences in densities observed among Early, Mid, and Late Periods	Estimated number of birds seen per 100 km of river surveyed (standard error)[1]
Foraging Group Level[2]		
Benthic Feeding Divers	Early and Mid > Late	Control: E: 32.8 (12.1); M: 32.1 (12.2); L: 9.2 (3.2) Impact: E: 98.1 (36.8); M: 95.9 (29.5); L: 27.5 (10.1)
Dabbling Ducks	No	Control: 413.2 (49.2) Impact: 289.5 (33.3)
Surface Feeding Terns/Gulls	Mid and Late > Early	Control: E: 0.3 (0.3); M: 10.7 (5.4); L: 14.2 (7.5) Impact: E: 0.9 (0.6); M: 30.4 (14.8); L: 40.1 (21.2)
Large Dabblers (Geese and Swans)	Early > Mid and Late	Control: E: 1,154.0 (136.7); M: 444.3 (48.7); L: 365.8 (40.2) Impact: E: 1,151.3 (136.2); M: 443.3 (44.7); L: 365.0 (40.4)
Piscivorous Divers	Early > Mid > Late	Control: E: 79.6 (16.9); M: 33.5 (6.3); L: 19.2 (3.7) Impact: E: 183.7 (33.8); M: 77.4 (13.3); L: 44.2 (8.5)
Shorebirds	Late > Early and Mid	Control: E: 1.1 (0.6); M: 1.9 (0.9); L: 52.9 (15.7) Impact: E: 1.3 (0.6); M: 2.2 (0.8); L: 63.2 (22.6)

[1] – E: early; M: mid; L: late.

[2] – Highest survey counts for Foraging Groups are indicated in red.

Table 3. Fall survey periods results.

Species or Forage Group	Differences in densities observed among Early, Early-Mid, Late-Mid, and Late Periods	Estimated number of birds seen per 100 km of river surveyed (standard error)[1]
Foraging Group Level[2]		
Benthic-Feeding Divers	No	Control: 1.0 (0.6) Impact: 7.6 (2.9)
Dabbling Ducks	Early-Middle and Late-Middle > Late	Control: E: 16.2 (7.5); E-M: 30.2 (11.3); L-M: 35.9 (12.1); L: 4.4 (2.7) Impact: E: 185.0 (78.2); E-M: 344.2 (117.8); L-M: 409.9 (163.1); L: 50.2 (25.8)
Surface Feeding Terns/Gulls	Early, Early-Middle and Late-Middle > Late	Control: E: 12.3 (6.1); E-M: 24.8 (8.8); L-M: 9.5 (3.6); L: 1.7 (1.1) Impact: E: 591.3 (220.3); E-M: 1,190.9 (480.2); L-M: 458.1 (175.1); L: 82.5 (49.8)
Large Dabblers (Geese and Swans)	Late and Late-Middle > Early; Late-Middle > Early-Middle	Control: E: 255.0 (63.4); E-M: 469.9 (110.9); L-M: 939.5 (193.5); L: 780.6 (263.7) Impact: E: 145.1 (37.1); E-M: 267.3 (55.6); L-M: 534.5 (115.2); L: 444.1 (152.0)
Piscivorous Divers	No	Control: 16.6 (3.9) Impact: 20.7 (4.0)
Shorebirds	Early > Early-Mid > Late-Mid	Control: E: 228.5 (40.4); E-M: 96.7 (15.4); L-M: 3.5 (0.9); L: 0 (--) Impact: E: 112.2 (19.0); E-M: 47.5 (7.6); L-M: 1.7 (0.5); L: 0 (--)

[1] – E: early; E-M: early-mid; L-M: late-mid; L: late.

[2] – Highest survey counts for Foraging Groups are indicated in red.

Statistical Analysis #2 - Statistical power analysis to estimate sampling efforts required to detect change in impact area relative to control

The second objective of the statistical analysis was to conduct a power analysis, based on the available 2017, 2018 and 2019 survey data, to estimate the sampling effort required to detect change of a specific magnitude in the impact area relative to the control area. Based on the results of the statistical analysis, this provides guidance on determining the magnitude and possibilities for allocating effort to detect, with 80% statistical power, a 50% change in foraging group abundance in the impact area contrasted with no change in the control area over time.

For Statistical Analysis #2 a baseline average of relative abundances for the impact and control areas were calculated from the 2017, 2018 and 2019 survey data. Within the 2017-2019 survey data, some foraging groups exhibited differences in counts among survey periods in a season, whereas other foraging groups did not. For the foraging groups for which there were statistically detectable differences in counts across survey periods, relative abundance estimates from particular survey periods are informative baselines as identifiable 'optimal' survey periods, such that averaging across survey periods would conceal important within-season differences in relative abundances. Therefore, for foraging groups exhibiting statistically detectable differences in counts across survey periods, baseline bird densities were estimated using the survey periods that yielded the highest densities. For foraging groups without statistically detectable differences in counts across survey periods (i.e., either due to counts that did not vary much across survey periods over a season, or where counts varied greatly among surveys within a survey period), relative abundance estimates from particular survey periods are not informative baselines. Rather, pooled baseline estimates of abundance across a season are best and will mitigate the impacts of survey-specific variation. Therefore, for foraging groups where there were not statistically detectable differences in counts among survey periods, baseline bird densities were estimated using averages across all surveys.

Relative abundance is the average number of birds that were counted during a survey in a study area (control vs flow and inundation impact), per 100 km length of river surveyed. Given the best estimates of foraging group relative abundances (and their standard errors) from the 2017-2019 survey data, the statistical power analyses estimated the sampling efforts required to detect changes of a specified magnitude in the impact area as contrasted with no change in the control area. For the purposes of this analysis, a 50% change in relative abundance in the impact area was seen as a reasonable target (i.e., both statistical and biological; Hatch 2003). Tables 4 and 5 give the survey effort required to detect 50% change in relative abundance in the impact area versus no change in the control area given 2017-2019 spring (Table 4) and fall (Table 5) survey baselines. Note that survey effort is given in the number of surveys and the estimated number of years to detect change (i.e., should the current survey effort be maintained over time).

In spring (Table 4), the survey effort required to detect a 50% change in relative abundance (i.e., based on the 2017-2019 spring survey data) in the impact area versus no change in the control area was the least for Large Dabblers (Geese and Swans), with increasing survey effort to detect change in Piscivorous Divers, Dabbling Ducks, Benthic-Feeding Divers, and Surface Feeding Terns/Gulls. Note that early and mid surveys are not informative for estimating relative abundance of Shorebirds. In fall (Table 5), the survey effort required to detect a 50% change in relative abundance (i.e., based on the 2017-2019 fall survey data) in the impact area versus no change in the control area was the least for Shorebirds, with increasing survey effort to detect change in Large Dabblers, Dabbling Ducks, Piscivorous Divers, Surface Feeding Terns/Gulls, and Benthic-Feeding Divers.

Table 4. Survey effort required to detect a 50% change in relative abundance in the impact area contrasted with no change in the control area given a 2017-2019 Spring Survey baseline. [1]

Forage Group	Survey Periods Used for Estimating Baseline Abundance (number of complete river surveys in 2017-2019)	2017-2019 Baseline Average Relative Abundance per 100 km (Standard Error)	Estimated survey effort required beyond 2017-2020 baseline period
Benthic-Feeding Divers	Early & Mid (n = 10 surveys)	Control: 32.4 (9.7) Impact: 97.0 (24.8)	12 (3 years; assuming 2 early and 2 mid surveys each year)
Dabbling Ducks	Early, Mid, Late (n = 15 surveys)	Control: 413.2 (49.2) Impact: 289.5 (33.3)	9 (~3 years; assuming 4 complete river surveys per year)
Surface Feeding Terns/Gulls	Mid & Late (n = 11 surveys)	Control: 12.3 (4.9) Impact: 34.9 (13.5)	18 (~9 years; assuming 2 mid surveys per year)
Large Dabblers (Geese and Swans)	Early (n = 4 surveys)	Control: 1154.0 (136.7) Impact: 1151.3 (136.2)	1 (1 year; assuming 2 early surveys per year)
Piscivorous Divers	Early (n = 4 surveys)	Control: 79.6 (16.9) Impact: 183.7 (33.8)	3 (2 years; assuming 2 early surveys per year)
Shorebirds	Late (n = 5 surveys)	Control: 52.9 (15.7) Impact: 63.2 (22.6)	10 (n/a; no additional late surveys planned)

[1] – Red indicates foraging groups that should not be the focus of surveys within this season.

Table 5. Survey effort required to detect a 50% change in relative abundance in the impact area contrasted with no change in the control area given a 2017-2019 Fall Survey baseline. [1]

Forage Group	Survey Periods Used for Estimating Baseline Abundance (number of complete river surveys in 2017-2019)	2017-2019 Baseline Average Relative Abundance per 100 km (Standard Error)	Estimated survey effort required beyond 2017-2020 baseline period
Benthic-Feeding Divers	Early, Early-Mid, Late-Mid, Late (n = 18 surveys)	Control: 1.0 (0.6) Impact: 7.6 (2.9)	> 210 (> 70 years; assuming 3 complete river surveys per year)
Dabbling Ducks	Early, Early-Mid, Late-Mid, (n = 16 surveys)	Control: 26.0 (6.9) Impact: 296.7 (76.3)	9 (3 years; assuming 1 early, 1 early-mid and 1 late-mid survey per year)
Surface Feeding Terns/Gulls	Early, Early-Mid, Late-Mid (n = 16 surveys)	Control: 14.3 (4.2) Impact: 685.8 (173.2)	24 (~8 years; assuming 1 early, 1 early-mid and 1 late-mid survey per year)
Large Dabblers (Geese and Swans)	Early-Mid, Late-Mid, Late (n = 14 surveys)	Control: 701.1 (124.8) Impact: 398.8 (69.0)	2 (1 year; assuming 1 early-mid and 1 late-mid survey per year)
Piscivorous Divers	Early, Early-Mid, Late-Mid, Late (n = 18 surveys)	Control: 16.6 (3.9) Impact: 20.7 (4.0)	15 (5 years; assuming 1 early, 1 early-mid and 1 late-mid survey per year)
Shorebirds	Early (n = 4 surveys)	Control: 228.5 (40.4) Impact: 112.2 (19.0)	2 (2 years; assuming 1 early survey per year)

[1] – Red indicates foraging groups that should not be the focus of surveys within this season.

The sensitivity of these results to exclusion of the survey data collected on back channels via unmanned aerial vehicles (UAVs) was also examined. For each survey and survey area, the proportion of the area surveyed by UAV was excluded from the measure of survey effort (i.e., surveyed river length) and all birds observed during UAV surveys were excluded from total bird counts. A summary of the proportions of area surveyed by UAV and total birds counted by UAV is provided in Table 6. In the fall, UAV surveys accounted for a large proportion of the Large Dabblers counted overall and for Dabbling Ducks counted in the impact area.

Table 6. Average proportion of River Survey Area and Total Birds counted by UAV.

Study Area	River Area	Benthic-Feeding Divers	Dabbling Ducks	Surface-Feeding Terns/Gulls	Large Dabblers	Piscivorous Divers	Shorebirds
Spring Surveys							
Control	0.038	0.082	0.050	0.172	0.120	0.112	0.000
Impact	0.063	0.073	0.165	0.050	0.141	0.060	0.030
Fall Surveys							
Control	0.026	0.000	0.128	0.000	0.476	0.032	0.005
Impact	0.033	0.208	0.459	0.001	0.286	0.128	0.032

Adjusted baseline average relative abundances were calculated, omitting the UAV data, and power analyses re-run to estimate sampling effort required to detect, with 80% statistical power, 50% changes in relative abundance in the impact area versus no change in the control area given 2017-2019 spring (Table 7) and fall (Table 8) survey baselines.

Table 7. Survey effort required to detect a 50% change in relative abundance in the impact area contrasted with no change in the control area given a 2017-2019 Spring Survey baseline (UAV data omitted). [1]

Forage Group	Survey Periods Used for Estimating Baseline Abundance (number of complete river surveys in 2017-2019)	2017-2019 Baseline Average Relative Abundance per 100 km (Standard Error)	Estimated survey effort required beyond 2017-2020 baseline period
Benthic-Feeding Divers	Early & Mid (n = 10 surveys)	Control: 31.3 (9.6) Impact: 95.9 (24.7)	11 (~3 years; assuming 2 early and 2 mid surveys each year)
Dabbling Ducks	Early, Mid, Late (n = 15 surveys)	Control: 392.6 (44.8) Impact: 246.9 (27.3)	8 (2 years; assuming 4 complete river surveys per year)
Surface Feeding Terns/Gulls	Mid & Late (n = 11 surveys)	Control: 7.9 (3.3) Impact: 41.2 (16.9)	80 (40 years; assuming 2 mid surveys per year)
Large Dabblers (Geese and Swans)	Early (n = 4 surveys)	Control: 1121.6 (138.4) Impact: 1096.7 (134.5)	1 (~1 year; assuming 2 early surveys per year)
Piscivorous Divers	Early (n = 4 surveys)	Control: 79.0 (18.9) Impact: 197.3 (41.9)	2 (~2 years; assuming 2 early surveys per year)

Forage Group	Survey Periods Used for Estimating Baseline Abundance (number of complete river surveys in 2017-2019)	2017-2019 Baseline Average Relative Abundance per 100 km (Standard Error)	Estimated survey effort required beyond 2017-2020 baseline period
Shorebirds	Late (n = 5 surveys)	Control: 54.1 (13.1) Impact: 54.5 (15.2)	10 (n/a; no additional late surveys planned)

1 – Red indicates foraging groups that should not be the focus of surveys within this season.

Table 8. Survey effort required to detect a 50% change in relative abundance in the impact area contrasted with no change in the control area given a 2017-2019 Fall Survey baseline (UAV data omitted). [1]

Forage Group	Survey Periods Used for Estimating Baseline Abundance (number of complete river surveys in 2017-2019)	2017-2019 Baseline Average Relative Abundance per 100 km (Standard Error)	Estimated survey effort required beyond 2017-2020 baseline period
Benthic-Feeding Divers	Early, Early-Mid, Late-Mid, Late (n = 18 surveys)	Control: 0.9 (0.6) Impact: 6.5 (3.2)	> 210 (> 70 years; assuming 3 complete river surveys per year)
Dabbling Ducks	Early, Early-Mid, Late-Mid, (n = 16 surveys)	Control: 24.8 (7.2) Impact: 198.9 (56.0)	12 (4 years; assuming 1 early, 1 early-mid and 1 late-mid survey per year)
Surface Feeding Terns/Gulls	Early, Early-Mid, Late-Mid (n = 16 surveys)	Control: 14.8 (4.4) Impact: 720.8 (184.5)	12 (4 years; assuming 1 early, 1 early-mid and 1 late-mid survey per year)
Large Dabblers (Geese and Swans)	Early-Mid, Late-Mid, Late (n = 14 surveys)	Control: 505.0 (89.2) Impact: 323.9 (57.6)	2 (1 year; assuming 1 early-mid and 1 late-mid survey per year)
Piscivorous Divers	Early, Early-Mid, Late-Mid, Late (n = 18 surveys)	Control: 15.6 (3.9) Impact: 17.8 (3.7)	13 (~4 years; assuming 1 early, 1 early-mid and 1 late-mid survey per year)
Shorebirds	Early (n = 4 surveys)	Control: 230.7 (40.4) Impact: 113.0 (19.0)	2 (2 years; assuming 1 early survey per year)

1 – Red indicates foraging groups that should not be the focus of surveys within this season.

Given the estimates of survey effort required beyond 2019 and survey periods suited to characterizing relative abundance or use by each foraging group, we can consider different scenarios for survey plans in future years. Factors to consider for future efforts include the following:

- If a foraging group is observed in lower abundances or with greater variability across survey periods, the ability to detect a 50% change in relative abundance in the impact area contrasted with no change in the control area may not be achievable within a reasonable time period, which is defined as ≤ 10 years, or the post-construction monitoring period. The foraging groups shaded in grey tone in Tables 9 and 10 fall into this category. BC Hydro may want to consider tailoring their spring and fall survey plans to exclude certain foraging groups, for which detecting statistically significant differences over time is unlikely during the period of the waterbird monitoring program (e.g., Surface Feeding Terns/Gulls and shorebirds in spring; Benthic-Feeding Divers in fall).
- If peak abundances for a foraging group are observed uniquely in a survey period, the region should be surveyed during that time period. For example, the early survey period is important to characterize relative abundances of Large Dabblers and Piscivorous Divers in spring, compared to the early survey time for Shorebirds in fall.
- For species whose relative abundances or use are well captured during any survey within a survey period (e.g., Dabbling Ducks in spring and fall; Benthic-Feeding Divers and Piscivorous Divers in fall), the particular timing of surveys does not play much of a role. It is simply the overall survey effort that helps to moderate the variability observed across survey occasions.

Tables 9 and 10 consider the impacts of survey timing scenarios given that an early survey is necessary in the spring and late-mid or late surveys may be necessary in the fall. In general, a 50% change in relative abundance in the impact area contrasted with no change in the control area would be detected within 10 years for five of the foraging groups in spring. It will take 8 years of effort of 3 or more fall surveys/year to detect a 50% change in relative abundance in the impact area contrasted with no change in the control area for five of the foraging groups.

Table 9. Impacts of modified Spring Waterbird Survey plans beyond 2020. [1]

Foraging Group	**Periods useful for Characterizing Foraging Group Use**	**Estimated survey effort (number of surveys) required beyond 2017-2020 baseline period**	**Number of years required if 1 Early Survey is conducted per year** *(n= 2 survey days required/spring season)*	**Number of years required if 2 Early Surveys is conducted per year** *(n= 4 survey days required/spring season)*	**Number of years required if 2 Early Surveys, 1 Mid Survey are conducted per year** *(n= 6 survey days required/spring season)*	**Number of years required if 2 Early Surveys, 2 Mid Surveys conducted are per year** *(n= 8 survey days required/spring season)*
Dabbling Ducks	Any	9	9	5	3	3
Large Dabblers	Early	1	1	1	1	1
Piscivorous Divers	Early	3	3	2	2	2
Benthic Feeding Divers	Early, Mid	12	12	6	4	3
Surface Feeding Terns/Gulls	Mid, Late	18	-	-	18	9
Shorebirds	Late	10	-	-	-	-

[1] – Grey indicates foraging groups where 50% change cannot be detected within 10 years, with 80% statistical power, with the survey scenarios described.

Table 10. Impacts of modified Fall Waterbird Survey plans beyond 2020. [1]

Foraging Group	Periods useful for Characterizing Foraging Group Use	Estimated survey effort (number of surveys) required beyond 2017-2020 baseline period	Number of years required if 1 Early Survey, 1 Late-Mid Survey is conducted per year (*n= 4 survey days required/fall season)*	Number of years required if 1 Early Survey, 1 Late-Mid, 1 Late Survey are conducted per year (*n= 6 survey days required/fall season)*	Number of years required if 1 Early Survey, 1 Early-Mid, 1 Late-Mid Survey are conducted per year (*n= 6 survey days required/fall season)*	Number of years required if 1 Early Survey, 1 Early-Mid, 1 Late-Mid, 1 Late Survey are conducted per year (*n= 8 survey days required/fall season)*
Piscivorous Divers	Any	15	8	5	5	4
Large Dabblers	Early-Middle, Late-Middle, Late	2	2	1	1	1
Surface Feeding Terns/Gulls	Early, Early-Middle, Late-Middle	24	12	12	8	8
Dabbling Ducks	Early-Middle, Late-Middle, Late	9	9	5	5	3
Shorebirds	Early	2	2	2	2	2
Benthic-Feeding Divers	Any	> 210	> 105	> 70	> 70	> 53

[1] – Grey indicates foraging groups where 50% change cannot be detected within 10 years, with 80% statistical power, with the survey scenarios described.

Discussion

For the spring 2017-2019 survey data, optimal survey periods were identified for most foraging groups, except for Dabbling Ducks. The early and mid-surveys in spring yielded the highest counts for Benthic-Feeding Divers, Large Dabblers and Piscivorous Divers, while the late survey yielded the highest survey counts for Gulls/Surface Feeding Terns and Shorebirds. As presented in the statistical analyses of the 2017-2019 waterbird data, Dabbling Duck density was variable among surveys, but peak counts did not align with particular survey periods; it is overall survey effort rather than a particular allocation across survey periods that is useful for moderating the effects of survey-to-survey variability in Dabbling Duck counts.

For the fall 2017-2019 survey data, no optimal survey periods were clear for Piscivorous Divers or Benthic-Feeding Divers, due to high survey-to-survey variation in counts that did not align with particular survey periods. Low counts coupled with high variation, as seen with the Benthic-Feeding Divers, results in a high survey effort required to detect change in the fall (Table 5).

In order to efficiently detect, with 80% statistical power, 50% changes in relative abundance in the impact area versus no change in the control area, survey effort should be focused on the survey period(s) that best characterize the relative abundance of each foraging group. Tables 9 and 10 demonstrated various scenarios of survey effort and the subsequent number of years it will take to detect a 50% change in relative abundance in the impact area versus no change in the control for each foraging group.

Based on the results of the power analysis of survey effort scenarios in spring, conducting two early surveys per year will allow for the detection of 50% change in relative abundance in the impact area versus no change in the control within 1-6 years for Dabbling Ducks (n=18 field surveys days required), Large Dabblers (n=2 early field survey days required), Piscivorous Divers (n=6 early field survey days required) and Benthic-Feeding Divers (n=24 early or mid field survey days required) (Table 9). We recommend that Surface Feeding Terns/Gulls or Shorebirds not be the focus in spring surveys, because of the low likelihood of being able to detect statistically significant changes in these foraging groups within the waterbird monitoring program (i.e., during construction and the first 10 years of operations).

Based on the results of power analysis of survey effort scenarios in fall, conducting 1 early and 1 late-mid survey per year will allow for the detection of 50% change in relative abundance in the impact area versus no change in the control within 2-9 years for Piscivorous Divers (n=30 survey days), Large Dabblers (n=4 late-mid survey days), Dabbling Ducks (n=18 late-mid survey days) and Shorebird (n=4 early survey days). Changes in the impact areas (relative to no change in the control areas) for Surface Feeding Terns/Gulls can be detected within 12 years (n=48 survey days) with 1 early and 1 late-mid survey. Adding one more early, early-mid or late-mid survey per fall season does improve the power to detect changes in Surface Feeding Terns/Gulls in a shorter period (n=8 years; 48 survey days; Table 10).

For fall surveys we recommend that the focus is not on Benthic-feeding Divers because of the greater survey effort required to detect this foraging group within the fall season as compared to the spring season. Under the scenarios presented in Table 10 a 50% change in the impact area versus no change in the control for Benthic-Feeding Divers cannot be detected within 10 years.

Each foraging group varies from one another on life characteristics such as nesting and foraging behaviors, diet preferences and habitat preferences. Variation can also be seen within a foraging group as well. For example, Piscivorous Divers have similar food preferences, but vary in nesting behaviors. This makes it difficult to use one foraging group as an indicator for another. Statistically, Shorebirds and Surface Feeding Terns/Gulls have similar peaks in abundance, however they differ from all other foraging groups in this regard, which also makes the use of other foraging groups as an indicator difficult.

Overall, this suggests that to create more efficiency within the Waterbird survey program the early and mid surveys should be the focus during the spring survey period. Reduction in fall survey effort could include eliminating the early-mid and late-mid replicates, and the late period to detect of Surface Feeding Terns/Gulls within 8 years (n=48 survey days), with the caveat that focus of detecting Benthic Feeding Divers will be in the spring season.

The removal of the UAV data had little impact on the required survey effort (Tables 7 and 8) with exception to the Surface Feeding Terns/Gulls in the Spring survey period. Survey effort for this foraging group increased from 9 years to 40 years (given 2 mid surveys) with the exclusion of UAV data. If it is determined to be in the best interest of the survey program to eliminate the UAV portion of the waterbird surveys the detection of Surface Feeding Terns/Gulls should be focused on in the fall season.

References

BC Hydro. 2018. Site C Vegetation and Wildlife Waterbird Migration Follow-up Monitoring Program (v4 January 2018). 30 pp.

Hatch, S. A. 2003. Statistical power for detecting trends with applications to seabird monitoring. Biological Conservation 111:317-329.

Native Plant Solutions (NPS). 2018. Waterbird monitoring 2018 program technical memo: review of survey effort and timing. 12 pp.

Appendix A – Complete list of species and foraging groups observed during 2017/2018/2019 surveys, along the Peace River.

Species Code	Common Name	Latin Name	Foraging Mode Species Group
CONI	Common Nighthawk	*Chordeiles minor*	Aerial Insectivores
AMDI	American Dipper	*Cinclus mexicanus*	Benthic-Feeding Divers
BAGO	Barrow's Goldeneye	*Bucephala islandica*	Benthic-Feeding Divers
BUFF	Bufflehead	*Bucephala albeola*	Benthic-Feeding Divers
COGO	Common Goldeneye	*Bucephala clangula*	Benthic-Feeding Divers
HADU	Harlequin Duck	*Histrionicus histrionicus*	Benthic-Feeding Divers
LTDU	Long-tailed Duck	*Clangula hyemalis*	Benthic-Feeding Divers
RUDU	Ruddy Duck	*Oxyura jamaicensis*	Benthic-Feeding Divers
SUSC	Surf Scoter	*Melanitta perspicillata*	Benthic-Feeding Divers
UNGO	Unknown Goldeneye	-	Benthic-Feeding Divers
UNKN SCOTER	Unknown Scoter	*Mellanita sp.*	Benthic-Feeding Divers
WWSC	White-winged Scoter	*Melanitta fusca*	Benthic-Feeding Divers
GBHE	Great blue heron	*Ardea herodias*	Cranes and Herons
SACR	Sandhill Crane	*Grus canadensis*	Cranes and Herons
AMCO	American Coot	*Fulica americana*	Dabbling Ducks
AMWI	American Wigeon	*Anas americana*	Dabbling Ducks
BWTE	Blue-winged Teal	*Anas discors*	Dabbling Ducks
CANV	Canvasback	*Aythya valisineria*	Dabbling Ducks
CITE	Cinnamon Teal	*Anas cyanoptera*	Dabbling Ducks
GADW	Gadwall	*Anas strepera*	Dabbling Ducks
GRSC	Greater Scaup	*Aythya marila*	Dabbling Ducks
GWTE	Green-winged Teal	*Anas crecca*	Dabbling Ducks
LESC	Lesser Scaup	*Aythya affinis*	Dabbling Ducks
MALL	Mallard	*Anas platyrhynchos*	Dabbling Ducks
NOPI	Northern Pintail	*Anas acuta*	Dabbling Ducks
NSHO	Northern Shoveler	*Anas clypeata*	Dabbling Ducks
REDH	Redhead	*Aythya americana*	Dabbling Ducks
RNDU	Ring-necked Duck	*Aythya collaris*	Dabbling Ducks
UNDA	Unknown Dabbling Duck	-	Dabbling Ducks
UNSC	Unknown Scaup	-	Dabbling Ducks
UNTE	Unknown Teal	-	Dabbling Ducks
BLTE	Black Tern	*Chlidonias niger*	Surface Feeding Terns/Gulls
BHGU	Black-headed Gull	*Chroicocephalus ridibundus*	Surface Feeding Terns/Gulls
BOGU	Bonaparte's Gull	*Chroicocephalus philadelphia*	Surface Feeding Terns/Gulls

Species Code	Common Name	Latin Name	Foraging Mode Species Group
CAGU	California Gull	*Larus californicus*	Surface Feeding Terns/Gulls
FRGU	Franklin's Gull	*Leucophaeus pipixcan*	Surface Feeding Terns/Gulls
HEGU	Herring Gull	*Larus argentatus*	Surface Feeding Terns/Gulls
MEGU	Mew Gull	*Larus canus*	Surface Feeding Terns/Gulls
RBGU	Ring-billed Gull	*Larus delawarensis*	Surface Feeding Terns/Gulls
SAGU	Sabine's Gull	*Xema sabini*	Surface Feeding Terns/Gulls
ICGU	Thayer's Gull	*Larus glaucoides*	Surface Feeding Terns/Gulls
UNGU	Unknown Gull	-	Surface Feeding Terns/Gulls
CACG	Cackling Goose	*Branta hutchinsii*	Large Dabblers
CAGO	Canada Goose	*Branta canadensis*	Large Dabblers
GWFG	Greater White-fronted Goose	*Anser albifrons*	Large Dabblers
SNGO	Snow Goose	*Chen caerulescens*	Large Dabblers
TRUS	Trumpeter Swan	*Cygnus buccinator*	Large Dabblers
TUSW	Tundra Swan	*Cygnus columbianus*	Large Dabblers
UNSW	Unknown Swan	-	Large Dabblers
SORA	Sora	*Porzana carolina*	Marsh Birds
WISN	Wilson's Snipe	*Gallinago delicata*	Marsh Birds
YERA	Yellow Rail	*Coturnicops noveboracensis*	Marsh Birds
ARTE	Arctic Tern	*Sterna paradisaea*	Piscivorous Divers
BEKI	Belted Kingfisher	*Megaceryle alcyon*	Piscivorous Divers
COLO	Common Loon	*Gavia immer*	Piscivorous Divers
COME	Common Merganser	*Mergus merganser*	Piscivorous Divers
COTE	Common Tern	*Sterna hirundo*	Piscivorous Divers
EAGR	Eared Grebe	*Podiceps nigricollis*	Piscivorous Divers
HOME	Hooded Merganser	*Lophodytes cucullatus*	Piscivorous Divers
HOGR	Horned Grebe	*Podiceps auritus*	Piscivorous Divers
PBGR	Pied-billed Grebe	*Podilymbus podiceps*	Piscivorous Divers
RBME	Red-breasted Merganser	*Mergus serrator*	Piscivorous Divers
RNGR	Red-necked Grebe	*Podiceps grisegena*	Piscivorous Divers
UNGR	Unknown Grebe	-	Piscivorous Divers
UNLO	Unknown Loon	-	Piscivorous Divers
UNME	Unknown Merganser	-	Piscivorous Divers

Species Code	Common Name	Latin Name	Foraging Mode Species Group
UNKN TERN	Unknown Tern	-	Piscivorous Divers
WEGR	Western Grebe	*Aechmophorus occidentalis*	Piscivorous Divers
AMKE	American Kestrel	*Falco sparverius*	Raptors
BAEA	Bald Eagle	*Haliaeetus leucocephalus*	Raptors
COHA	Cooper's Hawk	*Accipiter cooperii*	Raptors
GOEA	Golden Eagle	*Aquila chrysaetos*	Raptors
MERL	Merlin	*Falco columbarius*	Raptors
NOHA	Northern Harrier	*Circus cyaneus*	Raptors
OSPR	Osprey	*Pandion haliaetus*	Raptors
RTHA	Red-tailed Hawk	*Buteo jamaicensis*	Raptors
RLHA	Rough-legged Hawk	*Buteo lagopus*	Raptors
SSHA	Sharp-shinned Hawk	*Accipiter striatus*	Raptors
UNAC	Unknown Accipiter	-	Raptors
UNHA	Unknown Hawk	-	Raptors
UNRA	Unknown Raptor	-	Raptors
GRYE	Greater Yellowlegs	*Tringa melanoleuca*	Shorebirds
KILL	Killdeer	*Charadrius vociferus*	Shorebirds
LESA	Least Sandpiper	*Calidris minutilla*	Shorebirds
LEYE	Lesser Yellowlegs	*Tringa flavipes*	Shorebirds
LBDO	Long-billed Dowitcher	*Limnodromus scolopaceus*	Shorebirds
RNPH	Red-necked Phalarope	*Phalaropus lobatus*	Shorebirds
SEPL	Semi-palmated Plover	*Charadrius semipalmatus*	Shorebirds
SESA	Semi-palmated Sandpiper	*Calidris pusilla*	Shorebirds
SOSA	Solitary Sandpiper	*Tringa solitaria*	Shorebirds
SPSA	Spotted Sandpiper	*Actitis macularius*	Shorebirds
UNSA	Unknown Sandpiper	-	Shorebirds
UNSH	Unknown Shorebird	-	Shorebirds
PEEP	Unknown small calidrid	*Calidris sp.*	Shorebirds
UNYE	Unknown Yellowlegs	-	Shorebirds
UNDI	Unknown Diving Bird	-	Unknown Waterbirds
UNDU	Unknown Duck	-	Unknown Waterbirds
UNKN	Unkown spp	-	Unknown Waterbirds

APPENDIX B

Waterbird Species List, Foraging Guild Categories, and Cumulative Abundances from 2017 through 2021 (Table B-1 [2017, 2018, 2019, 2021] and B-2 [2021])

Table B-1 Waterbird Species List, Foraging Guild Categories, and Cumulative Abundances from 2017, 2018, 2019, 2020 and 2021

Foraging Guild	English Name	Scientific Name	River Boat Survey Abundance [a]	Wetland Standwatch Abundance [b]	Wetland Transect Abundance [c]
Benthic Feeding Divers			**2,504**	**1,290**	**1**
	American Dipper	*Cinclus mexicanus*	1	0	0
	Barrow's Goldeneye	*Bucephala islandica*	135	26	0
	Benthic Feeding Diver sp.	*n/a*	1	27	0
	Bufflehead	*Bucephala albeola*	205	821	1
	Common Goldeneye	*Bucephala clangula*	1,677	206	0
	Goldeneye sp.	*Bucephala sp.*	257	40	0
	Harlequin Duck	*Histrionicus histrionicus*	3	0	0
	Long-tailed Duck	*Clangula hyemalis*	1	22	0
	Ruddy Duck	*Oxyura jamaicensis*	5	28	0
	Scoter sp.	*Melanita sp.*	2	1	0
	Surf Scoter	*Melanitta perspicillata*	206	111	0
	White-winged Scoter	*Melanitta fusca*	11	8	0
Cranes and Herons			**56**	**0**	**0**
	Great Blue Heron	*Ardea herodias*	1	0	0
	Sandhill Crane	*Antigone canadensis*	55	0	0
Dabbling Ducks			**17,054**	**4,456**	**171**
	American Coot	*Fulica americana*	58	267	9
	American Wigeon	*Mareca americana*	1,517	307	7
	Blue-winged Teal	*Spatula discors*	443	310	15
	Canvasback	*Aythya valisineria*	19	106	0
	Cinnamon Teal	*Spatula cyanoptera*	2	0	2
	Dabbling Duck sp.	*n/a*	1,235	287	5
	Eurasian Wigeon	*Mareca penelope*	1	0	0
	Gadwall	*Mareca strepera*	30	12	0
	Greater Scaup	*Aythya marila*	28	43	0
	Green-winged Teal	*Anas crecca*	1,649	384	20
	Lesser Scaup	*Aythya affinis*	46	176	0
	Mallard	*Anas platyrhynchos*	9,849	1,082	47
	Northern Pintail	*Anas acuta*	1,617	78	4
	Northern Shoveler	*Spatula clypeata*	212	205	62
	Redhead	*Aythya americana*	7	5	0
	Ring-necked Duck	*Aythya collaris*	40	715	0
	Scaup sp.	*n/a*	144	460	0
	Teal sp.	*n/a*	157	19	0

Table B-1 Waterbird Species List, Foraging Guild Categories, and Cumulative Abundances from 2017, 2018, 2019, 2020 and 2021

Foraging Guild	English Name	Scientific Name	River Boat Survey Abundance [a]	Wetland Standwatch Abundance [b]	Wetland Transect Abundance [c]
Gulls and Surface Feeding Terns			**14,214**	**195**	**0**
	Black Tern	*Chlidonias niger*	0	21	0
	Bonaparte's Gull	*Chroicocephalus philadelphia*	5,387	161	0
	California Gull	*Larus californicus*	35	0	0
	Franklin's Gull	*Leucophaeus pipixcan*	5,030	1	0
	Gull sp.	*n/a*	1,053	6	0
	Herring Gull	*Larus argentatus*	197	0	0
	Ring-billed Gull	*Larus delawarensis*	2,163	0	0
	Sabine's Gull	*Xema sabini*	1	0	0
	Short-billed Gull	*Larus brachyrhynchos*	342	6	0
	Iceland Gull	*Larus glaucoides*	6	0	0
Large Dabblers			**33,774**	**303**	**5**
	Cackling Goose	*Branta hutchinsii*	26	0	0
	Canada Goose[d]	*Branta canadensis*	33,078	93	3
	Greater White-fronted Goose	*Anser albifrons*	11	0	0
	Large Dabbler sp.	*n/a*	219	0	0
	Snow Goose	*Anser caerulescens*	3	0	0
	Trumpeter Swan[d]	*Cygnus buccinator*	434	210	2
	Tundra Swan	*Cygnus columbianus*	3	0	0
Marsh Birds			**0**	**53**	**117**
	Sora	*Porzana carolina*	0	43	53
	Wilson's Snipe	*Gallinago delicata*	0	10	61
	Yellow Rail	*Coturnicops noveboracensis*	0	0	3
Piscivorous Divers			**4,167**	**495**	**2**
	Arctic Tern	*Sterna paradisaea*	2	0	0
	Belted Kingfisher	*Megaceryle alcyon*	91	5	0
	Common Loon	*Gavia immer*	26	123	0
	Common Merganser	*Mergus merganser*	3,924	26	0
	Common Tern	*Sterna hirundo*	3	0	0
	Double-crested Cormorant	*Nannopterum auritum*	4	0	0
	Eared Grebe	*Podiceps nigricollis*	6	78	0
	Grebe sp.	*n/a*	2	7	0
	Hooded Merganser	*Lophodytes cucullatus*	27	32	0
	Horned Grebe	*Podiceps auritus*	2	83	0
	Loon sp.	*n/a*	5	0	0
	Merganser sp.	*n/a*	24	0	0
	Pacific Loon	*Gavia pacifica*	1	0	0
	Pied-billed Grebe	*Podilymbus podiceps*	0	43	2
	Piscivorous Diver sp.	*n/a*	3	0	0
	Red-breasted Merganser	*Mergus serrator*	11	6	0
	Red-necked Grebe	*Podiceps grisegena*	33	80	0
	Red-throated Loon	*Gavia stellata*	1	0	0
	Tern sp.	*n/a*	1	0	0
	Western Grebe	*Aechmophorus occidentalis*	1	12	0

Table B-1 Waterbird Species List, Foraging Guild Categories, and Cumulative Abundances from 2017, 2018, 2019, 2020 and 2021

Foraging Guild	English Name	Scientific Name	River Boat Survey Abundance [a]	Wetland Standwatch Abundance [b]	Wetland Transect Abundance [c]
Shorebirds			**2,249**	**157**	**51**
	Greater Yellowlegs	*Tringa melanoleuca*	3	12	3
	Killdeer	*Charadrius vociferus*	28	1	0
	Least Sandpiper	*Calidris minutilla*	15	0	0
	Lesser Yellowlegs	*Tringa flavipes*	17	36	11
	Long-billed Dowitcher	*Limnodromus scolopaceus*	2	0	0
	Peep Sp.	*Calidris sp.*	37	0	0
	Red-necked Phalarope	*Phalaropus lobatus*	11	9	0
	Sandpiper sp.	*n/a*	29	7	0
	Shorebird sp.	*n/a*	60	1	0
	Solitary Sandpiper	*Tringa solitaria*	14	38	9
	Spotted Sandpiper	*Actitis macularius*	1,903	53	28
	Semipalmated Plover	*Charadrius semipalmatus*	11	0	0
	Semipalmated Sandpiper	*Calidris pusilla*	117	0	0
	Yellowlegs sp.	*Tringa sp.*	2	0	0
Unknown Waterbirds			**2,179**	**888**	**0**
	Diving Bird sp.	*n/a*	14	0	0
	Duck sp.	*n/a*	1,864	845	0
	Unknown sp.	*n/a*	301	43	0
Grand Total			**76,197**	**7,837**	**347**

Notes:

[a] - Includes flying records as birds were often flushed to flight in front of boat. Includes all habitat types, all treatment areas, and data from incomplete surveys.

[b] - Excludes flying records. Includes records of birds observed in open water and sedge habitat.

[c] - Excludes flying records. Includes records of waterbirds observed in sedge, and willow sedge habitat.

[d] - Trumpeter swans and Canada geese, include a small proportion (<5%) of tundra swans and cackling geese, respectively.

Table B-2 Waterbird Species List, Foraging Guild Categories, and Cumulative Abundances in 2021

Foraging Guild	English Name	Scientific Name	River Boat Survey Abundance [a]	Wetland Standwatch Abundance [b]	Wetland Transect Abundance [c]
Benthic Feeding Divers			**241**	**261**	**0**
	Barrow's Goldeneye	*Bucephala islandica*	7	2	0
	Benthic Feeding Diver sp.	*n/a*	0	27	0
	Bufflehead	*Bucephala albeola*	23	158	0
	Common Goldeneye	*Bucephala clangula*	155	31	0
	Goldeneye sp.	*Bucephala sp.*	43	10	0
	Scoter sp.	*Mellanita sp.*	0	1	0
	Surf Scoter	*Melanitta perspicillata*	12	32	0
	White-winged Scoter	*Melanitta fusca*	1	0	0
Dabbling Ducks			**4,699**	**1,271**	**28**
	American Coot	*Fulica americana*	0	210	2
	American Wigeon	*Mareca americana*	250	23	0
	Blue-winged Teal	*Spatula discors*	4	73	0
	Canvasback	*Aythya valisineria*	4	0	0
	Dabbling Duck sp.	*n/a*	1,111	14	0
	Eurasian Wigeon	*Mareca penelope*	1	0	0
	Greater Scaup	*Aythya marila*	0	2	0
	Green-winged Teal	*Anas crecca*	137	37	1
	Lesser Scaup	*Aythya affinis*	4	6	0
	Mallard	*Anas platyrhynchos*	2,402	674	20
	Northern Pintail	*Anas acuta*	734	18	0
	Northern Shoveler	*Spatula clypeata*	41	14	5
	Redhead	*Aythya americana*	0	1	0
	Ring-necked Duck	*Aythya collaris*	3	194	0
	Scaup sp.	*Aythya sp.*	7	2	0
	Teal sp.	*n/a*	1	3	0
Gulls			**571**	**4**	**0**
	Black Tern	*Chlidonias niger*	0	1	0
	Bonaparte's Gull	*Chroicocephalus philadelphia*	226	3	0
	California Gull	*Larus californicus*	6	0	0
	Franklin's Gull	*Leucophaeus pipixcan*	139	0	0
	Gull sp.	*n/a*	106	0	0
	Herring Gull	*Larus argentatus*	10	0	0
	Ring-billed Gull	*Larus delawarensis*	66	0	0
	Short-billed Gull	*Larus brachyrhynchos*	18	0	0
Large Dabblers			**6,421**	**88**	**1**
	Cackling Goose	*Branta hutchinsii*	2	0	0
	Canada Goose [d]	*Branta canadensis*	6,227	19	1
	Trumpeter Swan [d]	*Cygnus buccinator*	26	69	0
	Large Dabbler sp.	*n/a*	164	0	0
	Snow Goose	*Anser caerulescens*	2	0	0

Table B-2 Waterbird Species List, Foraging Guild Categories, and Cumulative Abundances in 2021

Foraging Guild	English Name	Scientific Name	River Boat Survey Abundance [a]	Wetland Standwatch Abundance [b]	Wetland Transect Abundance [c]
Marsh Birds			**0**	**4**	**13**
	Sora	*Porzana carolina*	0	4	6
	Wilson's Snipe	*Gallinago delicata*	0	0	7
Piscivorous Divers			**753**	**108**	**0**
	Belted Kingfisher	*Megaceryle alcyon*	3	0	0
	Common Loon	*Gavia immer*	2	18	0
	Common Merganser	*Mergus merganser*	729	0	0
	Double-crested Cormorant	*Nannopterum auritum*	4	0	0
	Eared Grebe	*Podiceps nigricollis*	0	1	0
	Grebe sp.	*n/a*	0	1	0
	Hooded Merganser	*Lophodytes cucullatus*	4	16	0
	Horned Grebe	*Podiceps auritus*	0	31	0
	Merganser sp.	*n/a*	6	0	0
	Pacific Loon	*Gavia pacifica*	1	0	0
	Pied-billed Grebe	*Podilymbus podiceps*	0	26	0
	Red-breasted Merganser	*Mergus serrator*	2	0	0
	Red-necked Grebe	*Podiceps grisegena*	1	9	0
	Red-throated Loon	*Gavia stellata*	1	0	0
	Western Grebe	*Aechmophorus occidentalis*	0	6	0
Shorebirds			**321**	**40**	**2**
	Killdeer	*Charadrius vociferus*	4	0	0
	Lesser Yellowlegs	*Tringa flavipes*	0	9	1
	Peep Sp.	*Calidris sp.*	3	0	0
	Red-necked Phalarope	*Phalaropus lobatus*	0	9	0
	Sandpiper sp.	*n/a*	9	1	0
	Shorebird sp.	*n/a*	1	0	0
	Solitary Sandpiper	*Tringa solitaria*	0	6	1
	Spotted Sandpiper	*Actitis macularius*	303	15	0
	Yellowlegs sp.	*Tringa sp.*	1	0	0
Unknown Waterbirds			**80**	**1**	**0**
	Duck sp.	n/a	63	1	0
	Unknown sp.	n/a	17	0	0
Grand Total			**13,086**	**1,777**	**44**

Notes:

[a] - Includes flying records as birds were often flushed to flight in front of boat. Includes all habitat types, all treatment areas, and data from incomplete surveys.

[b] - Excludes flying records. Includes records of birds observed in open water and sedge habitat.

[c] - Excludes flying records. Includes records on waterbirds observed in sedge, and willow sedge habitat.

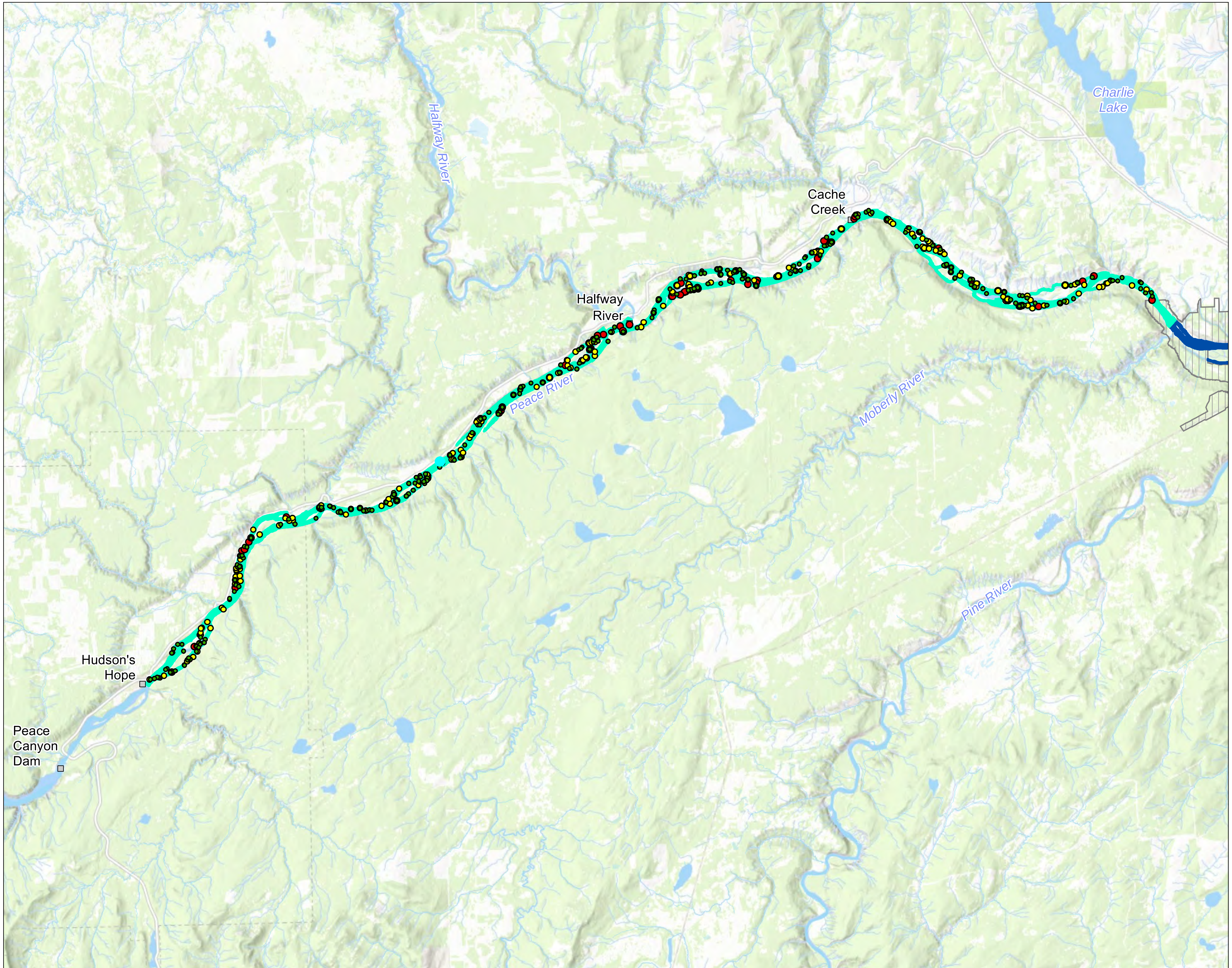
[d] - Trumpeter swans and Canada geese, include a small proportion (<5%) of tundra swans and cackling geese, respectively.

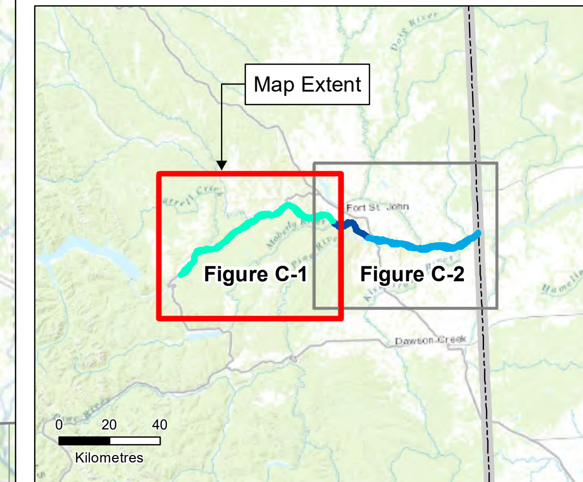
APPENDIX C

Spatial Representation of Waterbird Observations within the Peace River Study Area in Spring and Fall 2021 (Figures C-1 to C-4)

Migratory Waterbird Follow-up Monitoring Program
2021 Report
Site C, Peace River, BC

Waterbirds Recorded within Inundation Impact Area Spring 2021





Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area
- Proposed Dam Site

Number of Bird Observations

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

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

N

1:220,000

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Kilometres

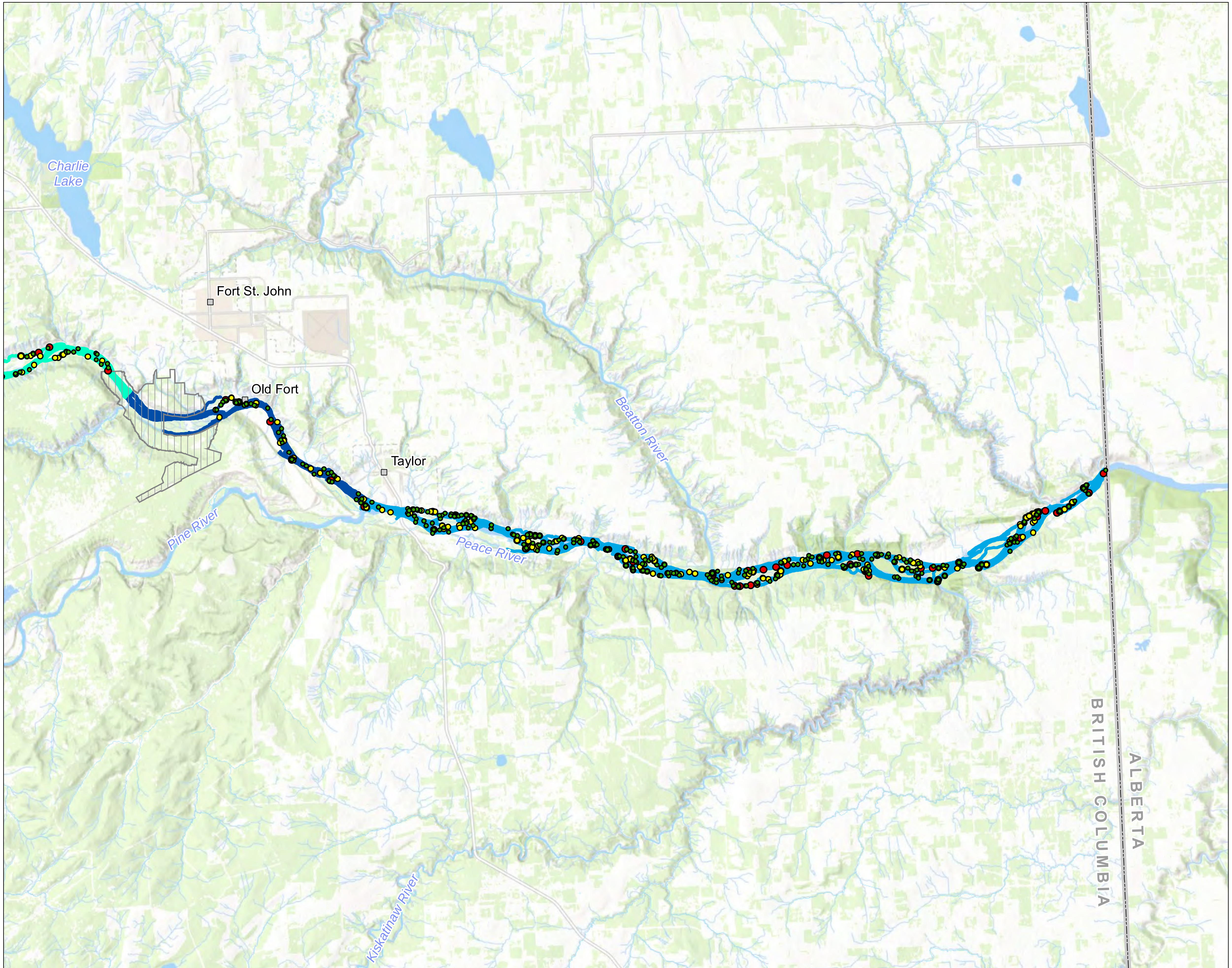
NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

989619-07	Production Date: Jan 14, 2022	Figure C-1

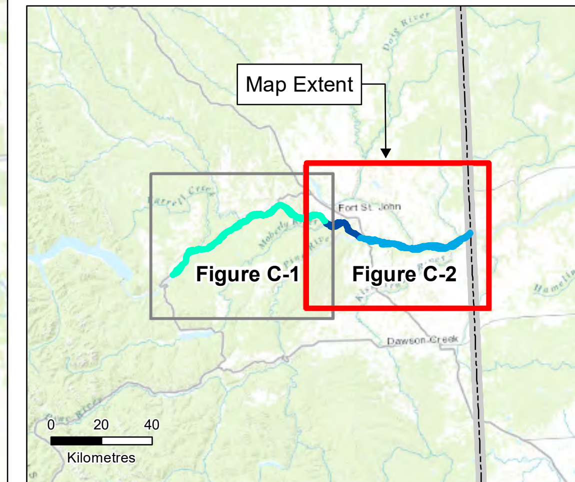
Hemmera An Ausenco Company

BC hydro



Migratory Waterbird Follow-up Monitoring Program
2021 Report
Site C, Peace River, BC

Waterbirds Recorded within Flow Regime Impact Area and Control Area Spring 2021



Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area
- Proposed Dam Site

Number of Bird Observations

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

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

N

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0 2 4 6 8 10

Kilometres

NAD 1983 UTM Zone 10N

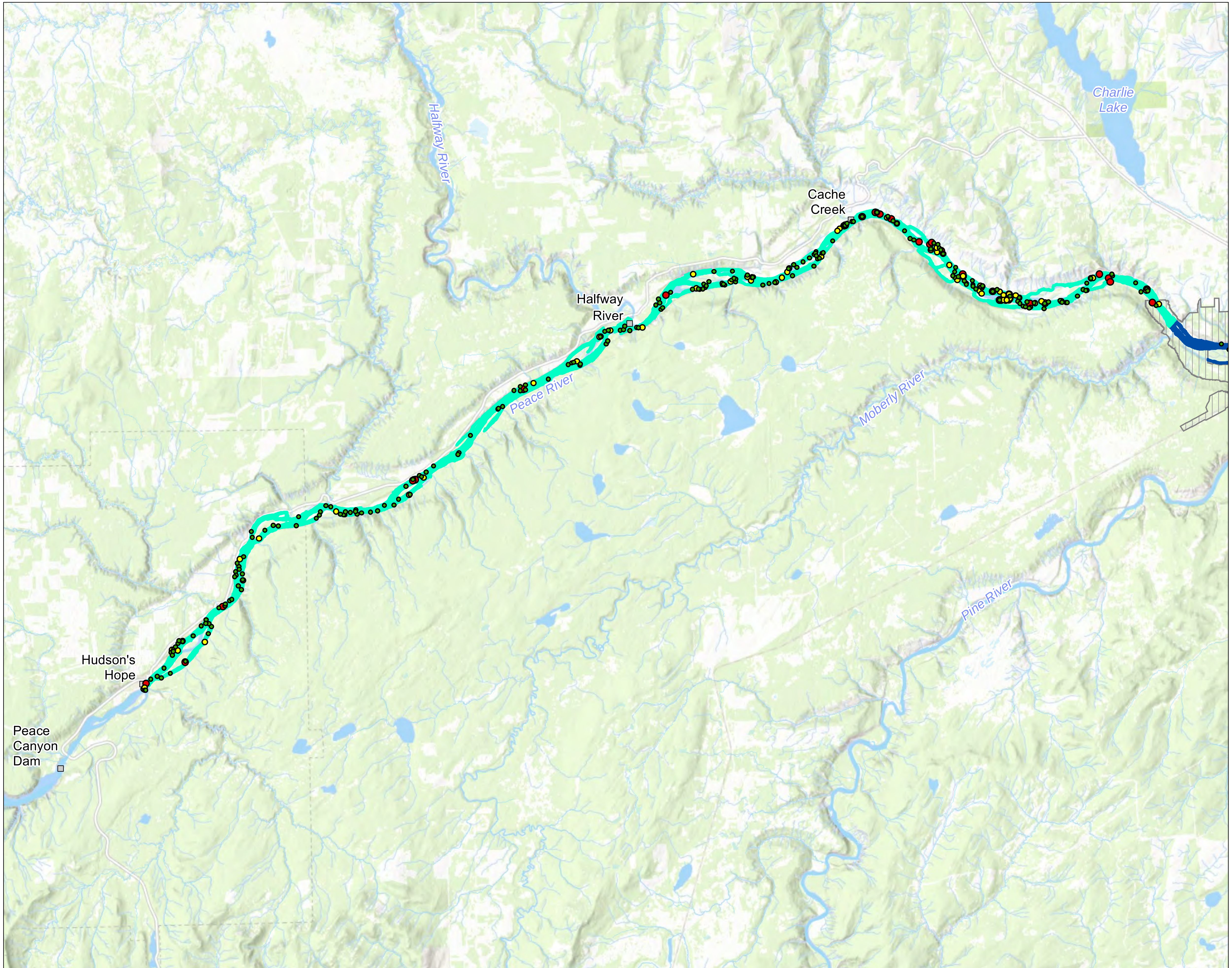
Page Size: 11" x 17"

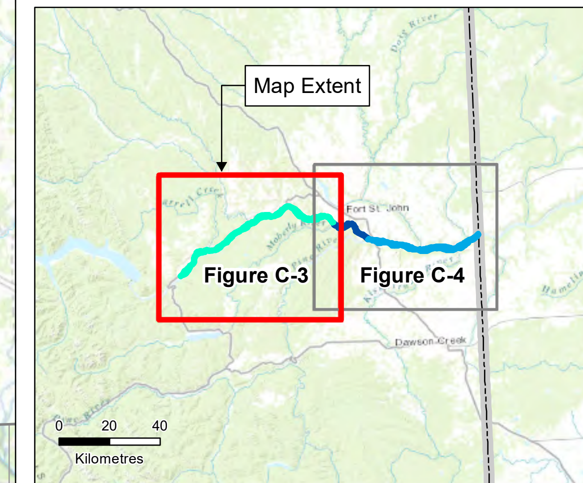
989619-07	Production Date: Jan 14, 2022	Figure C-2

Hemmera An Ausenco Company
BC hydro

Migratory Waterbird Follow-up Monitoring Program
2021 Report
Site C, Peace River, BC

Waterbirds Recorded within Inundation Impact Area Fall 2021





Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area
- Proposed Dam Site

Number of Bird Observations

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

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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0 2 4 6 8 10
Kilometres

NAD 1983 UTM Zone 10N

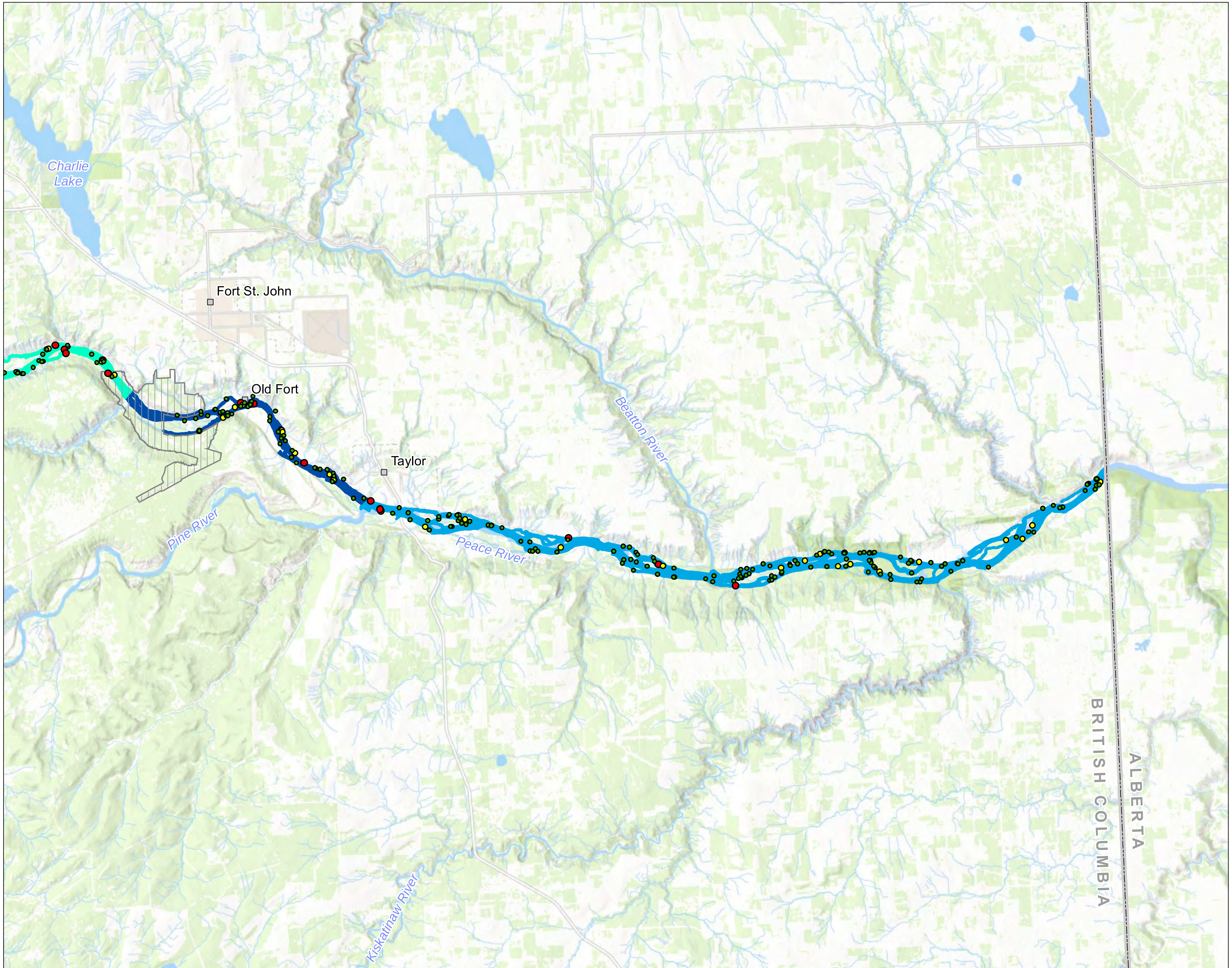
Page Size: 11" x 17"

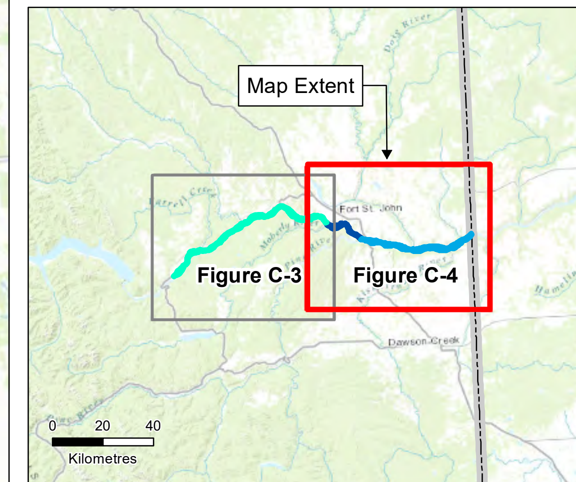
989619-07	Production Date: Jan 14, 2022	Figure C-3

Hemmera An Ausenco Company   BC hydro

Migratory Waterbird Follow-up Monitoring Program
2021 Report
Site C, Peace River, BC

Waterbirds Recorded within Flow Regime Impact Area and Control Area Fall 2021





Legend

- Inundation Impact Area
- Flow Regime Impact Area
- Control Area
- Proposed Dam Site

Number of Bird Observations

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

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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Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

989619-07	Production Date: Jan 14, 2022	Figure C-4

Hemmera
An Ausenco Company

BC hydro

APPENDIX D
Wetland Survey Station Photos

Photo 1 Aerial Photograph of Wetland Survey Station OW01 (September 9, 2018)

Photo 2 Aerial Photograph of Wetland Survey Station OW02 (September 18, 2018)

Photo 3 Aerial Photograph of Wetland Survey Station SE03 (lower left) and OW04 (upper right; August 22, 2019)

Photo 4 Aerial Photograph of Wetland Survey Station OW06 (October 17, 2018)

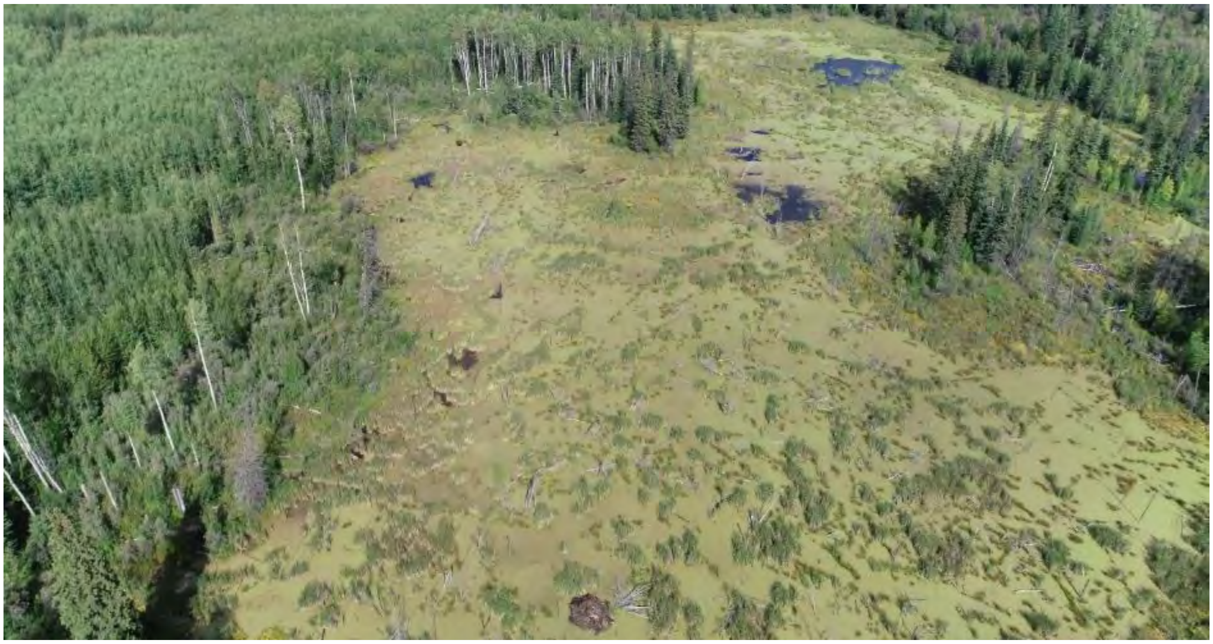


Photo 5 Aerial Photograph of Wetland Survey Station OW07 (August 22, 2019)

Photo 6 Photograph of Wetland Survey Station OW09 (October 17, 2018) Showing Habitat Representative of the Wetland Area Surveyed

Photo 7 Aerial Photograph of Wetland Survey Station OW10 (August 22, 2019)

Photo 8 Aerial Photograph of Wetland Survey Station OW11 (August 22, 2019)

Photo 9 Aerial Photograph of Wetland Survey Station SE02 (August 22, 2019)

Photo 10 Aerial Photograph of Wetland Survey Station SE04 (August 22, 2019)

Photo 11 Aerial Photograph of Wetland Survey Station SE05 (August 6, 2018)

Photo 12 Aerial Photograph of Wetland Survey Station SE06 (August 12, 2019)

Photo 13 Aerial Photograph of Wetland Survey Station SE07 (August 22, 2019)

Photo 14 Aerial Photograph of Wetland Survey Station SE08 (August 22, 2019)

Photo 15 Aerial Photograph of Wetland Survey Station SE09 (August 7, 2018)

Photo 16 Aerial Photograph of Wetland Survey Station SE10 (August 22, 2019)

Photo 17 Aerial Photograph of Wetland Survey Station SE11 (August 6, 2018)

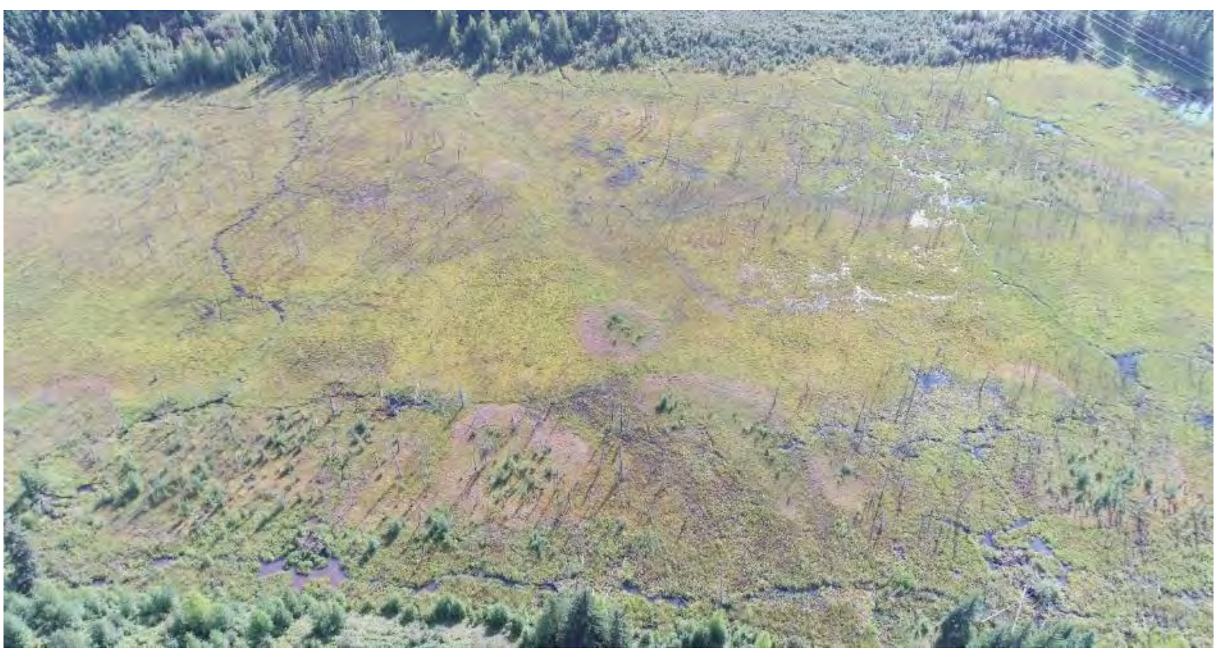


Photo 18 Aerial Photograph of Wetland Survey Station SE12 (August 12, 2019)

Photo 19 Aerial Photograph of Wetland Survey Station SE14 (August 6, 2018)

Photo 20 Aerial Photograph of Wetland Survey Station WS01 (August 6, 2018)

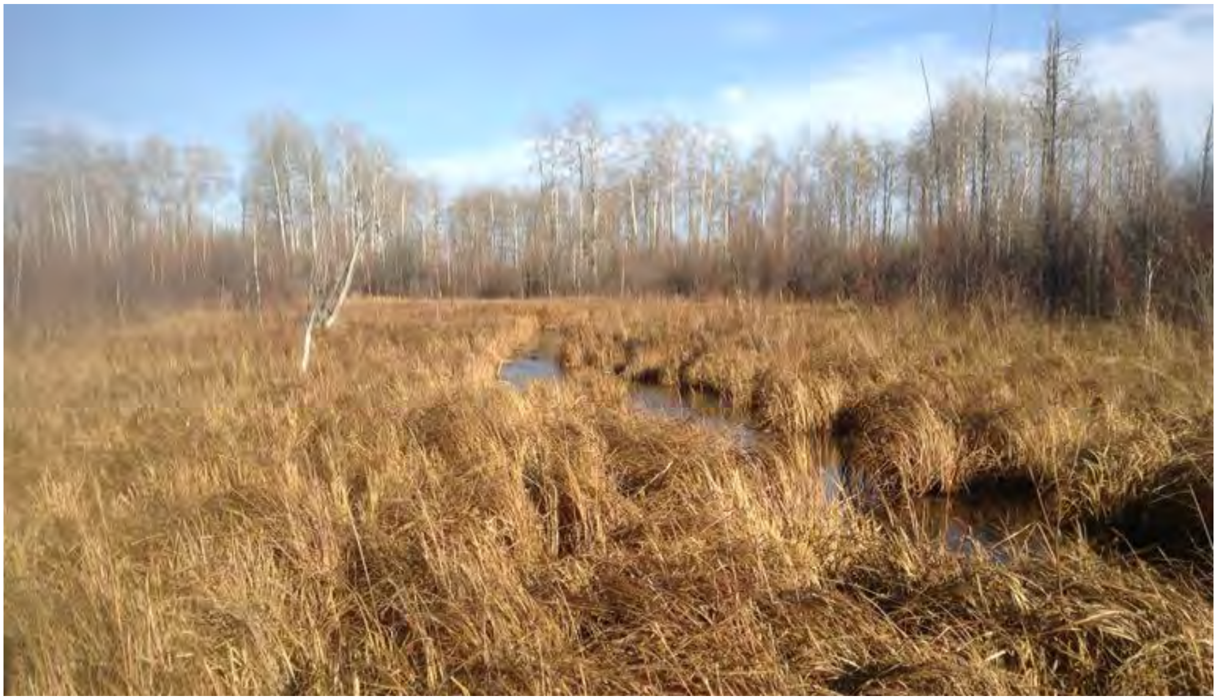


Photo 21 Photograph of Wetland Survey Station WS02 (October 17, 2018) Showing Habitat Representative of the Wetland Area Surveyed

Photo 22 Aerial Photograph of Wetland Survey Station WS03 (August 7, 2018)

APPENDIX E

Mean and Standard Devation Statistics Tables for Relative Abundance and Diversity Results

Note: To facilitate ease of referencing, tables in this appendix are numbered to correspond with tables in the report.

Table E-7 Mean Abundance Estimates (birds/survey round) and Variability (Standard Deviation) of Waterbird Foraging Guilds within the Peace River During Spring and Fall Survey Periods during 2017 Through 2021

Foraging Guild	Spring						Fall								Average of Means
	Early		Middle		Late		Early		Early-Middle		Late-Middle		Late		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Benthic Feeding Divers	169	76	168	196	23	14	2	3	21	44	14	19	5	-	**57**
Dabbling Ducks	1,006	870	661	346	489	115	102	51	308	229	345	470	51	-	**423**
Gulls	2	2	69	101	32	5	776	479	697	422	314	341	102	-	**284**
Large Dabblers	2,280	979	502	146	538	144	233	87	455	395	738	667	623	-	**767**
Piscivorous Divers	311	66	95	41	51	15	44	40	33	15	21	10	12	-	**81**
Shorebirds	1	1	6	6	115	33	216	151	130	96	4	3	0	-	**67**
Unknown Waterbirds	92	79	128	69	59	59	18	13	7	8	20	38	13	-	**48**
Total (All Waterbirds)	**3,861**	**-**	**1,629**	**-**	**1,308**	**-**	**1,391**	**-**	**1,652**	**-**	**1,455**	**-**	**805**	**-**	

Note: Sample size is 5 years except for late fall (2 years), middle and late spring (3 years). SD = standard deviation across years. SD only presented when at least 3 years of data were available. Dashes indicate insufficient or inappropriate data for calculations.

Table E-9 Mean 2017 Through 2021 Spring Densities (birds/km²/survey round), Estimated Abundances, and Variability (Standard Deviation) of Migrant Waterbirds by River Habitat Type and Treatment Area

Foraging Guild	Densities by River Habitat Type						Densities by Treatment Area					
	Limited Connectivity		Moderate Flow		Mainstem		Inundation Impact		Flow Impact		Control	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Benthic Feeding Divers	17.6	11.6	3.0	2.1	1.5	0.8	2.7	1.8	6.2	3.7	1.7	1.7
Dabbling Ducks	108.6	84.5	29.6	32.1	8.8	7.7	9.1	3.9	36.2	40.9	23.0	24.6
Gulls	0.0	0.0	<0.1	0.1	0.5	0.7	0.3	0.4	1.7	2.7	0.1	0.1
Large Dabblers	210.9	178.3	47.6	27.1	17.5	12.6	32.1	17.6	19.9	3.7	38.3	41.5
Piscivorous Divers	17.9	5.5	7.3	4.5	2.8	1.8	7.0	3.8	2.5	1.9	1.5	1.0
Shorebirds	3.4	3.3	1.1	1.0	0.2	0.2	0.6	0.5	0.6	0.6	0.4	0.4
Unidentified Waterbirds	6.1	8.5	2.1	2.6	1.0	0.4	1.8	2.0	1.0	1.1	1.1	1.1
Total (All Waterbirds)	**364.7**	**-**	**90.8**	**-**	**32.2**	**-**	**53.5**	**-**	**68.1**	**-**	**66.2**	**-**
Total Estimated Abundance	**1,187**	**-**	**679**	**-**	**1,400**	**-**	**1,417**	**-**	**407**	**-**	**1,441**	**-**

Note: Sample size is 5 years. SD = standard deviation across years. Dashes indicate insufficient or inappropriate data for calculations.

Table E-11 Mean 2017 Through 2021 Fall Densities (birds/km^2/survey round) and Variability (Standard Deviation) of Migrant Waterbirds by River Habitat Type and Treatment Area

Foraging Guild	Densities by River Habitat Type						Densities by Treatment Area					
	Limited Connectivity		Moderate Flow		Mainstem		Inundation Impact		Flow Impact		Control	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Benthic Feeding Divers	0.4	0.1	<0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.2	0.1	0.1
Dabbling Ducks	38.6	13.5	6.5	13.5	1.0	0.7	5.0	2.7	10.4	17.1	1.1	1.3
Gulls	2.3	0.8	0.9	0.8	11.8	4.7	8.3	4.9	50.9	30.1	0.2	0.2
Large Dabblers	51.9	7.0	9.4	7.0	5.4	3.2	7.6	5.5	12.1	10.9	9.1	5.0
Piscivorous Divers	3.1	0.5	0.8	0.5	0.3	0.1	0.7	0.5	0.3	0.2	0.4	0.4
Shorebirds	8.6	1.7	3.7	1.7	1.0	0.7	1.7	1.2	0.9	0.2	2.2	1.5
Unidentified Waterbirds	3.0	0.2	0.2	0.2	0.1	0.1	0.3	0.3	0.7	1.0	<0.1	0.05
Total (All Waterbirds)	**107.9**	**-**	**21.5**	**-**	**19.8**	**-**	**23.9**	**-**	**75.5**	**-**	**13.1**	**-**
Total Estimated Abundance	**351**	**-**	**160**	**-**	**860**	**-**	**634**	**-**	**452**	**-**	**285**	**-**

Note: Sample size is 5 years. SD = standard deviation across years. Dashes indicate insufficient or inappropriate data for calculations.

Table E-13 Mean 2017 Through 2021 Diversity Metrics for Waterbird Foraging Guilds on the Peace River Across Seasons and Survey Periods, with Variability (Standard Deviation)

Foraging Guild	Spring species richness by survey period						Spring		Fall species richness by survey period								Fall	
	Early		Middle		Late				Early		Early-Middle		Late-Middle		Late			
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Benthic Feeding Divers	2.3	0.8	2.8	0.8	3.7	1.0	**2.8**	**0.6**	0.6	0.5	0.5	0.5	1.0	1.2	0.0	-	**0.7**	**0.4**
Dabbling Ducks	4.8	0.8	6.3	1.2	7.0	1.0	**5.7**	**0.3**	2.3	0.8	3.3	1.6	2.4	0.7	1.5	-	**2.5**	**0.7**
Gulls	0.4	0.7	1.8	1.9	3.3	0.6	**1.4**	**0.8**	4.5	1.3	3.6	0.9	3.1	1.1	3.5	-	**3.7**	**0.8**
Large Dabblers	2.2	0.4	2.0	1.0	1.3	0.3	**1.9**	**0.3**	1.1	0.2	1.6	0.5	1.7	0.8	2.0	-	**1.5**	**0.3**
Piscivorous Divers	1.6	0.5	2.5	0.5	3.5	0.9	**2.3**	**0.4**	1.9	0.7	2.7	0.8	3.0	1.5	1.5	-	**2.4**	**0.8**
Shorebirds	0.6	0.4	0.5	0.5	1.2	0.3	**0.6**	**0.4**	2.6	2.5	1.2	0.4	1.0	0.4	0.0	-	**1.4**	**0.6**
Total Species Richness	**11.9**	**-**	**16.0**	**-**	**20.0**	**-**	**14.8**	**-**	**13.0**	**-**	**12.9**	**-**	**12.2**	**-**	**8.5**	**-**	**12.2**	**-**
Species Evenness	**0.5**	**-**	**0.6**	**-**	**0.6**	**-**	**0.5**	**-**	**0.6**	**-**	**0.5**	**-**	**0.5**	**-**	**0.4**	**-**	**0.5**	**-**

Note: Sample size is 5 years except for late fall (2 years). SD = standard deviation across years. Dashes indicate insufficient or inappropriate data for calculations.

Table E-18 Mean 2017 Through 2021 Waterbird Densities (birds/ha/survey) and Variability (Standard Deviation) within Open Water Habitat Reported by Foraging Guild from Standwatch Surveys

Foraging Guild	Spring				Fall							
	Middle		Late		Early		Early-Middle		Late-Middle		Late	
	Mean Density	SD	Mean Density	SD	Mean Density	SD	Mean Density	SD	Mean Density	SD	Mean Density	SD
Benthic Feeding Divers	143.0	1.2	131.3	1.1	227.6	0.8	181.0	1.9	151.8	2.3	41.2	-
Dabbling Ducks	530.5	4.3	596.5	3.7	694.8	3.3	631.6	4.1	489.0	4.7	96.2	-
Gulls and Surface-Feeding Terns	1.9	<0.1	6.0	0.1	1.3	0.0	0.0	<0.1	0.0	0.0	0.0	-
Large Dabblers	67.5	0.8	55.3	0.4	16.0	0.6	23.8	0.2	7.0	0.3	0.8	-
Marsh Birds	1.1	<0.1	28.2	0.4	1.4	0.2	14.9	<0.1	0.0	0.2	0.0	-
Piscivorous Divers	4.1	0.1	21.8	0.1	28.5	0.1	42.5	0.2	24.9	0.5	23.8	-
Shorebirds	19.5	0.3	91.1	1.0	107.4	0.5	12.4	1.6	0.0	0.2	0.0	-
Unknown Waterbirds	0.1	0.0	18.6	0.4	26.2	0.2	5.2	0.5	41.7	<0.1	26.3	-
Total (All Waterbirds)	**767.7**	**-**	**949.1**	**-**	**1,103.1**	**-**	**911.3**	**-**	**714.4**	**-**	**188.4**	**-**

Note: Sample size is 5 years except for late fall (2 years). SD = standard deviation across years. Dashes indicate insufficient or inappropriate data for calculations.

Table E-20 Mean 2018 through 2021 Waterbird Densities (birds/km/survey) and Variability (Standard Deviation) within Vegetated Wetland (sedge, willow-sedge) Habitat Reported by Foraging Guild from Transect Surveys

Foraging Guild	Spring				Fall							
	Middle		Late		Early		Early-Middle		Late-Middle		Late	
	Mean Density	SD	Mean Density	SD	Mean Density	SD	Mean Density	SD	Mean Density	SD	Mean Density	SD
Benthic Feeding Divers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-
Dabbling Ducks	1.72	2.21	5.32	3.45	0.09	0.18	0.73	0.64	1.71	3.42	0.00	-
Gulls	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-
Large Dabblers	0.33	0.23	0.10	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-
Marsh Birds	0.74	1.19	3.09	3.00	1.32	1.07	1.49	1.05	0.26	0.30	0.00	-
Piscivorous Divers	0.00	0.00	0.11	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-
Shorebirds	0.68	0.63	1.56	2.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-
Unknown Waterbirds	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-
Total (All Waterbirds)	**3.48**	**-**	**10.18**	**-**	**1.41**	**-**	**2.22**	**-**	**1.97**	**-**	**0.00**	**-**

Note: Sample size is 4 years except for late fall (2 years). SD = standard deviation across years. Dashes indicate insufficient or inappropriate data for calculations.

Table E-24 Species Richness of Waterbird Foraging Guilds Observed During Standwatch Surveys of Wetland Habitats in 2017 through 2021, with Variability (Standard Deviation)

Foraging Guild	Spring species richness by survey period						Spring		Fall species richness by survey period								Fall	
	Early		Middle		Late				Early		Early-Middle		Late-Middle		Late			
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Benthic Feeding Divers	-	-	2.6	1.3	3.1	1.6	**2.9**	**1.3**	1.8	0.8	1.9	0.8	2.2	0.6	2.0	-	**2.0**	**0.5**
Dabbling Ducks	-	-	5.6	2.9	7.2	3.0	**6.4**	**2.6**	5.3	2.7	6.3	2.7	4.6	1.8	4.0	-	**5.3**	**1.9**
Gulls	-	-	0.2	0.4	0.8	0.8	**0.5**	**0.4**	0.6	0.9	0.0	0.0	0.0	0.0	0.0	-	**0.2**	**0.3**
Large Dabblers	-	-	1.4	0.9	1.8	0.6	**1.6**	**0.6**	0.8	0.4	1.2	0.3	0.9	0.2	1.0	-	**1.0**	**0.1**
Marsh Birds	-	-	0.5	0.5	0.7	0.4	**0.6**	**0.3**	0.3	0.4	0.8	0.6	0.0	0.0	0.0	-	**0.3**	**0.2**
Piscivorous Divers	-	-	1.4	1.8	2.8	1.3	**2.1**	**1.5**	3.0	1.6	3.0	1.5	2.6	2.6	2.0	-	**2.8**	**1.5**
Shorebirds	-	-	0.8	1.3	2.2	1.1	**1.5**	**1.0**	1.4	0.9	0.4	0.5	0.0	0.0	0.0	-	**0.5**	**0.2**
Total Species Richness	**-**	**-**	**11.9**	**8.4**	**18.7**	**7.5**	**15.3**	**7.2**	**12.8**	**4.6**	**13.1**	**4.4**	**10.3**	**4.2**	**9.0**	**-**	**12.1**	**3.8**
Species Evenness	**-**	**-**	**0.8**	**0.1**	**0.8**	**0.1**	**0.8**	**0.0**	**0.8**	**0.1**	**0.8**	**0.0**	**0.7**	**0.2**	**0.7**	**-**	**0.8**	**0.1**

Note: Sample size is 5 years except for late fall (2 years). SD = standard deviation across years. Dashes indicate insufficient or inappropriate data for calculations.

Table E-26 Species Richness of Waterbird Foraging Guilds Observed During Transect Surveys of Wetland Habitats in 2018 through 2021, with Variability (Standard Deviation)

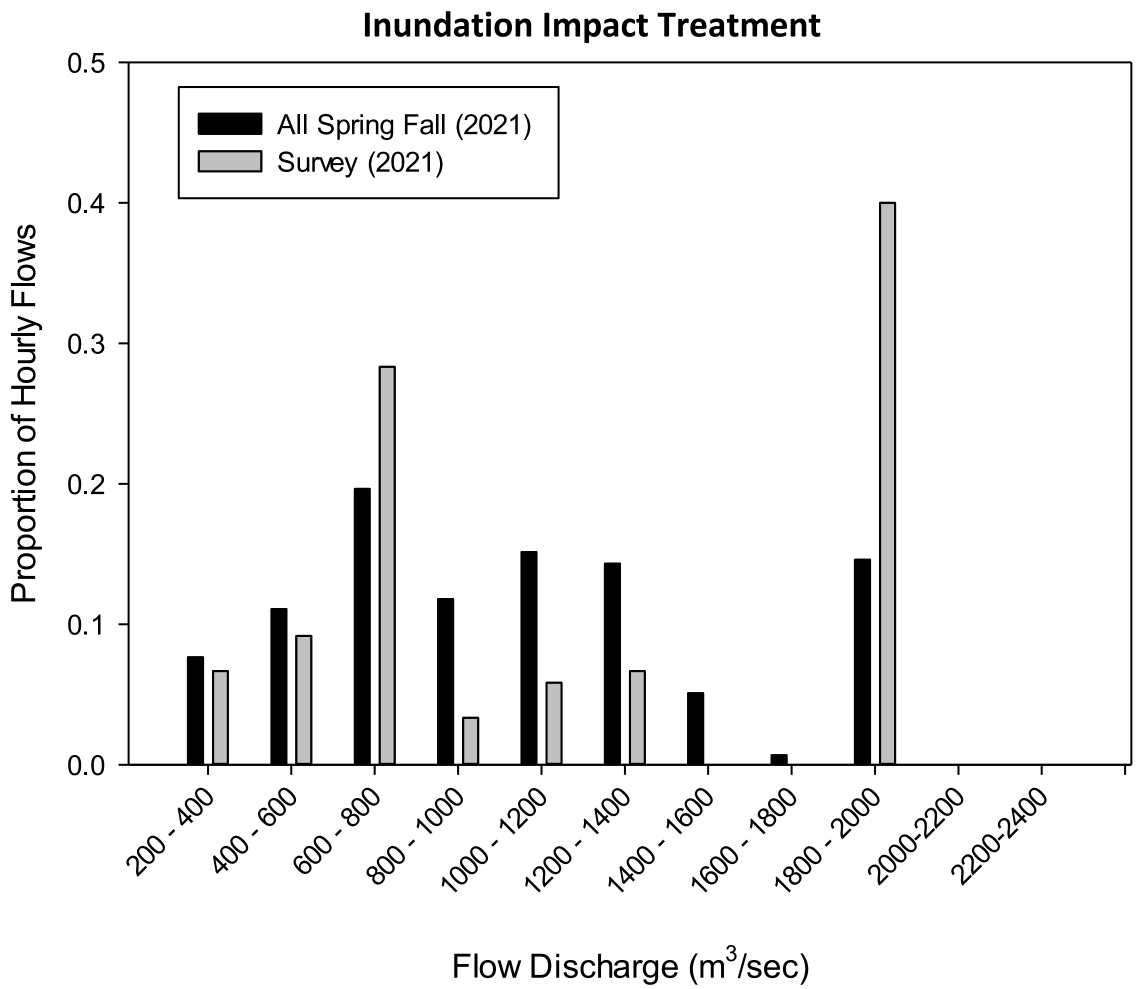
Foraging Guild	Spring species richness by survey period						Spring		Fall species richness by survey period								Fall	
	Early		Middle		Late				Early		Early-Middle		Late-Middle		Late			
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Benthic Feeding Divers	-	-	0.0	0.0	0.1	0.3	**0.1**	**0.1**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	**0.0**	**0.0**
Dabbling Ducks	-	-	1.4	1.4	2.9	0.9	**2.1**	**0.6**	1.0	1.4	0.6	0.5	0.4	0.5	0.0	-	**0.6**	**0.6**
Gulls	-	-	0.0	0.0	0.0	0.0	**0.0**	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	**0.0**	**0.0**
Large Dabblers	-	-	0.6	0.5	0.1	0.3	**0.4**	**0.1**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	**0.0**	**0.0**
Marsh Birds	-	-	1.3	1.5	1.9	0.9	**1.6**	**1.0**	1.5	1.0	1.4	0.5	0.5	0.6	0.0	-	**1.0**	**0.5**
Piscivorous Divers	-	-	0.0	0.0	0.3	0.5	**0.1**	**0.3**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	**0.0**	**0.0**
Shorebirds	-	-	1.3	1.0	1.0	1.1	**1.1**	**0.3**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	**0.0**	**0.0**
Total Species Richness	**-**	**-**	**4.4**	**4.3**	**6.3**	**3.0**	**5.3**	**2.3**	**2.8**	**1.7**	**1.5**	**1.3**	**0.9**	**0.9**	**0.0**	**-**	**1.5**	**1.0**
Species Evenness	**-**	**-**	**0.7**	**0.2**	**0.8**	**0.1**	**0.7**	**0.1**	**0.8**	**0.3**	**0.9**	**0.1**	**0.4**	**-**	**-**	**-**	**0.8**	**0.1**

Note: Sample size is 4 years except for early spring (no surveys) and late fall (2 years). SD = standard deviation across years. Dashes indicate insufficient or inappropriate data for calculations.

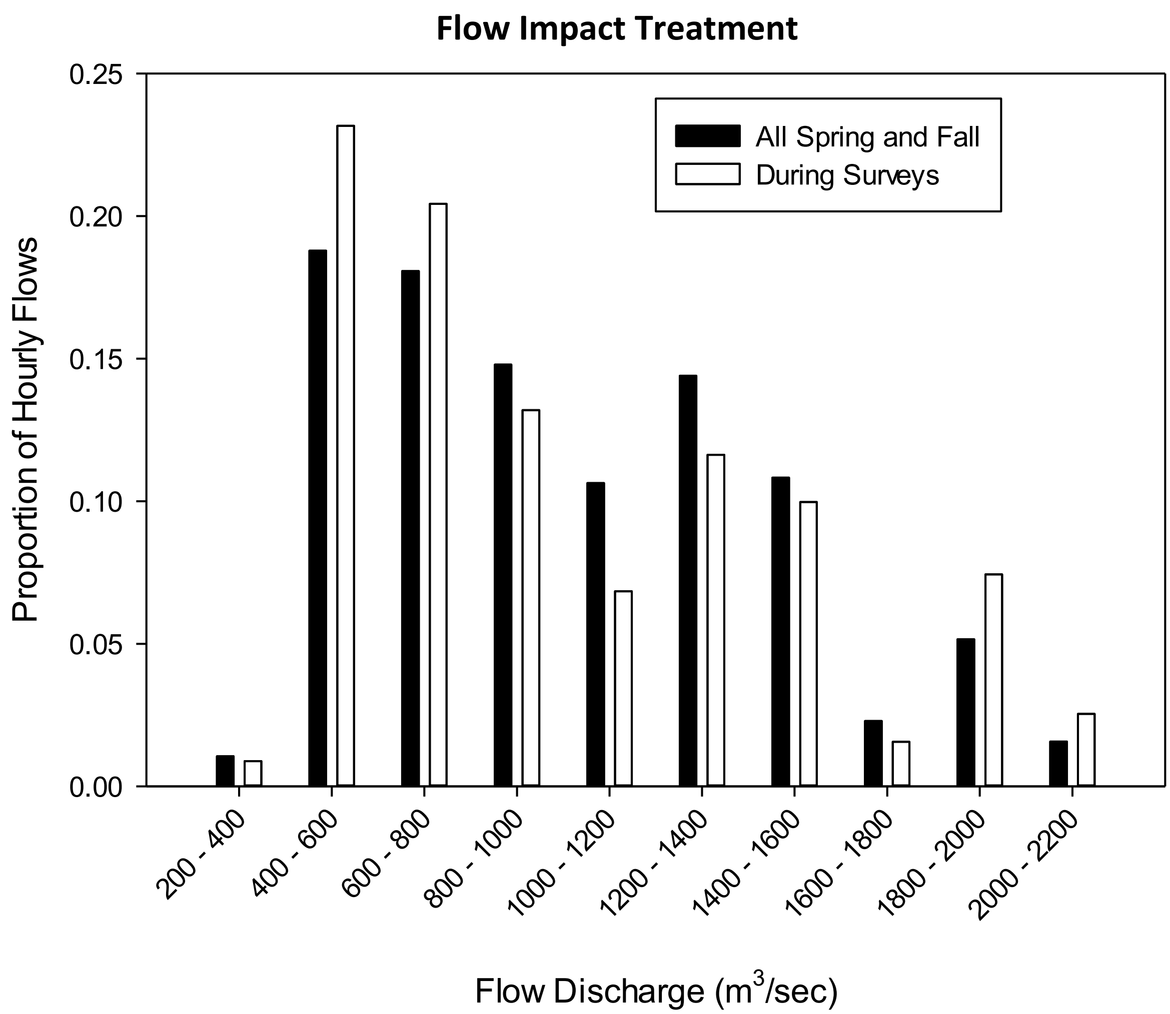
APPENDIX F

Flow Rates in 2021 during Surveys Relative to Flow Rates during All Spring and Fall Migration Periods

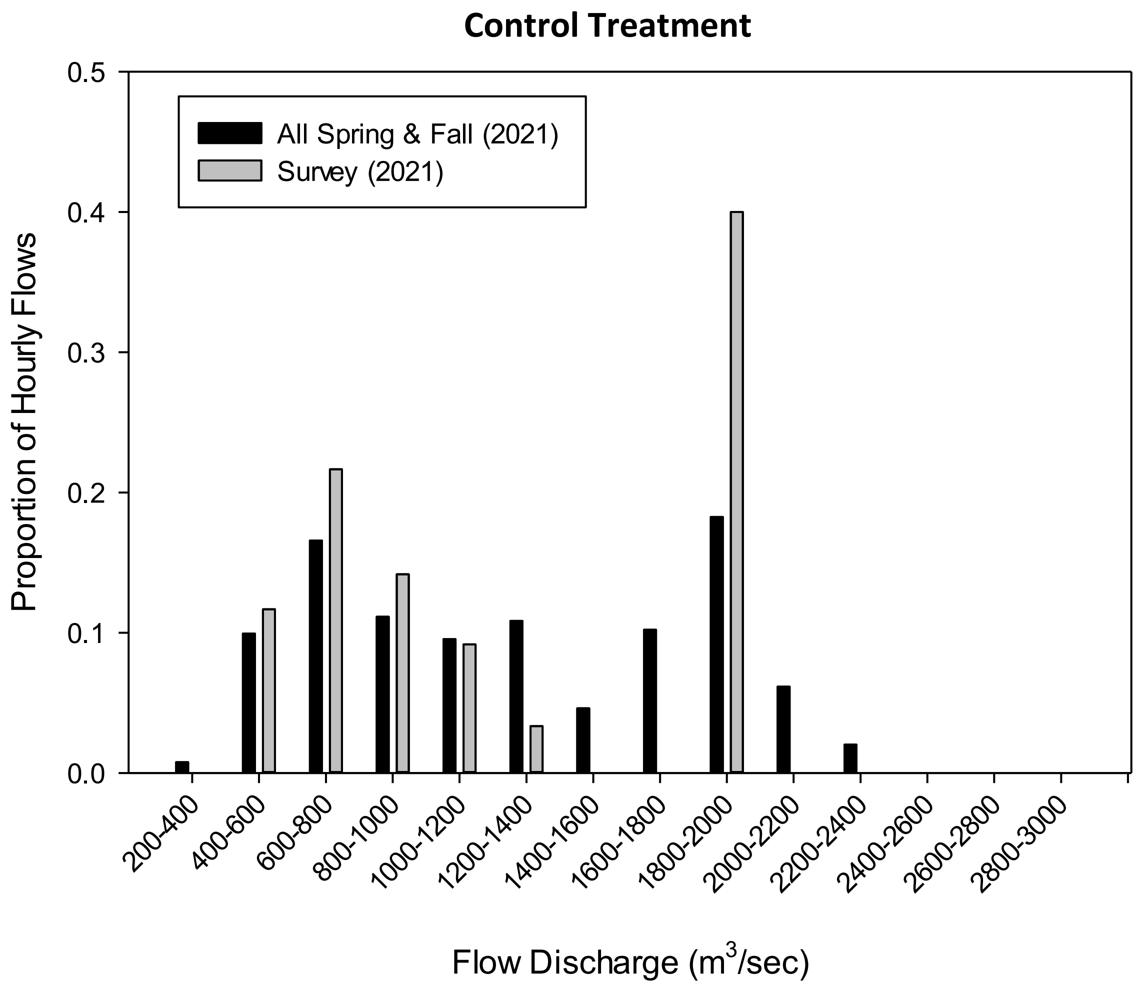
Appendix F-1 Distribution of 2021 hourly flow rates (shown as proportion of total) in the Inundation Impact treatment area during surveys relative to across spring and fall.



Appendix F-2 Distribution of 2021 hourly flow rates (shown as proportion of total) in the Flow Impact treatment area during surveys relative to across spring and fall.



Appendix F-3 Distribution of 2021 hourly flow rates (shown as proportion of total) in the Flow Control treatment area during surveys relative to across spring and fall.



Appendix 4. Site C Migratory Bird Nest Monitoring 2021 Annual Report

Site C Migratory Bird Nest Monitoring Program – 2021 Annual Report

Photo Credit: Shae Turner

Photo Credit: Chris Coxson

Prepared for:

BC Hydro
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March 2, 2022

EXECUTIVE SUMMARY

BC Hydro has developed a program, in consultation with Environment Canada, to monitor and mitigate potential disturbance to breeding migratory birds during the Site C Clean Energy Project (the Project), where risks to migratory bird nests could occur during reservoir construction, filling, and operations.

The Project is currently in the construction phase and water level changes in the headpond (upstream of the dam site) are expected to be pronounced relative to normal river level changes due to the flow restriction represented by the river diversion tunnels. These changes to the water level have the potential to affect the productivity of nesting birds and these effects will be evaluated to determine the relative contribution of the Project to documented nest impacts.

The first year of nesting bird field surveys took place in 2021 and this annual report summarizes those survey results.

Two survey methods were used to assess the disturbance or mortality of nesting migratory birds in the study area:

1. Nest searching and monitoring – nesting attempts of migratory bird species were monitored on selected plots from the various habitat types within the study area.
2. Point count surveys – these surveys were used to describe the nesting migratory bird communities within the different habitat types within the study area.

Twenty-four plots covering an area of 33.1 ha were surveyed regularly during the 2021 breeding season. Eight weeks of nest searching and monitoring surveys were conducted from May 30 to July 21, 2021 and point count surveys were completed for 18 of the 24 nest monitoring plots between June 22 and June 26, 2021.

A total of 126 nests of 30 species were located, including 94 nests of 23 species that were on the intensively-surveyed nest monitoring plots. One federally listed species, Common nighthawk (*Chordeiles minor*), was detected nesting on a plot downstream of the dam site. Point counts detected 28 species on nest monitoring plots and 50 species overall.

Across the entire study area, 44% of nests detected were considered successful, 33% failed, and 23% had an unknown outcome. The most common cause of nest failure was predation, as is typical for breeding birds.

Flooding caused the failure of 6% of monitored nests and affected 7 nests in the headpond above the dam and 1 in the downstream river channel. There was an increase in water levels in late June and early July that overlapped with the peak in bird breeding activity, causing nest flooding to occur. Nest flooding affected 5 species and primarily impacted birds nesting on or low to the ground; however, it also affected cedar waxwing, which nested more than a metre (m) above the ground, but bred at a lower elevation. Notably, two nests were found on previously flooded plots after water levels dropped again in July, indicating that birds can be quick to begin using habitat again after flooding recedes.

One of the challenges in 2021 was inconsistencies in the previous habitat mapping, thus the accuracy of the habitat mapping will be improved prior to the 2022 field season. It is also suggested that point counts not be completed in 2022, and that the field surveys focus on documenting all breeding bird territories on nest monitoring plots to improve the accuracy of nest density estimates.

This work was performed in accordance with Contact No. 4500023118 between Hemmera Envirochem Inc. (Hemmera), a wholly owned subsidiary of Ausenco Engineering Canada Inc. (Ausenco), and BC Hydro (Client), dated December 22, 2021 (Contract). 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.

This Executive Summary is not intended to be a stand-alone document, but a summary of findings as described in the following Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

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LIST OF ACRONYMS AND ABBREVIATIONS

Acronym / Abbreviation	Definition
DRC	Downstream river channel
Hemmera	Hemmera Envirochem Inc.
HPZ	Headpond zone
Project	Site C Clean Energy Project
RDZ	Reservoir drawdown zone

LIST OF SYMBOLS AND UNITS OF MEASURE

Symbol / Unit of Measure	Definition
ha	hectare
km	kilometre
m	metre
m ASL	metres above sea level

1.0 INTRODUCTION

1.1 Background

BC Hydro used key species groups, including migratory birds, to assess the potential effects of the Site C Clean Energy Project (Project) on Wildlife Resources in the Site C Environmental Impact Statement. The report of the Joint Review Panel concluded that the Project would likely cause significant adverse effects to migratory birds relying on valley bottom habitat during their life cycle. The recommendations of the Joint Review Panel included that, should the Project proceed, BC Hydro develop a program, in consultation with Environment Canada, to monitor and mitigate potential disturbance to breeding migratory birds where risks to migratory bird nests could occur during reservoir construction, filling, and operations.

The Project is currently in the construction phase and, beginning in fall 2020, the river was diverted around the construction site, creating a headpond upstream of the site. During construction, water level changes in the headpond (upstream of the dam site) are expected to be pronounced relative to normal river level changes due to the flow restriction represented by the river diversion tunnels. These pronounced changes to the water level have the potential to affect the productivity of nesting birds.

The Peace River water regime downstream of the Site C dam is expected to change very little during construction because the rate of water input from the Peace Canyon dam will be matched to outputs from the Site C dam (BC Hydro 2013).

The first year of field surveys took place in 2021 during the construction phase of the Project and this annual report summarizes those survey results. Additional background to the monitoring program is provided in the Site C Vegetation and Wildlife Migratory Bird Nest Monitoring Program (BC Hydro 2021).

1.2 Study Area

The Peace River valley is in northeastern British Columbia and the Project site is along the river near Fort St. John (**Figure 1.1**). Above the dam site, the river flows east from the Williston and Dinosaur Reservoirs and, downstream of the dam, it continues through Alberta to Great Slave Lake.

The river valley is within the Moist Warm subzone of the Boreal White and Black Spruce biogeoclimatic zone. The zone receives little precipitation compared to other northern regions of the province and is dominated by upland forest and muskeg (Government of British Columbia 1991).

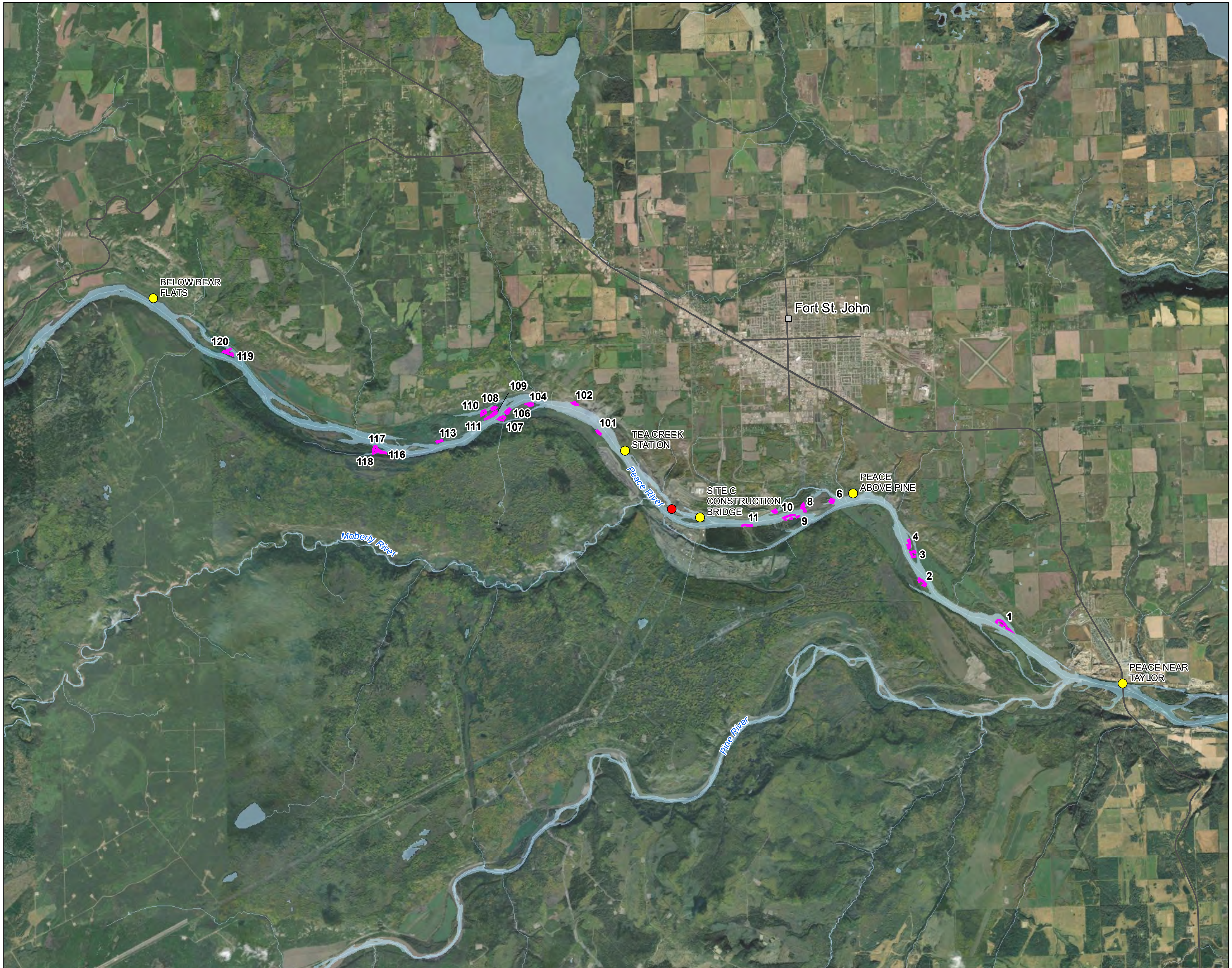
The study area for the nest monitoring program focuses on areas that may be affected by water level fluctuations and consists of 3 sub-areas:

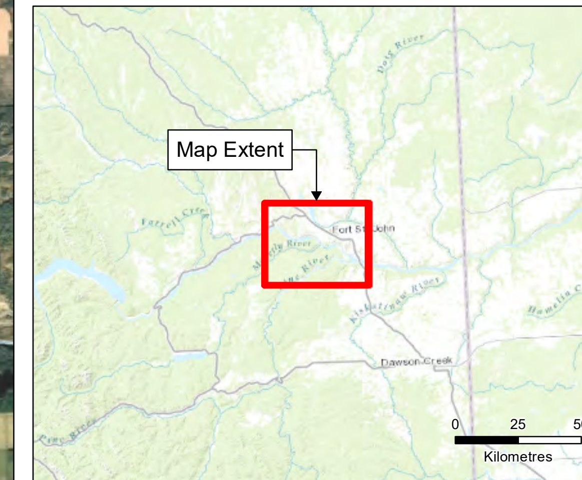
- Headpond Zone (HPZ): during construction, the temporary headpond upstream of the dam is expected to have pronounced fluctuations relative to normal river levels.
- Reservoir Drawdown Zone (RDZ): during operations, the water level of the reservoir impounded upstream of the dam will fluctuate. The zone of fluctuation between the minimum normal (460 m) and maximum normal (461.8 m) reservoir water levels will be monitored.
- Downstream River Channel (DRC): during construction and operations, the volume of water released from the Site C dam will dictate the river channel footprint between the Site C dam and the Pine River. The Pine River adds sufficient volume to make expected Site C fluctuations indistinguishable downstream of its confluence with the Peace River.

Nest monitoring in 2021 took place within the HPZ and DRC. Once the dam is operating, upstream nest monitoring will shift from the HPZ to the RDZ.

2021 Nest Monitoring
Site C, Peace River, BC

Overview





Legend

- Site C Dam
- Water Level Monitoring Station
- Nest Monitoring Plot
- City
- Major Road
- Watercourse
- River / Waterbody

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

- Contains information licensed under the Open Government Licence - Province of British Columbia
- Aerial Image: ESRI World Imagery
- Inset Basemap: ESRI World Topographic Map

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BC hydro

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1.3 Monitoring Objectives

The objective of this program is to document the effects of fluctuating water levels due to the Site C Project on breeding migratory birds that use the habitat around the Site C reservoir and along the Peace River downstream of the dam. The disturbance to and mortality of breeding migratory birds caused by fluctuating water levels will be evaluated to determine the relative contribution of the Project to documented nest impacts.

Data gathered during the migratory bird nest monitoring program will address the following questions:

- During construction, 1) how many nesting migratory bird species and associated nests are present in the fluctuation zone of the construction headpond, and 2) how many of these nests experience disturbance or mortality due to fluctuating water levels?
- During operations, 1) how many nesting migratory bird species and associated nests are present in the Site C reservoir drawdown zone and in the Site C dam to Pine River zone of fluctuation, and 2) how many of these nests experience disturbance or mortality due to fluctuating water levels?

2.0 METHODS

2.1 Habitat Classification and Plot Selection

Previously completed habitat mapping had classified all habitat within the study area into 8 habitat categories: Aspen Shrubland, Forested Wetland, Grassland, Non Vegetated/Anthropogenic, Riparian Forest, Riparian Wetland, Upland Forest, and Water (BC Hydro 2013). The Nest Monitoring Plan (BC Hydro 2021) outlines methodology for sampling these habitats relative to their availability, and, prior to fieldwork, a tentative set of plots was selected. However, in many cases, the habitat observed in the field did not match the previously completed mapping. Much of the previously forested habitat had been logged and some areas that had been mapped as unvegetated at lower elevation were vegetated.

Thus, plots were re-selected to represent the range of habitat types that were observed in the field, to capture the diversity of habitats present in the study area. These plots were classified into 7 general habitat types: riparian forest, upland forest, riparian shrub, upland shrub, wetland, open habitat (includes grassland), and unvegetated (includes sparsely vegetated habitat). These field-based habitat types were used when data were summarized by habitat.

2.2 Survey Timing

The avian breeding period in the study area is from late April to late August (the Project area falls within Zone B5 of the general nesting periods of migratory birds in Canada (Government of Canada 2018)), but late May through mid July is when most species likely to be found within the study area are expected to be actively breeding (Rousseu and Drolet 2015). In 2021, field surveys were planned to cover an 8-week breeding season from late May though mid-July.

2.3 Field Surveys

Two survey methods were used to assess the disturbance or mortality of nesting migratory birds in the study area:

1. Nest searching and monitoring – nesting attempts of migratory bird species breeding in the sub-areas were monitored to provide a study of each of the habitats in the sub-areas during Site C construction and operations.
2. Point count surveys – these surveys were used to describe the nesting migratory bird community within the different habitat types encompassed by the study area. Point count surveys allowed for the detection of species with nests that may not have been encountered during nest searching.

2.3.1 Nest Monitoring

Nest searching was primarily conducted by walking through plots and watching birds for behavioural cues indicating nesting. Occasionally, systematic searches were conducted in areas where nests were suspected. Nests were also found incidentally, such as by accidentally flushing a bird from a nest while walking by. Nest searching was conducted in a manner that minimized disturbance to breeding birds and vegetation concealing the nest, while still maintaining search effectiveness. Nest searching and monitoring methods are described in detail in the Nest Monitoring Plan (BC Hydro 2021).

2.3.2 Point Counts

The methods for the collection of point count data were consistent with RIC methods (RIC 1999a), with the exception of using distance-to-detection intervals at 0-50 m, 51-100 m, and >100 m. A sample datasheet is provided in **Appendix A**. All surveys were completed in June within 4 hours of sunrise. Plots were not sampled if they were completely flooded because the intention of the surveys was to sample the species present in each habitat.

2.4 Data Management and Analysis

During the field season, the daily survey and plot visit data were tracked in spreadsheets and nest observation data were tracked on nest cards (see example in Nest Monitoring Plan (BC Hydro 2021)). This information was backed up daily to ensure no loss of information occurred.

After the field season, all data were entered into a custom database, which will provide consistent data management and organization throughout the nest monitoring program. For analysis, custom data queries were exported from the database and data analysis was completed using R (R Core Team 2021).

2.4.1 Water Levels

Water level data were available for multiple stations in the HPZ and DRC for every hour of each day. For plotting purposes, daily averages were calculated to minimize clutter on the figures.

To visualize overall water levels within the study sub-areas, we used the Tea Creek 02 station for the HPZ and the Site C Construction Bridge Primary station for the DRC (**Figure 1.1**). These stations are close to the nest monitoring plots and had few missing data.

When examining water level in relation to plot elevation, additional monitoring stations were included to reflect the water level at each plot more accurately. The additional stations were Below Bear Flats, which was closer to the most upstream HPZ plots, and Peace Above Pine and Peace Near Taylor, which were closer to the farthest downstream DRC plots (**Figure 1.1**).

2.4.2 Nest Monitoring

A summary of nest monitoring survey effort was tabulated by calculating the number of person-hours spent conducting field activities on plots of each habitat type.

Nest records and monitoring data were summarized to provide information about migratory bird nesting activity within the study area. Only data from nest monitoring plots were included when summarizing results by habitat type, but all nest records were included for other types of summaries.

Taxonomic information was drawn from the most recent ABA Checklist, which follows changes made to the American Ornithological Society's North and Middle American Birds checklist (American Birding Association 2021).

The numbers of nests detected within the HPZ and the DRC (both on and off plot), and within each habitat type, were calculated. For each habitat type, species richness (i.e., the number of species) and species evenness (i.e., the degree of similarity in abundance of each species) were calculated. Species evenness was calculated using Pielou's evenness:

$$Species\ evenness = \frac{(-\sum_{i=1}^{s}(p_i \times \ln p_i))}{(\ln S)}$$

where S is the number of species (i.e., species richness), p_i is the proportion of all sampled birds represented by species i, and ln is the natural logarithm (MacDonald et al. 2017). Species diversity metrics were calculated using the R package 'vegan' (Oksanen et al. 2020).

The ground elevation at the nest site and the nest height above ground were added together to determine the actual elevation in metres above sea level (m ASL) for each nest. Ground elevations for plots and nest locations were estimated from a digital elevation model (DEM) and compared to elevations recorded in the field with a handheld GPS. These nest elevations were used when considering the potential for nests to interact with fluctuating water levels.

Nest phenology information was calculated for each nest, to allow for the estimation of the time periods during which nests are likely to be active for each species. The nest initiation date (the date when nest-building began) was either determined from recorded observations of nest-building activity in the field or estimated based on known nest construction timelines for that species if the clutch initiation date was known (or could be estimated). Date of clutch initiation (date the first egg was laid) was estimated by combining recorded dates of egg laying (when eggs were counted) or nestling observations (when nestling age is estimated), with published knowledge of incubation periods (Billerman et al. 2020), and making the assumption that one egg was laid per day and that incubation began on the day when the final egg was laid.

The last observation at a nest was used to determine the end of the nesting period. Using the nest initiation dates and last observation dates, a data set was generated indicating the status of each nest (active/inactive, 1/0) on each day during the time span when known nests were active. The percentage of nests that were active on each day was determined by summing the number of nests active on that day and dividing that value by the total number of nests in the data set. To visualize nest phenology, these values were then plotted using a loess smoother (span = 0.2) within the 'geom_smooth' function in the R package 'ggplot2' (Wickham 2016).

The number of nests per hectare (nest density) was calculated for each habitat type by dividing the sum of the numbers of nests found in each habitat type by the sum of the areas of the monitored plots for each habitat type. These estimates do not account for the detectability of individual species, thus should be considered minimums, although the repeated nest searching visits helps to decrease this uncertainty. Nest density calculations by habitat type are cumulative (include all nests from the entire monitoring period), thus do not represent the density of active nests on a plot at any one time.

Nest outcome percentages were calculated by dividing the total number of nests for each nest outcome by the total number of nests with known outcomes for the overall study area, each study sub-area, and each habitat type.

2.4.3 Point Counts

Data were summarized to provide information regarding the migratory bird species present within the study area. The numbers of individual birds detected within the HPZ and the DRC, and within each habitat type, were calculated. For each habitat type, species richness (i.e., the number of species) and species evenness (i.e., the degree of similarity in abundance of each species) were calculated. Species diversity metrics were calculated using the R package 'vegan' (Oksanen et al. 2020).

3.0 RESULTS

3.1 Water Levels

The water levels in the both the HPZ (Tea Creek Station) and DRC (Site C Construction Bridge Station) were decreasing during the early part of the breeding season and remained relatively low in early June before rising quickly toward the end of that month (**Figure 3.1**). Water levels peaked in early July and then decreased throughout the rest of the month. In the DRC, the fluctuation pattern was the same, but the relative change in elevation was smaller than in the HPZ (**Figure 3.1**).

The maximum water levels in the HPZ and DRC during the field season (May 28 through July 21) were 418.4 m ASL on July 5 and 411.3 m ASL on July 4, respectively. Nest monitoring plots were spread throughout the study area, and some were closer to other water monitoring stations, but for simplicity only 2 stations are shown in **Figure 3.1**. Water level fluctuations at all stations followed the same pattern.

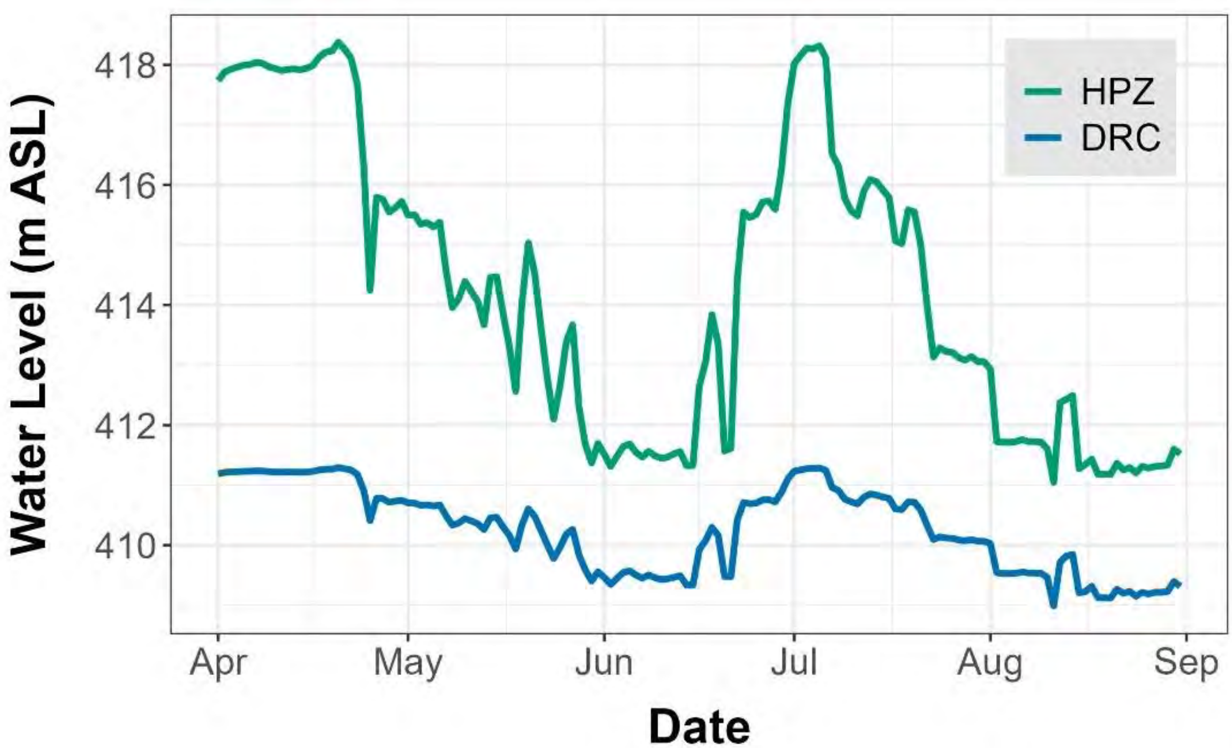

Figure 3.1 **Water levels (m ASL) in the headpond (HPZ) and downstream river channel (DRC) during the 2021 bird breeding season. Data is from the Tea Creek 02 (HPZ) and Site C Construction Bridge Primary (DRC) monitoring stations.**

3.2 Plot Selection and Habitat

Twenty-four plots covering an area of 33.1 ha were surveyed regularly during the 2021 breeding season, including 13.2 ha in the HPZ and 19.9 ha in the DRC. The elevations of plots surveyed in the HPZ and DRC ranged from 412 to 422 m and 405 to 412 m, respectively (**Table 3.1**).

Additional plots were surveyed during the early part of the season that were later dropped from regular surveying because there was not enough time to survey them thoroughly. The dropped plots represented additional areas of the same habitats represented in the final set of 24 plots.

Due to inaccuracies in existing habitat mapping, habitat plot selection was based on the habitat types observed in the field (see **Section 2.1**). The selected plots covered 5 of the 8 previously mapped habitat classes and were categorized into 7 field-based habitat types (**Table 3.1**). All 7 field-based habitat types were sampled in the HPZ; 3 of these habitat types were sampled in the DRC (**Table 3.2**).

Table 3.1 Habitat Classifications, Area, and Elevations of Nest Monitoring Plots

Plot ID	Mapped Habitat Type	Field Habitat Type	Area (ha)	Minimum Elevation (m ASL)	Average Elevation (m ASL)	Maximum Elevation (m ASL)
Headpond						
101	Upland Forest	Upland Shrub	0.42	413	418	419
102	Non Vegetated/Anthropogenic, Riparian Forest, Upland Forest, Water	Riparian Forest	0.40	412	416	422
104	Riparian Forest	Upland Shrub	0.90	416	418	419
106	Riparian Forest	Upland Forest	1.19	415	418	418
107	Riparian Forest	Riparian Forest	1.82	413	415	416
108	Non Vegetated/Anthropogenic	Open Habitat	0.82	414	415	415
109	Non Vegetated/Anthropogenic	Unvegetated	0.87	413	415	416
110	Non Vegetated/Anthropogenic	Riparian Shrub	1.58	414	415	416
111	Non Vegetated/Anthropogenic	Unvegetated	0.46	413	413	414
113	Non Vegetated/Anthropogenic	Riparian Shrub	0.38	415	416	416
116	Riparian Forest, Upland Forest, Water	Riparian Shrub	0.79	415	417	420
117	Upland Forest	Riparian Forest	1.20	416	418	421
118	Riparian Forest, Upland Forest	Wetland	1.02	416	416	418
119	Non Vegetated/Anthropogenic	Unvegetated	1.27	418	419	420
120	Riparian Wetland, Water	Unvegetated	0.13	418	419	419
Downstream River Channel						
1	Riparian Wetland, Water	Riparian Shrub	4.08	407	407	407
2	Non Vegetated/Anthropogenic	Riparian Shrub	2.76	405	407	408
3	Riparian Forest, Water	Riparian Forest	2.33	406	408	408
4	Non Vegetated/Anthropogenic, Water	Unvegetated	1.64	405	406	406
6	Non Vegetated/Anthropogenic, Riparian Forest, Water	Riparian Shrub	1.14	407	408	409
8	Non Vegetated/Anthropogenic, Water	Unvegetated	1.84	407	408	409
9	Non Vegetated/Anthropogenic, Water	Unvegetated	4.52	407	410	412
10	Non Vegetated/Anthropogenic, Upland Forest, Water	Riparian Shrub	0.83	409	411	412
11	Riparian Forest, Water	Riparian Shrub	0.76	409	410	411

Table 3.2 Habitat Sampling Summary

Habitat Type	Number of Plots Sampled (n)	Total Downstream (DRC) Area Sampled (ha)	Total Headpond (HPZ) Area Sampled (ha)	Total Area Sampled (ha)
Open Habitat	1	0	0.82	0.82
Riparian Forest	4	2.33	3.41	5.74
Riparian Shrub	8	9.57	2.75	12.32
Unvegetated	7	8.0	2.73	10.73
Upland Forest	1	0	1.19	1.19
Upland Shrub	2	0	1.32	1.32
Wetland	1	0	1.02	1.02
Total	**24**	**19.90**	**13.24**	**33.14**

3.3 Nest Monitoring

3.3.1 Survey Effort

Eight weeks of nest searching and monitoring surveys were conducted from May 30 to July 21, 2021. Total field effort totaled 524 person-hours, including 496 person-hours on nest monitoring plots (initial monitoring of plots that were later dropped from the survey set was considered off-plot monitoring). Survey effort on nest monitoring plots included 387 person-hours searching for nests, 81 checking nests, and 28 completing other field activities (e.g., point counts). On average, more effort was spent on plots with more complex vegetation structure (e.g., shrubs and forests) (**Table 3.3**).

Table 3.3 Average Survey Effort on Nest Monitoring Plots by Habitat Type

Habitat Type (Field Classified)	Number of Plots (n)	Average Nest Searching Effort (total person-hours)	Average Nest Checking Effort (total person-hours)	Average Other Activity Effort (total person-hours)	Average Total Effort (person-hours)
Open Habitat	1	1	0	0	2
Riparian Forest	4	27	6	2	35
Riparian Shrub	8	18	4	1	23
Unvegetated	7	2	1	1	3
Upland Forest	1	30	1	0	31
Upland Shrub	2	40	6	1	47
Wetland	1	16	7	2	25

3.3.2 Nest Records

A total of 126 nests were found in 2021, 60 in the HPZ and 66 in the DRC (**Table 3.4**). Ninety-four (75%) of the nests found were located on nest monitoring plots and 32 nests (25%) were found off-plot (**Table 3.4**).

Table 3.4 Nest Locations Summary

Nest Location	DRC	HPZ	Total
On-plot	51	43	**94**
Off-plot	15	17	**32**
Total	**66**	**60**	**126**

Thirty species were found nesting within the study area (**Table 3.5**). This included 23 species nesting on nest monitoring plots and 7 additional species detected nesting outside of nest monitoring plots. There were 22 species detected in the HPZ and 18 in the DRC.

The most nests were detected in the HPZ for song sparrow (*Melospiza melodia*, 8 nests), red-winged blackbird (*Agelaius phoeniceus*, 7 nests), and yellow warbler (*Setophaga petechia*, 6 nests) (**Table 3.5**). In the DRC, the most nests were detected for song sparrow (21 nests), spotted sandpiper (*Actitis macularius*, 17 nests), and American robin (*Turdus migratorius*, 8 nests) (**Table 3.5**).

Common nighthawk (*Chordeiles minor*), a species federally listed as threatened, was detected nesting on plot 2 in the DRC. It was first observed on the plot while surveying in early June, but, despite regular surveys, a nighthawk was not observed there again until the nest was found on July 21 (**Photo 1**).

Other notable observations included a trumpeter swan (*Cygnus buccinator*) nest in a wetland (off-plot) in the HPZ. This was the only location in the study area where wetland habitat was observed and a plot in this area was the only location where red-winged blackbirds were observed nesting.

Table 3.5 Species Nesting in the Headpond (HPZ) and Downstream River Channel (DRC)

Common Name	Scientific Name	DRC		HPZ		Total
		Off-plot	On-plot	Off-plot	On-plot	
Trumpeter swan	*Cygnus buccinator*	-	-	1	-	**1**
Canada goose	*Branta canadensis*	1	8	-	-	**9**
Mallard	*Anas platyrhynchos*	1	-	-	1	**2**
American coot	*Fulica americana*	-	-	-	1	**1**
Killdeer	*Charadrius vociferus*	-	2	-	-	**2**
Spotted sandpiper	*Actitis macularius*	3	10	1	3	**17**
Common nighthawk	*Chordeiles minor*	-	1	-	-	**1**
Alder flycatcher	*Empidonax alnorum*	1	1	-	4	**6**
Least flycatcher	*Empidonax minimus*	1	3	-	-	**4**
Eastern kingbird	*Tyrannus tyrannus*	1	-	-	-	**1**
Red-eyed vireo	*Vireo olivaceus*	-	-	-	1	**1**
American crow	*Corvus brachyrhynchos*	-	-	1	1	**2**
Black-capped chickadee	*Poecile atricapillus*	-	-	-	1	**1**
Swainson's thrush	*Catharus ustulatus*	-	-	1	-	**1**
American robin	*Turdus migratorius*	1	7	-	1	**9**

Common Name	Scientific Name	DRC		HPZ		Total
		Off-plot	On-plot	Off-plot	On-plot	
Gray catbird	*Dumetella carolinensis*	-	-	1	-	**1**
Cedar waxwing	*Bombycilla cedrorum*	1	3	2	2	**8**
Yellow warbler	*Setophaga petechia*	-	1	4	2	**7**
Yellow-rumped warbler	*Setophaga coronata*	-	1	-	-	**1**
Black-and-white warbler	*Mniotilta varia*	-	-	-	1	**1**
American redstart	*Setophaga ruticilla*	-	-	-	3	**3**
Common yellowthroat	*Geothlypis trichas*	1	-	-	-	**1**
Chipping sparrow	*Spizella passerina*	-	-	1	-	**1**
Clay-colored sparrow	*Spizella pallida*	-	2	2	1	**5**
Song sparrow	*Melospiza melodia*	1	12	3	5	**21**
Lincoln's sparrow	*Melospiza lincolnii*	1	-	-	3	**4**
White-throated sparrow	*Zonotrichia albicollis*	1	-	-	3	**4**
Dark-eyed junco	*Junco hyemalis*	-	-	-	3	**3**
Red-winged blackbird	*Agelaius phoeniceus*	-	-	-	7	**7**
Brewer's blackbird	*Euphagus cyanocephalus*	1	-	-	-	**1**
Total		**15**	**51**	**17**	**43**	**126**

Photo Credit: Chris Coxson

Photo 1 Common nighthawk nest on plot 2

3.3.3 Nest Elevation

Nests were located both at and above ground level on nest monitoring plots in both the DRC and HPZ (**Figure 3.2**). Some nests were found at elevations below the maximum water level that was measured at the water monitoring station closest to the plot the nest was located on (indicated by the colours) (**Figure 3.2**). This illustrates potential for nest flooding to occur if those nests are active at the time when the water level is at that elevation. Nest timing in relation to water levels is discussed below in **Section 4.2.4** Nest Outcomes and Flooding.

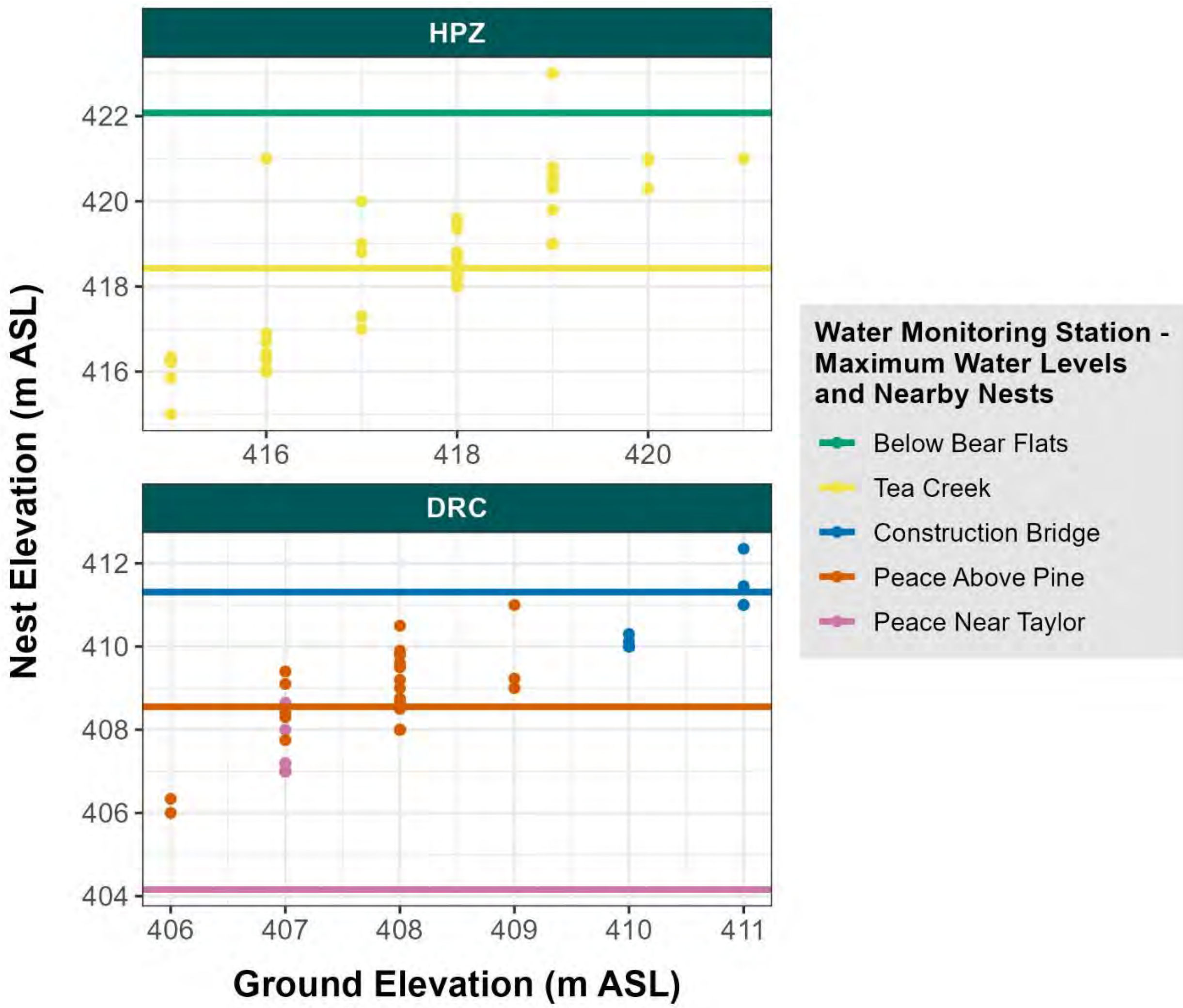

Figure 3.2 **Headpond (HPZ) and downstream river channel (DRC) nest elevations (points) and maximum water levels (horizontal lines) at nearby monitoring stations between April 1 and August 31, 2021.**

3.3.4 Nest Habitat

Species richness and diversity were highest in riparian forest, riparian shrub, and upland shrub (**Table 3.6**). Nest density was the highest in wetland, upland shrub, and riparian forest (**Table 3.6**). In the wetland habitat, nest density was higher, but diversity was low because most of the nests were red-winged blackbirds, which tend to nest in groups.

Only one nest (killdeer, *Charadrius vociferus*) was found in unvegetated habitat, and none were found in open habitat.

Table 3.6 Species Diversity and Nest Density Across Nest Plot Habitat Types

Habitat Type	Number of Nests (n)	Species Richness	Pielou Evenness	Nest Density (nests/ha)		
				DRC	HPZ	Overall
Open Habitat	0	-	-	-	-	-
Riparian Forest	32	13	0.92	6.01	5.27	5.57
Riparian Shrub	41	10	0.83	3.76	1.82	3.33
Unvegetated	1	1	-	0.13	-	0.09
Upland Forest	3	2	0.92	-	2.53	2.53
Upland Shrub	9	7	0.97	-	6.82	6.82
Wetland	8	2	0.54	-	7.85	7.85

3.3.5 Nest Phenology

Nest phenology curves show a similar trend in nest timing for the HPZ and DRC, with the peak in nesting activity in mid-June (**Figure 3.3**). The curve is cut off in late July because the field season ended on July 21.

There were differences in nest timing among some species (**Figure 3.4**). For example, song sparrow and American robin initiated nests throughout the season, whereas alder flycatcher (*Empidonax alnorum*) and cedar waxwing (*Bombycilla cedrorum*) did not begin nesting until later in June **(Figure 3.4**). For many species, the nest sample size after one year of data collection is relatively small.

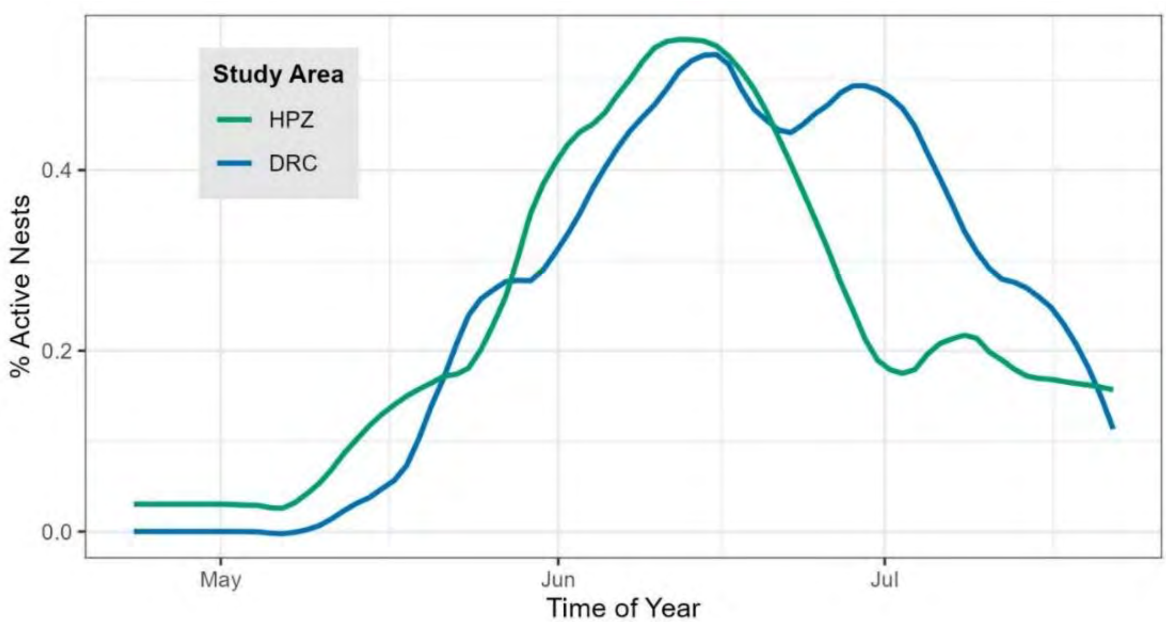

Figure 3.3 Percent of monitored nests active on nest monitoring plots in the headpond (HPZ) and downstream river channel (DRC) throughout the field season.

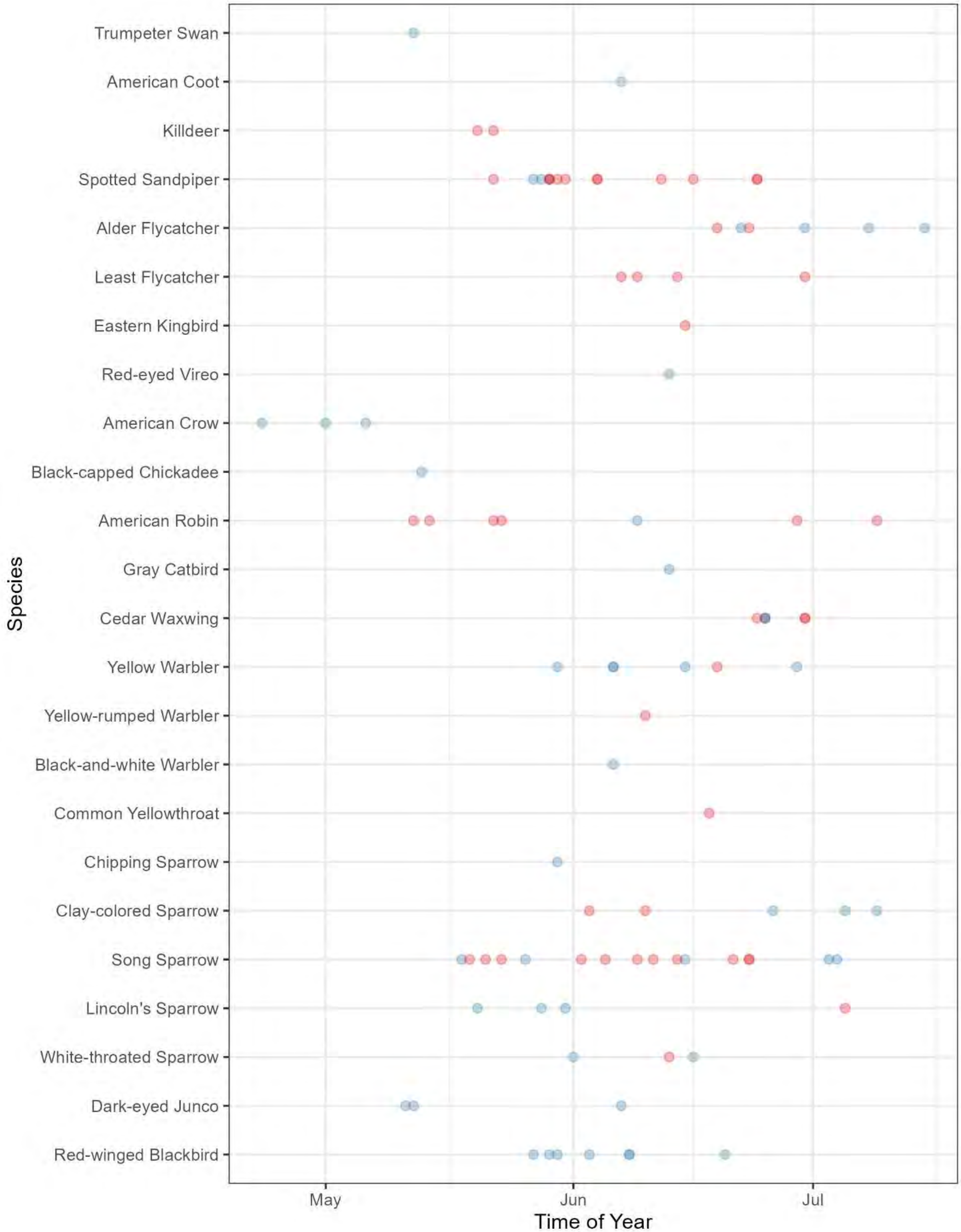

Figure 3.4 Estimated first egg dates for species nesting in the headpond (HPZ, blue) and downstream river channel (DRC, red).

3.3.6 Nest Outcomes

Across the entire study area, 44% of nests detected were considered successful, 33% failed, and 23% had an unknown outcome (**Table 3.7**). The most common cause of nest failure was predation. Flooding caused the failure of 6% of nests and affected 7 nests monitored in the HPZ and 1 in the DRC (**Table 3.7**).

Table 3.7 Nest Outcomes – Percentage of Total Nests in Each Area

Nest Outcome	HPZ (% of total nests)	DRC (% of total nests)	Overall (% of total nests)
Abandoned	3	0	2
Failed by unknown means	3	2	2
Flooded	12	2	6
Predation	25	21	23
Successful	35	52	44
Unknown	7	17	12
Unknown due to end of season	15	8	11

Nest outcomes were also examined by habitat, however some habitat types (e.g., unvegetated and upland forest) had very few nests (**Table 3.8**) so these percentages should be interpreted cautiously.

Table 3.8 Nest Outcomes – Percentage of Total Nests for Each Habitat Type

Habitat Type	Number of Nests (n)	Successful (%)	Failed – Flooding (%)	Failed – Predation (%)	Failed – Other (%)	Unknown (%)	Unknown (end of season) (%)
Open Habitat	0	-	-	-	-	-	-
Riparian Forest	32	40	3	25	6	-	25
Riparian Shrub	41	54	2	17	-	21	5
Unvegetated	1	100	-	-	-	-	-
Upland Forest	3	67	33	-	-	-	-
Upland Shrub	9	33	-	33	11	11	11
Wetland	8	50	25	25	-	-	-

3.3.7 Nest Flooding

Flooding affected 8 nests of 5 species (**Table 3.9**, **Photo 1**). Nest flooding occurred in late June and early July as the water level increased in both the HPZ and DRC (**Section 3.1** Water Levels).

Flooding primarily affected birds nesting on or low to the ground; however, it also affected cedar waxwing, which nested more than a metre above the ground, but bred on a lower elevation plot (**Table 3.9**).

Table 3.9 Summary of Flooded Nests Observed within the Study Area

Typical Nesting Location	Common Name	Plot Habitat Types	Number of Nests Flooded	Average Nest Height (m)	Average Nest Elevation (m ASL)	
					DRC	HPZ
Ground	Spotted sandpiper	Riparian forest, riparian shrub	2	0	407.0	416.0
	Dark-eyed junco	Upland forest	1	0	-	418.0
Low Shrub	Song sparrow	Upland shrub	1	0	-	417.0
	Red-winged blackbird	Wetland	2	0.51	-	416.5
Shrub	Cedar waxwing	Riparian shrub	2	1.26	-	416.3

Some nests were found on previously flooded plots after water levels dropped in July. On plot 110, a cedar waxwing was found on a nest in an area where 2 cedar waxwing nests had failed due to flooding. Additionally, a white-throated sparrow was found nesting on plot 107 soon after the water level dropped. This nest was elevated above the ground, which is less common for this typically ground-nesting sparrow. It is possible that the nest was initiated above water while the plot was still flooded, when nesting on the ground was not an option.

Photo Credit: Catherine Craig

Photo 2 Flooded spotted sandpiper nest on plot 113

3.4 Point Counts

3.4.1 Survey Effort

One point count survey was completed for 18 of the 24 nest monitoring plots between June 22 and June 26, 2021. The plots not surveyed were flooded by this date, meaning that the open habitat (grassland) plot and 5 unvegetated plots were not sampled (**Table 3.10**).

3.4.2 Results Summary

Fifty-seven species were detected during point count surveys, of which 28 were located on nest monitoring plots (**Table 3.11**). The greatest numbers of individual birds and bird species detected were in riparian forest, riparian shrub, and upland shrub habitat types (**Table 3.10**). Only one species, song sparrow, was detected on an unvegetated plot and it is unlikely that it was breeding there.

Table 3.10 Point Count Survey Results by Habitat Type

Habitat Type	Number of Plots	Number of Individuals	Species Richness	Pielou Evenness
Open Habitat	0	-	-	-
Riparian Forest	4	46	21	0.95
Riparian Shrub	8	45	14	0.85
Unvegetated	2	1	1	-
Upland Forest	1	11	8	0.97
Upland Shrub	2	23	10	0.96
Wetland	1	8	6	0.93
Total	**18**	**134**	**-**	-

Table 3.11 Species Detected on Nest Monitoring Plots During Point Counts

Common Name	Scientific Name	DRC	HPZ	Total
Alder flycatcher	*Empidonax alnorum*	1	9	10
American crow	*Corvus brachyrhynchos*	-	6	6
American redstart	*Setophaga ruticilla*	-	2	2
American robin	*Turdus migratorius*	7	4	11
Baltimore oriole	*Icterus galbula*	1	-	1
Black-and-white warbler	*Mniotilta varia*	-	1	1
Brewer's blackbird	*Euphagus cyanocephalus*	2	-	2
Brown-headed cowbird	*Molothrus ater*	1	2	3
Clay-colored sparrow	*Spizella pallida*	3	4	7
Common yellowthroat	*Geothlypis trichas*	-	9	9
Dark-eyed junco	*Junco hyemalis*	-	4	4
Downy woodpecker	*Dryobates pubescens*	1	-	1

Common Name	Scientific Name	DRC	HPZ	Total
Killdeer	*Charadrius vociferus*	1	-	1
Least flycatcher	*Empidonax minimus*	1	2	3
Lincoln's sparrow	*Melospiza lincolnii*	2	7	9
Northern waterthrush	*Parkesia noveboracensis*	-	2	2
Purple finch	*Haemorhous purpureus*	-	1	1
Red-eyed vireo	*Vireo olivaceus*	5	6	11
Red-winged blackbird	*Agelaius phoeniceus*	-	7	7
Rose-breasted grosbeak	*Pheucticus ludovicianus*	-	1	1
Song sparrow	*Melospiza melodia*	13	19	32
Spotted sandpiper	*Actitis macularius*	3	3	6
Swainson's thrush	*Catharus ustulatus*	-	1	1
Trumpeter swan	*Cygnus buccinator*	-	6	6
White-throated sparrow	*Zonotrichia albicollis*	-	5	5
Wilson's snipe	*Gallinago delicata*	-	1	1
Yellow-bellied sapsucker	*Sphyrapicus varius*	-	1	1
Yellow warbler	*Setophaga petechia*	5	6	11
	Total individuals detected	**46**	**109**	**155**

4.0 DISCUSSION

Results for the nest monitoring program from 2021 provide information that will be useful for addressing the questions of how many migratory bird species and nests are present in the fluctuation zones of the HPZ and DRC, and how many nests are affected by fluctuating water levels. Further years of sampling will continue to enhance this knowledge and improve confidence in the results.

4.1 Plot Selection and Habitat

One of the challenges of the 2021 field season was that the previous habitat mapping did not accurately represent the distribution of habitat types observed in the field. This was partly due to logging for reservoir construction since the habitat mapping occurred, meaning that many previously forested areas had become early seral shrub habitat. However, there were inconsistencies with the other categories also, such that the previous mapping could not be used as a proxy for mapping new habitat types.

Due to these inconsistencies, time was spent at the beginning of the field season covering ground within the study area to determine how mapped habitat had changed, and what habitat types were present within the study area. Habitat selected for nest monitoring plots was classified into 7 habitat types, but these have not been mapped throughout the study area, so the total available area of each habitat type is unknown. This adjustment prevented us from meeting the habitat sampling goals outlined in the Nest Monitoring Plan (BC Hydro 2021) because meeting those sampling goals requires having knowledge of the total available area of each habitat type.

Based on field observations, the plots sampled are an approximate representation of available habitat, but this cannot be confirmed quantitatively. The sampling among habitats was more evenly distributed in the HPZ than in the DRC. There may also be additional habitat types available in the HPZ or DRC that were not observed and thus were not sampled this year.

4.2 Nest Monitoring

4.2.1 Nesting Species

Thirty species were found nesting during this first year of the study, and it is anticipated that additional nesting species will be detected in future years. During a similar project in southern BC, the cumulative species total increased quickly during the first few years of the study (Hemmera 2020).

The sub-areas had similar numbers of species detected nesting (22 in HPZ, 18 in DRC), but there were differences in the numbers of each species found in the sub-areas, and some species were only detected in one sub-area. For example, gray catbird (*Dumetalla carolinensis*) was only detected in the HPZ, and many more nests for spotted sandpiper were found in the DRC. Further sampling of habitats in each sub-area will provide additional insight into differences between the sub-areas.

The detection of common nighthawk nesting indicates the presence of breeding habitat for this at-risk species in the DRC. This species has high breeding site fidelity, suggesting that it may be present in this area in future years (Ng et al. 2018).

4.2.2 Nest Densities and Habitat Sampling

Species diversity was highest in more complex habitats because these provide a diversity of nest locations (i.e., ground, shrub, tree) suitable for a wider range of species. This finding matched the results of similar multi-species studies (Hemmera 2020). However, there were some species, such as killdeer, that were only found nesting in less complex habitats.

Due to the relatively small area of each habitat type surveyed so far and the lost survey effort on some plots due to flooding, the species-habitat associations and nest densities should be interpreted with caution, particularly for under-sampled habitats. For example, only 1 or 2 plots have been sampled so far for open habitat, upland forest, upland forest, and wetland, and an area of less than 2 ha was sampled for each habitat, compared to the 12 ha of riparian shrub that was sampled across 8 plots. Sampling was more evenly distributed in the HPZ than the DRC because not all habitat types were well-represented in the DRC.

Nest densities are likely slightly underestimated as there were known nesting pairs on plots that nests were not found for. This is particularly true for forested habitat types because nests situated higher up in trees are more difficult to detect.

Furthermore, unvegetated and open habitats were often at lower elevations, and some of these flooded early in the season. As they were then unavailable for monitoring, the nest densities calculated may be lower than they would have been if the habitats had remained available for nesting. Attempts will be made to locate some higher elevation plots of these habitats for monitoring in 2022.

4.2.3 Nest Phenology

Nesting activity peaked in mid-June, indicating that this is the core of the breeding season, as was expected based on previous data (BC Hydro 2021). However, since sampling only occurred between May 28 and July 21, early- and late-nesting species are likely slightly under-represented so far in the study. Some early-nesting species whose nests were still active when sampling began may have been detected, but nests that were only active prior to the start of sampling would have been missed.

There may also be a bias in the overall phenology estimate due to some habitats and related species being sampled more intensively. In the HPZ, habitats were sampled more evenly, but, in the DRC, most of the sampling occurred in only two habitat types (**Table 3.2**). This resulted in relatively larger numbers of spotted sandpiper, song sparrow, and American robin nests found in the DRC compared to other species, so the phenology of these species may be over-represented in **Figure 3.3**. Additional habitat types available within the DRC will be targeted for sampling in future years.

As noted above, some habitats were sampled less than others and lower elevation habitats were flooded, preventing the detection of later nesting species that might otherwise have used these habitats. This would be a larger factor in the HPZ where water level changes were more dramatic, and more plots were completely flooded. For example, the flooding of many plots in the HPZ occurred soon after cedar waxwing were first observed nest-building; therefore, it is possible we would have located additional nests of this late-nesting species if flooding had not occurred.

As noted in the Nest Monitoring Plan, the monitoring schedule will be adjusted throughout the study to target the times and locations for which more sampling is needed to characterize the nesting activity within the study area (BC Hydro 2021). These adjustments will allow for early- and late-nesting species to be documented nesting in the study area.

4.2.4 Nest Outcomes and Flooding

The primary cause of nest failure was predation, which is typical for nest monitoring studies (Ricklefs 1969; Hemmera 2020; Thompson 2007). However, nest flooding caused the failure of 8 nests, including 7 in the HPZ where there was a larger increase in water level in comparison to the DRC. Nest flooding occurred because there were lower water levels throughout June while nests were being established, followed by a water level increase in late June and early July while those nests were still active (**Figure 3.1**). This water level change coincided with the peak of the bird breeding season (**Figure 3.3**), maximizing the potential for nest flooding impacts.

Nesting activity was documented after the water levels dropped on 2 plots that had flooded, indicating that previously flooded habitat can be quickly used by nesting birds if it becomes available again. The observation of the white-throated sparrow nesting above ground-level may also indicate a change in typical nest site choice in response to the flooding.

Once more data have been collected, it should be possible to examine factors affecting daily nest survival for more common species, such as spotted sandpiper and song sparrow, for comparison with similar studies (Hemmera 2020). With updated habitat maps it will be possible to estimate the total impact of nest flooding in the study area based on elevation and habitat availability.

One additional challenge with determining potential nest flooding impacts is that water level data do not have good connectivity with all plots because some plots are distant from a water monitoring station due to the size of the study area. This will simply add a bit of uncertainty to the estimates.

4.3 Point Counts

The sample size for most habitat types is not large (e.g., only a single plot for upland forest and wetland), so results should be interpreted cautiously. The lower sample size is partly due to some of the plots (6) being flooded prior to point count surveys taking place. Additionally, due to time spent early in the season determining which plots to sample in 2021, there was only time for one round of point counts to be completed in this initial year of the survey.

Fewer total species were detected on plots during point count sampling (28) compared to nest monitoring surveys (30), although an additional point count round would likely have increased the number of species detected using point counts. There were several species detected during point counts for which nests were not found, and which had also been observed incidentally while conducting nest monitoring surveys.

If off-plot detections are included, then point counts detected a much larger number of species (57), but some these detections cannot be related to habitat and may not be within an area likely to be affected by water fluctuations. Many of the nest monitoring plots had an irregular or linear shape to capture an area of habitat along the edge of the river.

The habitat types determined to have the greatest diversity from point count data were the same as the most diverse habitat types as determined by nest monitoring. Thus, the point counts did not add much additional information to what was already known from the time spent nest searching on plots.

5.0 RECOMMENDATIONS

5.1 Plot Selection and Habitat

As mentioned above, the habitat sampling plan outlined in the Nest Monitoring Plan (BC Hydro 2021) could not be followed due to inconsistences in the habitat mapping. Additional mapping of the habitat types within the DRC and HPZ will be completed prior to the 2022 field season using aerial imagery and elevation data collected by BC Hydro in 2021. This will allow for an estimate of the total available area for each habitat type so that habitat types are sufficiently sampled in each sub-area. Sufficient sampling of each habitat type for nesting birds will provide better estimates of the nest densities within each habitat type and sub-area, and of the potential impact of nest flooding.

For 2022, efforts will be made to locate and sample habitat types within the DRC that were not sampled in 2021 (i.e., upland forest, upland shrub, open habitat, and wetland), but that exist in the HPZ, as well as to increase the amount of open/grassland habitat sampled overall, if available and accessible. This will add confidence to our knowledge of which species nest in each habitat type within each sub-area.

Structurally complex habitat (e.g., forest) requires greater effort to survey than many other habitat types. Survey effort will be reallocated to reduce the area of complex habitat surveyed (in comparison to 2021) to ensure sufficient time to locate as many nests as possible in all habitat types.

5.2 Nest Surveys

For 2022, the planned 6 weeks of sampling will take place over the peak breeding period of June and early July. This will allow for the detection of as many nests and nesting species as possible in the HPZ during this last year of monitoring for the construction phase of the Project.

Point counts are planned to be discontinued in 2022 because these surveys provided little new information about the numbers of individuals and species present on nest monitoring plots. Due to the amount of time spent on plots nest searching using behavioural observations, the field crew was aware of the number of potential breeding pairs and species present on each plot prior to point counts occurring. For 2022, we plan to record data more formally on the number of territories suspected to be on a plot. Tracking territories provides a way to document these observations and this information can be used to improve estimates of nest density, particularly for habitats that are harder to search (e.g., forests and dense shrubs). For example, if a pair of birds is regularly present on a plot and observed exhibiting breeding behaviour, but a nest is not found, it can be assumed that there was a nesting attempt. In these cases, the total number of nests for the plot will include these suspected nests. Nest searching and monitoring will continue to provide information about nest placement and nest outcomes, including documenting flooding impacts.

6.0 CLOSURE

We sincerely appreciate the opportunity to have assisted you with this project and if there are any questions, please do not hesitate to contact the undersigned by phone at 604.669.0424.

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APPENDIX A

Sample Point Count Data Sheet

Bird Point Count Data Form   Project: ____________________

POINT: ____ TIME: ______ OBS: __________________ DATE: ________________________
Month Day Year

Coordinates (UTM): ____________________________ Zone: ________________

Wind:
__ none
__ 1-5 kp/h (smoke drifts/leaves rustle)
__ 6-11 kp/h (wind felt on face)
__ 12-19 kp/h (flags extended/leaves move)
__ 20-28 kp/h (dust and small branches move)
__ >28 kp/h (branches of a moderate size move; small trees begin to sway)

Precipitation:
__ none
__ drizzling
__ raining

Temp: _________

% CC: _________

	0-3 Minutes				3-5 Minutes				5-10 Minutes				
SPECIES	< 50m	50-100	>100m	flyover	< 50m	50-100	>100m	flyover	< 50m	50-100	>100m	flyover	NOTES

Comments: ____

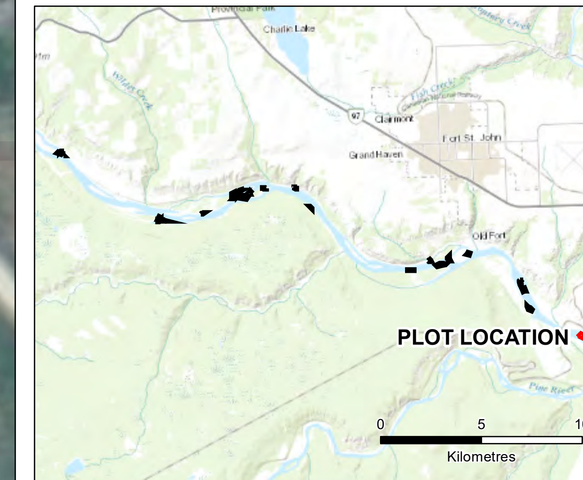
____

Record each bird heard with a tick (I). Change (I) to a cross (+) if later determined to be male (e.g., singing). Enter "V" for visual sightings; if male enter a "+". Birds originally detected >50m should be re-recorded as <50m if they move into the area. + = male, I = female or undetermined sex, J = juvenile.

APPENDIX B
Nest Monitoring Plots

2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 1



Legend

- Nest Location
- Nest Monitoring Plot

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

- Aerial Image: © Google Earth, 2020. Date of Imagery: 06/25/2021
- Inset Basemap: ESRI World Topographic Map

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Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

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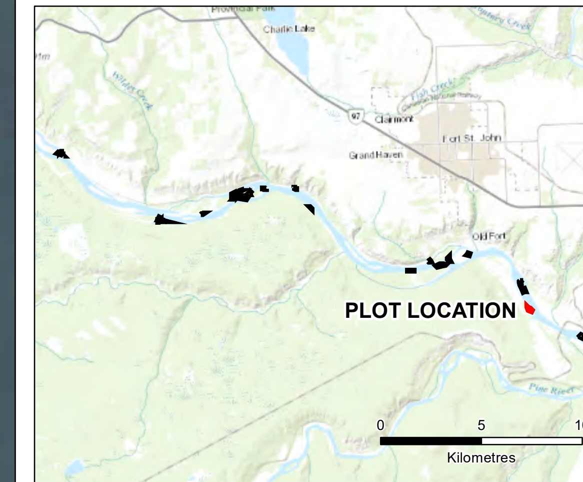
Hemmera
An Ausenco Company

BC hydro

2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 2



Legend

Nest Location

Nest Monitoring Plot

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
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N

1:1,500

0 20 40 60 80 100

Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

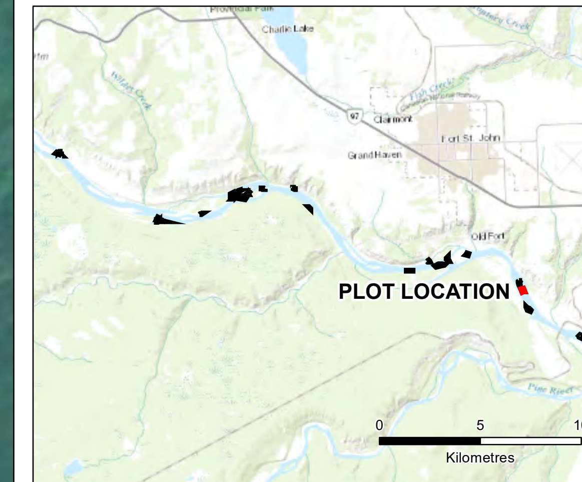
103707-03	Production Date: Mar 1, 2022	Appendix B-2

Hemmera An Ausenco Company

BC hydro

2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 3



Legend

- Nest Location
- Nest Monitoring Plot

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

- Aerial Image: © Google Earth, 2020. Date of Imagery: 06/25/2021
- Inset Basemap: ESRI World Topographic Map

N

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0 20 40 60 80 100
Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

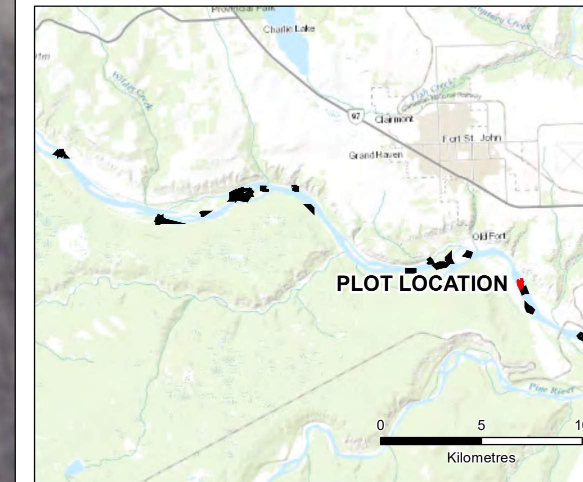
103707-03	Production Date: Mar 1, 2022	Appendix B-3

Hemmera
An Ausenco Company

BC hydro

2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 4



Legend

- Nest Location
- Nest Monitoring Plot

Notes

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Sources

- Aerial Image: © Google Earth, 2020. Date of Imagery: 06/25/2021
- Inset Basemap: ESRI World Topographic Map

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0 20 40 60 80 100
Metres

NAD 1983 UTM Zone 10N

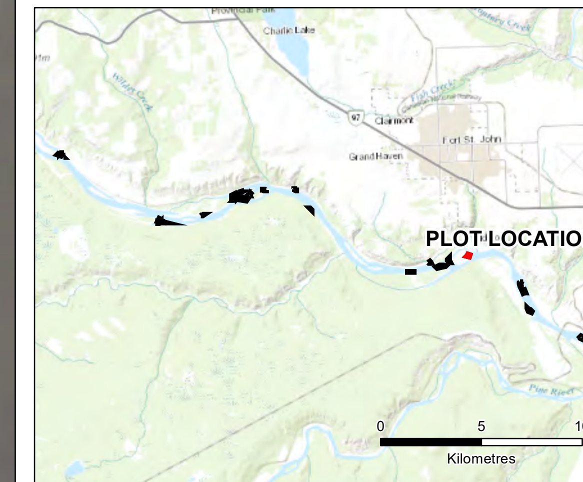
Page Size: 11" x 17"

103707-03	Production Date: Mar 1, 2022	Appendix B-4

Hemmera
An Ausenco Company
BC hydro

2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 6



Legend

- Nest Location
- Nest Monitoring Plot

Notes

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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

- Aerial Image: © Google Earth, 2020. Date of Imagery: 04/24/2019
- Inset Basemap: ESRI World Topographic Map

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Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

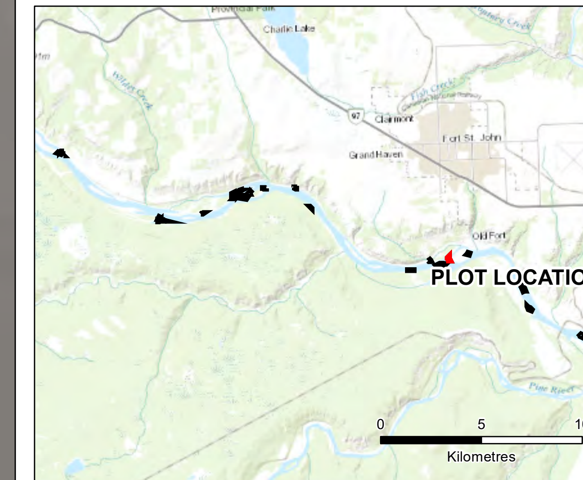
103707-03	Production Date: Mar 1, 2022	Appendix B-5

Hemmera
An Ausenco Company

BChydro

2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 9



Legend

- Nest Location
- Nest Monitoring Plot

Notes

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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

- Aerial Image: © Google Earth, 2020. Date of Imagery: 04/24/2019
- Inset Basemap: ESRI World Topographic Map

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Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

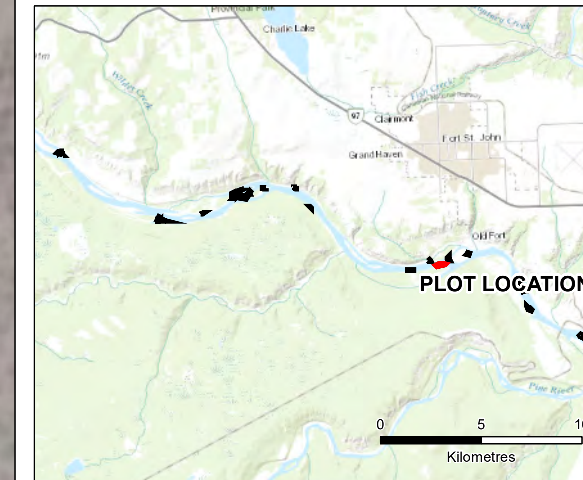
103707-03	Production Date: Mar 1, 2022	Appendix B-6

Hemmera
An Ausenco Company

BC hydro

2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 8



Legend

- Nest Location
- Nest Monitoring Plot

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

- Aerial Image: © Google Earth, 2020. Date of Imagery: 04/24/2019
- Inset Basemap: ESRI World Topographic Map

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0 20 40 60 80 100
Metres

NAD 1983 UTM Zone 10N

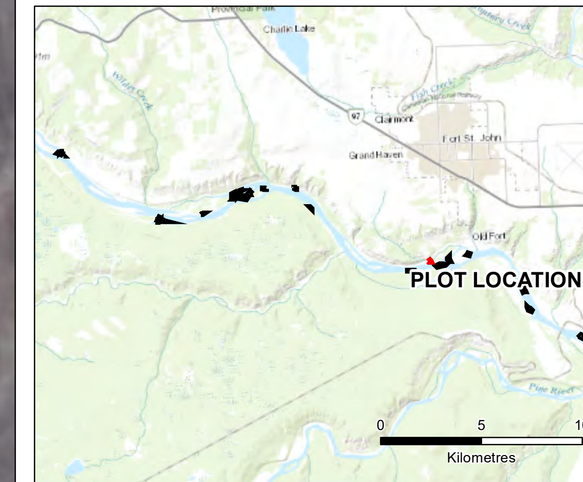
Page Size: 11" x 17"

103707-03	Production Date: Mar 1, 2022	Appendix B-7

Hemmera
An Ausenco Company
BC hydro

2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 10



Legend

- Nest Location
- Nest Monitoring Plot

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

- Aerial Image: © Google Earth, 2020. Date of Imagery: 04/24/2019
- Inset Basemap: ESRI World Topographic Map

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Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

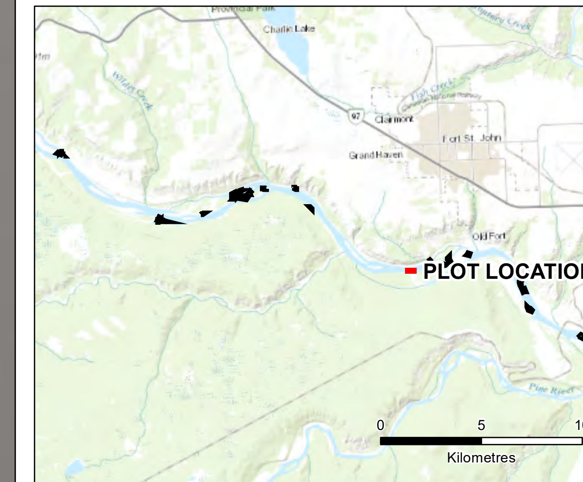
103707-03	Production Date: Mar 1, 2022	Appendix B-8

Hemmera
An Ausenco Company

BC hydro

2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 11



Legend

- Nest Location
- Nest Monitoring Plot

Notes

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Sources

- Aerial Image: © Google Earth, 2020. Date of Imagery: 04/24/2019
- Inset Basemap: ESRI World Topographic Map

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Metres

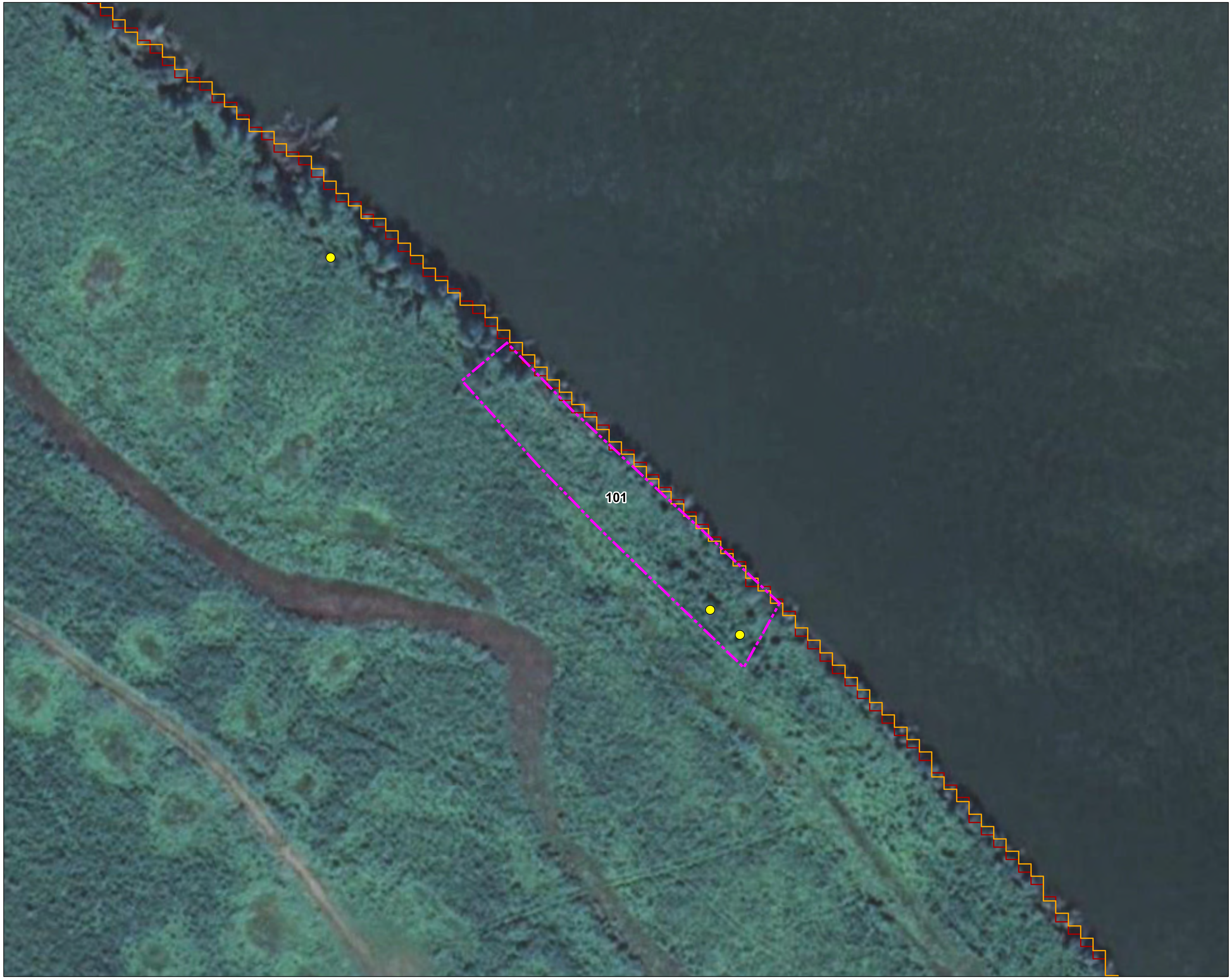
NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

103707-03	Production Date: Mar 1, 2022	Appendix B-9

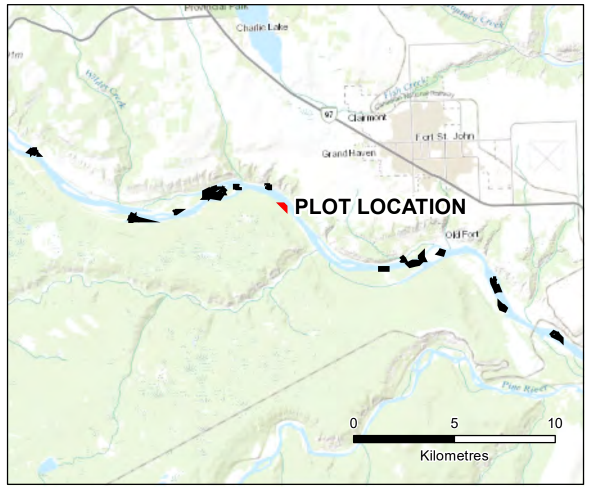
Hemmera
An Ausenco Company

BC hydro



2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 101



Legend

- Nest Location
- Nest Monitoring Plot
- Headpond Zone Mininum Normal Reservoir Level
- Headpond Zone Maximum Normal Reservoir Level

Notes

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Sources

- Aerial Image: © Google Earth, 2020. Date of Imagery: 07/22/2021
- Inset Basemap: ESRI World Topographic Map

N

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0 20 40 60 80 100

Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

103707-03	Production Date: Mar 1, 2022	Appendix B-10

Hemmera An Ausenco Company
BC hydro

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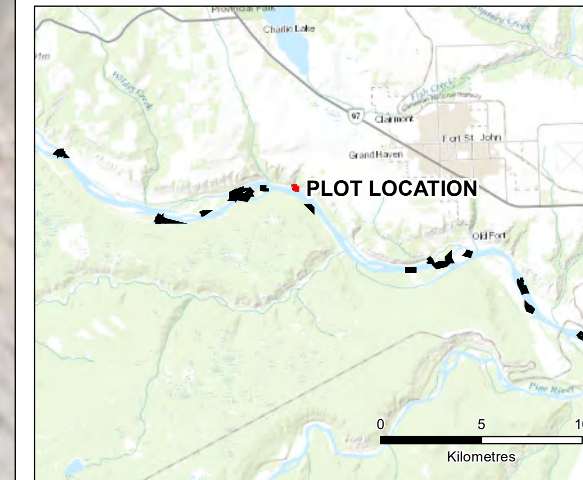
2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 102



Legend

- Nest Location
- Nest Monitoring Plot
- Headpond Zone Mininum Normal Reservoir Level
- Headpond Zone Maximum Normal Reservoir Level

Notes

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Sources

- Aerial Image: © Google Earth, 2020. Date of Imagery: 07/22/2021
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0 20 40 60 80 100
Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

103707-03	Production Date: Mar 1, 2022	Appendix B-11

Hemmera An Ausenco Company
BC hydro

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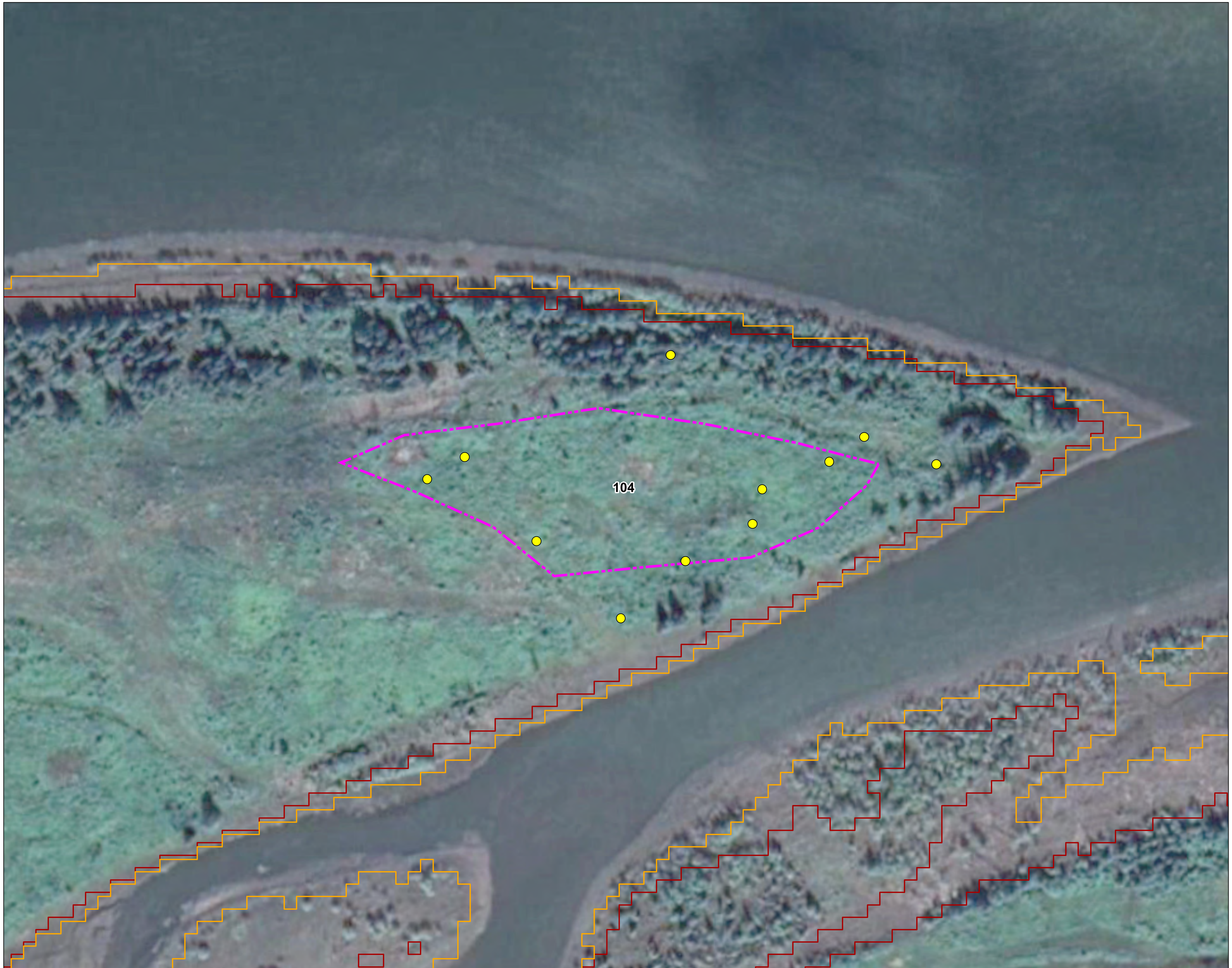
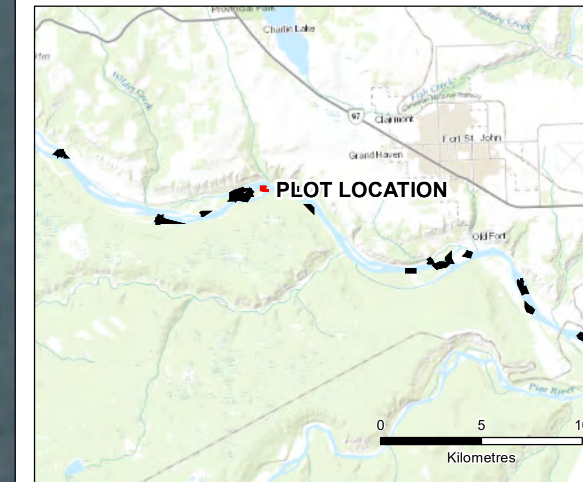
2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 104





Legend

- Nest Location
- Nest Monitoring Plot
- Headpond Zone Mininum Normal Reservoir Level
- Headpond Zone Maximum Normal Reservoir Level

Notes

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Sources

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- Inset Basemap: ESRI World Topographic Map

N

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0 20 40 60 80 100
Metres

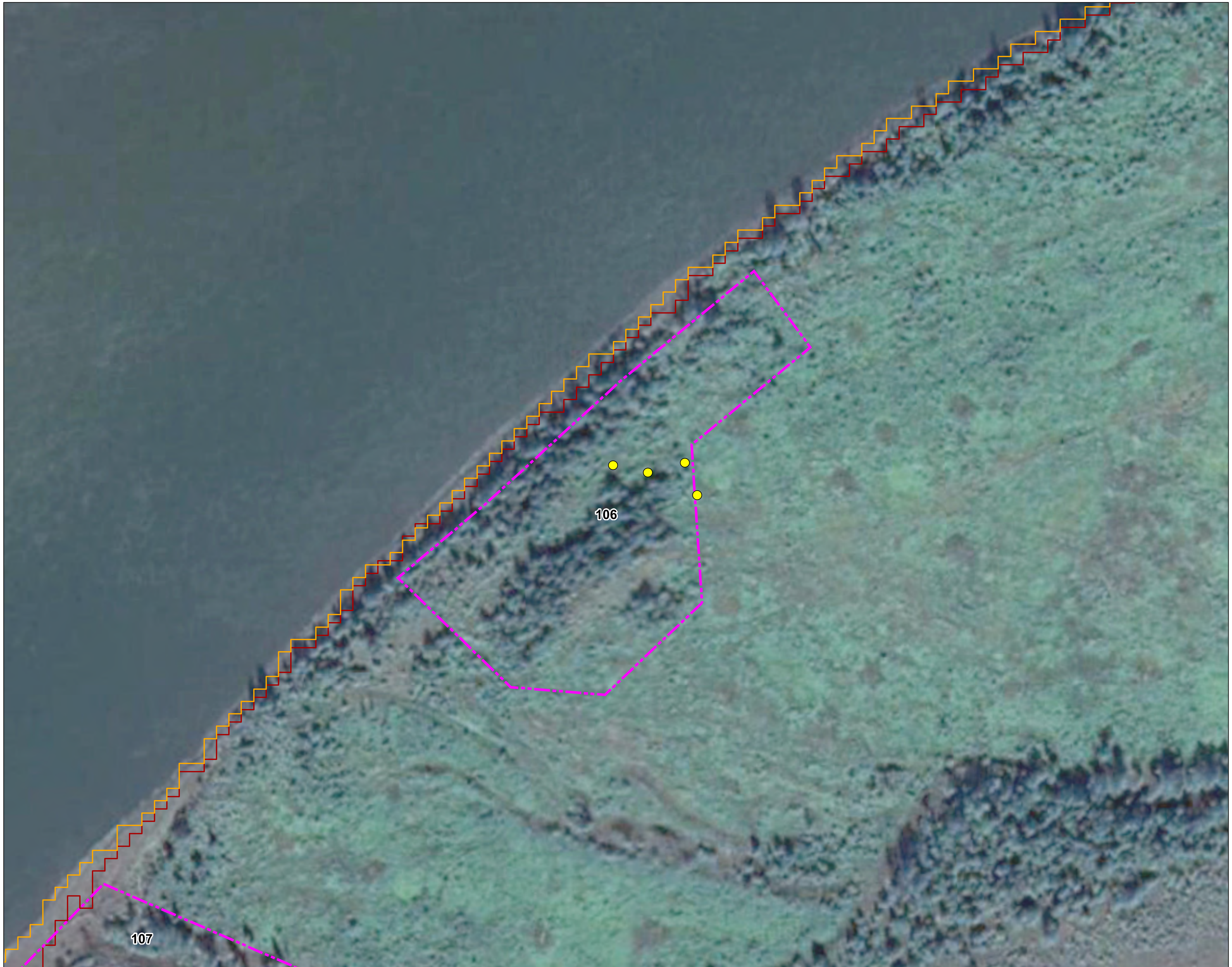
NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

103707-03	Production Date: Mar 1, 2022	Appendix B-12

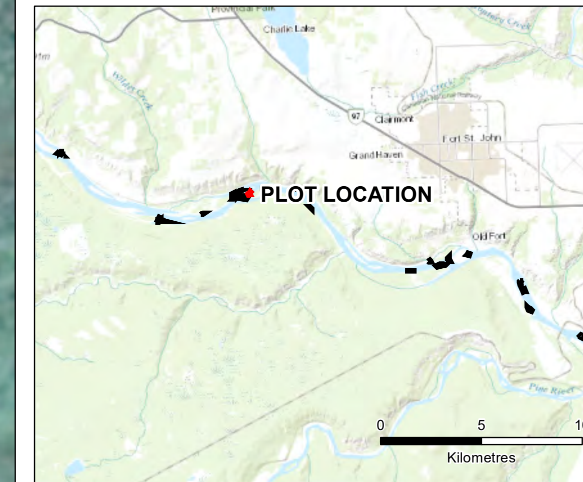
Hemmera An Ausenco Company

BC hydro



2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 106



Legend

- Nest Location
- Nest Monitoring Plot
- Headpond Zone Mininum Normal Reservoir Level
- Headpond Zone Maximum Normal Reservoir Level

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
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Sources

- Aerial Image: © Google Earth, 2020. Date of Imagery: 07/22/2021
- Inset Basemap: ESRI World Topographic Map

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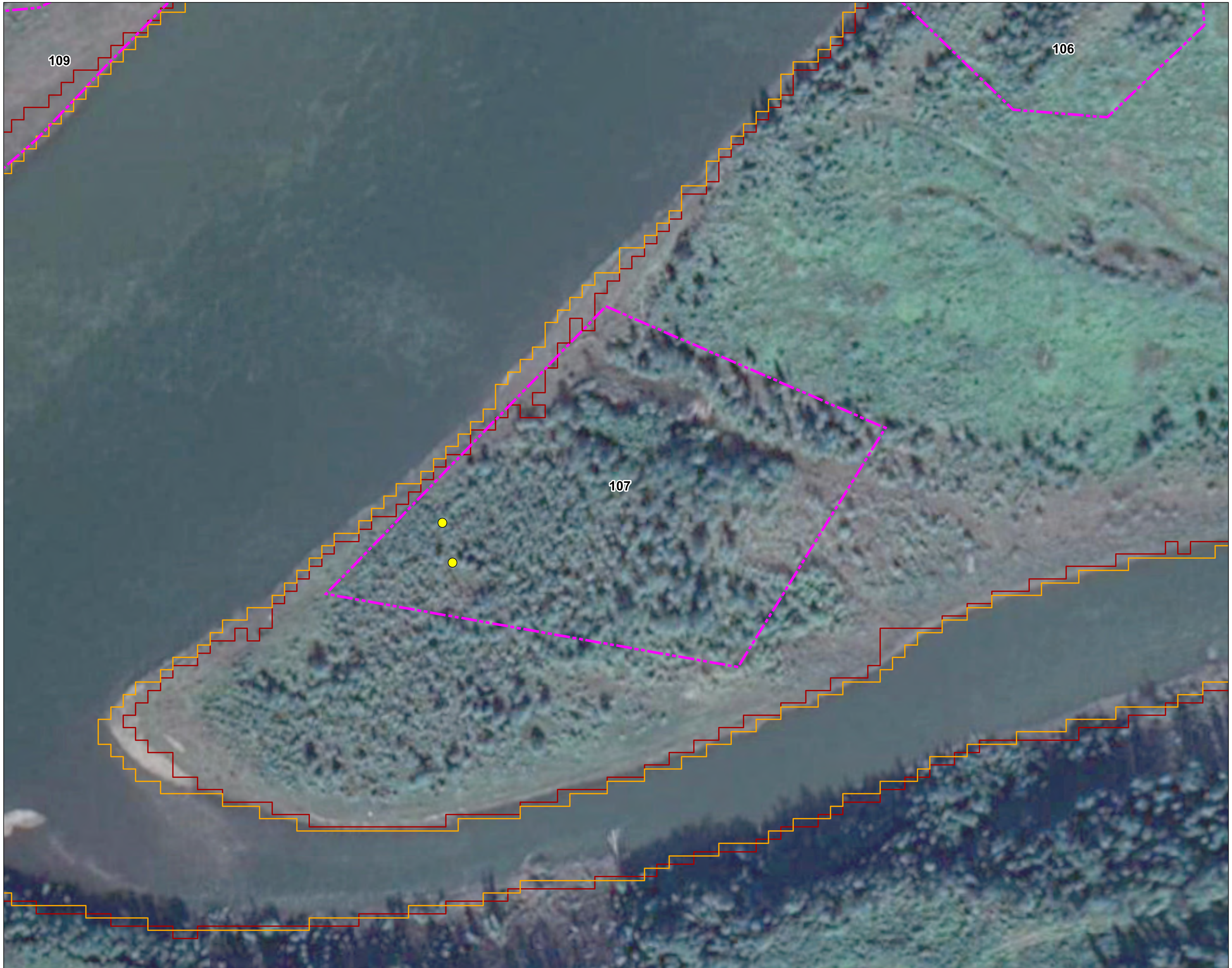
Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

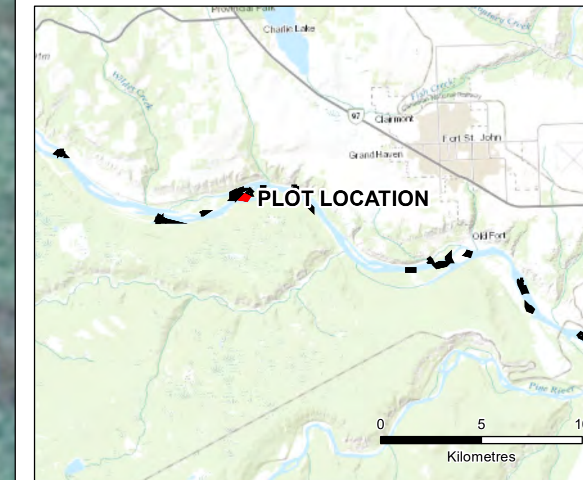
103707-03	Production Date: Mar 1, 2022	Appendix B-13

Hemmera
An Ausenco Company
BC hydro



2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 107



Legend

- Nest Location
- Nest Monitoring Plot
- Headpond Zone Mininum Normal Reservoir Level
- Headpond Zone Maximum Normal Reservoir Level

Notes

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0 20 40 60 80 100
Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

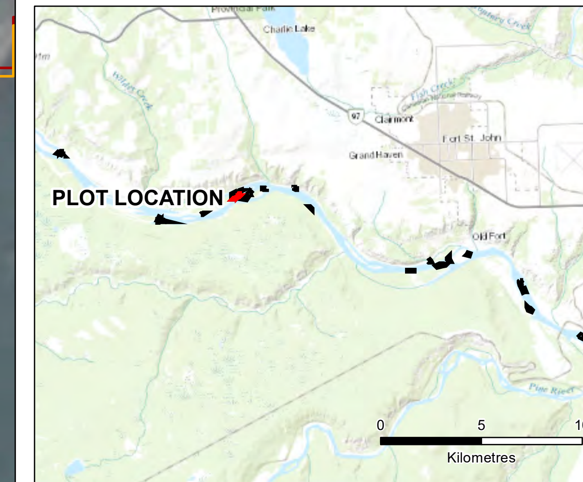
103707-03	Production Date: Mar 1, 2022	Appendix B-14

Hemmera
An Ausenco Company

BC hydro

2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 109 and 111



Legend

- Nest Location
- Nest Monitoring Plot
- Headpond Zone Mininum Normal Reservoir Level
- Headpond Zone Maximum Normal Reservoir Level

Notes

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N

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Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

103707-03	Production Date: Mar 1, 2022	Appendix B-15

Hemmera
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BC hydro

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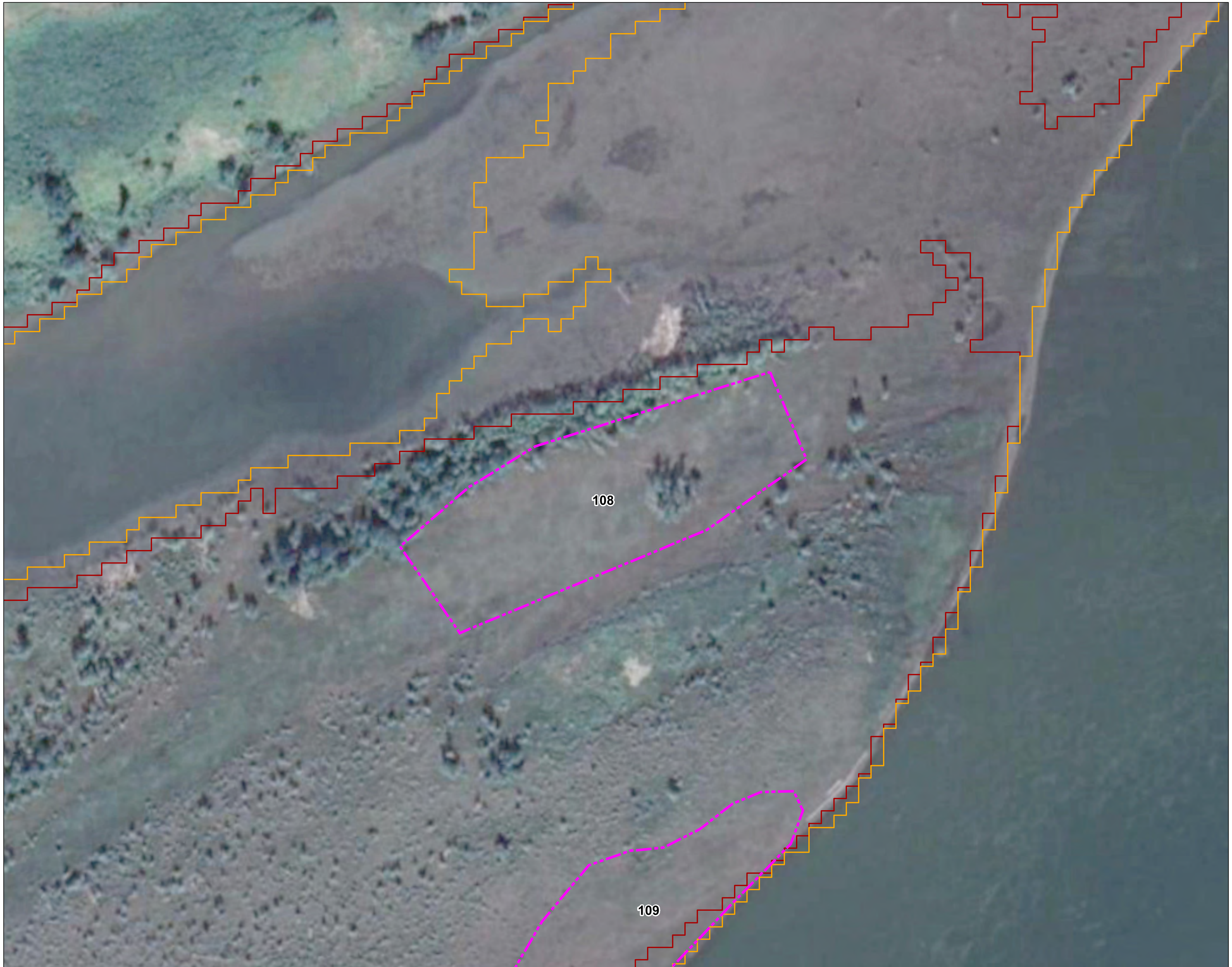
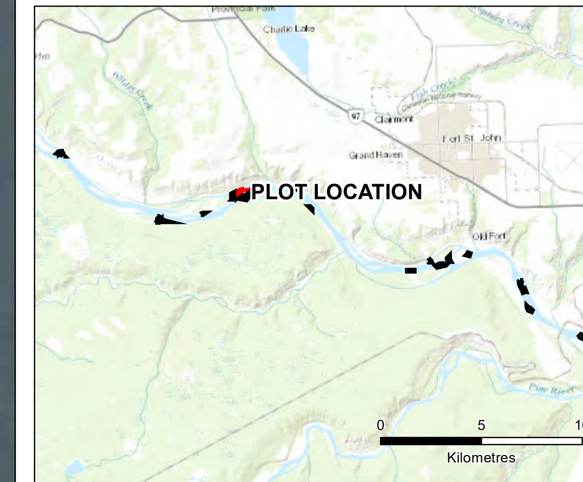


2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 108



Legend

- Nest Monitoring Plot
- Headpond Zone Mininum Normal Reservoir Level
- Headpond Zone Maximum Normal Reservoir Level

Notes

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Sources

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N

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Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

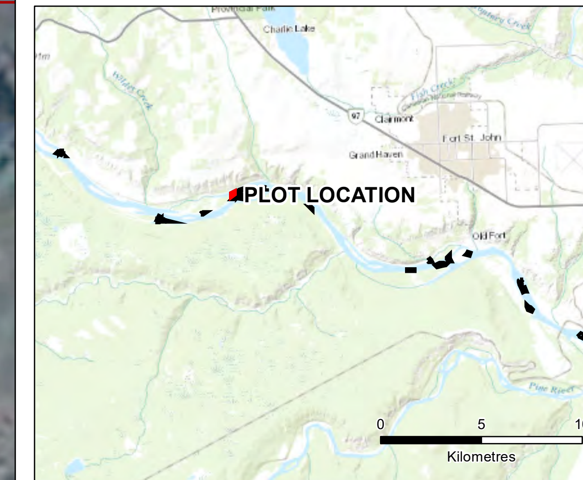
103707-03	Production Date: Mar 1, 2022	Appendix B-16

Hemmera
An Ausenco Company

BC hydro

2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 110



Legend

- Nest Location
- Nest Monitoring Plot
- Headpond Zone Mininum Normal Reservoir Level
- Headpond Zone Maximum Normal Reservoir Level

Notes

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Sources

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N

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Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

103707-03	Production Date: Mar 1, 2022	Appendix B-17

Hemmera An Ausenco Company
BC hydro

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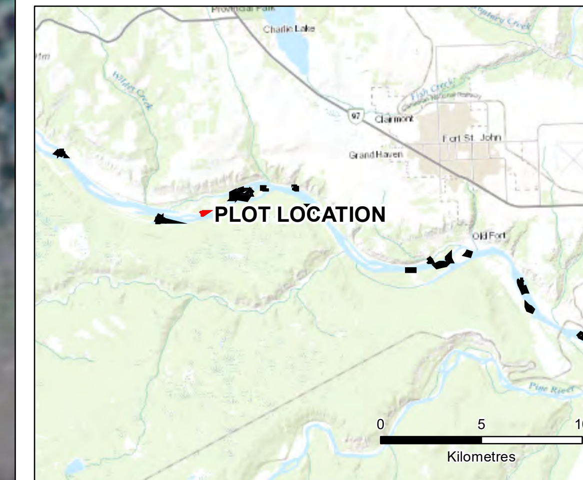
2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 113



Legend

- Nest Location
- Nest Monitoring Plot
- Headpond Zone Mininum Normal Reservoir Level
- Headpond Zone Maximum Normal Reservoir Level

Notes

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Sources

- Aerial Image: © Google Earth, 2020. Date of Imagery: 07/22/2021
- Inset Basemap: ESRI World Topographic Map

N

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Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

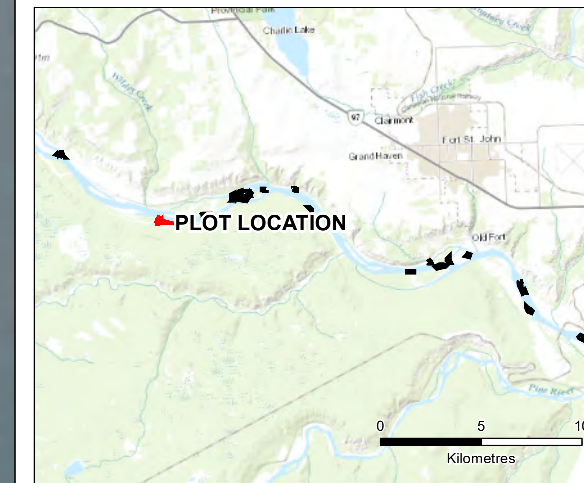
103707-03	Production Date: Mar 1, 2022	Appendix B-18

Hemmera
An Ausenco Company

BC hydro

2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 116, 117, and 118



Legend

- Nest Location
- Nest Monitoring Plot

Notes

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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

- Aerial Image: © Google Earth, 2020. Date of Imagery: 06/28/2021
- Inset Basemap: ESRI World Topographic Map

N

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Metres

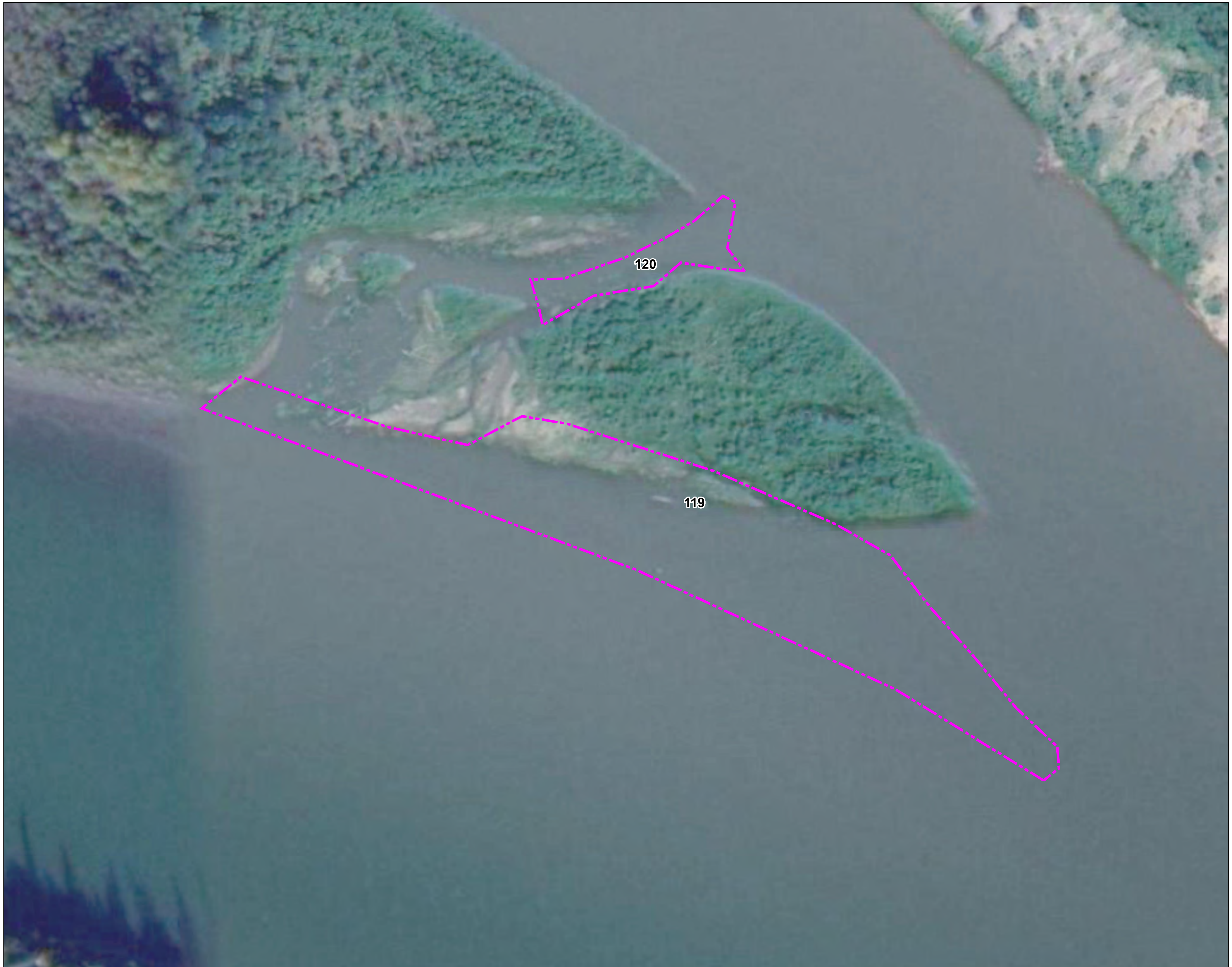
NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

103707-03	Production Date: Mar 1, 2022	Appendix B-19

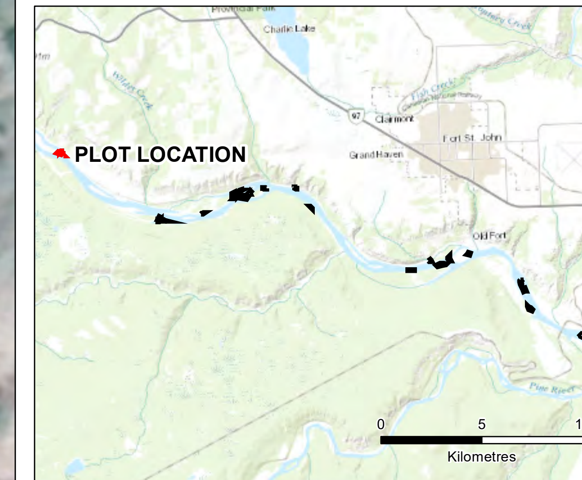
Hemmera
An Ausenco Company

BC hydro



2021 Nest Monitoring
Site C, Peace River, BC

Nest Monitoring Plot 119 and 120



Legend

Nest Monitoring Plot

Notes

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Sources

- Aerial Image: © Google Earth, 2020. Date of Imagery: 06/28/2021
- Inset Basemap: ESRI World Topographic Map

N

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0 20 40 60 80 100

Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

103707-03	Production Date: Mar 1, 2022	Appendix B-20

Hemmera
An Ausenco Company

BC hydro

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Appendix 5. Wetland Monitoring 2021 Field Summary Report

Site C Clean Energy Project
Wetland Monitoring Program
2021 Annual Report

DATE: MARCH 21, 2022

PRESENTED TO:

BC Hydro
1111 West Georgia Street, 9th floor
Vancouver, BC V6E 4G2

PRESENTED BY:

EcoLogic Consultants Ltd.
224 – 998 Harbourside Drive
North Vancouver, BC V7P 3T2
Phone: 604 803-7146

and

Tetra Tech Canada Incorporated
on behalf of Saulteau EBA Environmental
Services Joint Venture (SEES JV)
885 Dunsmuir Street, Suite 1000
Vancouver, BC V6C 1N5
Phone: 604 685-0275

EXECUTIVE SUMMARY

BC Hydro developed a Wetland Monitoring Program (the Program) for the Site C Clean Energy Project to address, in part, requirements outlined in the Federal Decision Statement (FDS) condition 11 and Environmental Assessment Certificate (EAC) condition 12:

- ***FDS condition 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.*

- ***FDS condition 11.4.3****. An approach to monitor and evaluate any changes to baseline conditions, as defined in condition 11.4.1 and identify improvements based on monitoring data.*

- ***EAC condition 12****. The EAC Holder must monitor construction and operation activities that could cause changes in wetland functions.*

The Program consists of two components: baseline wetland monitoring, which is focused on gathering information on the physical, ecological, biogeochemical, and hydrological conditions of wetlands prior to construction activities; and wetland monitoring during construction and operations, which is focused on gathering information to evaluate changes from baseline conditions due to Site C Project activities.

The 2021 field program was focused on construction phase monitoring of wetlands that were sampled in 2019, as well as full baseline assessment of the last two wetlands that were sampled in 2016 before the Project-specific monitoring methodologies were created. A total of 45 wetlands were sampled in 2021, with 40 sites along the transmission line and five sites in the downstream Project area along the Peace River. All targeted wetlands were sampled in 2021. From 2022 on, all field surveys will focus on construction phase monitoring, with 2022 resulting in the completion of the two-year sampling intervals. After 2022, wetlands will be re-assessed at five-year intervals. By 2027, all wetlands in the monitoring program will have a two and five-year monitoring assessment completed, which should allow for an analysis of change in wetland parameters.

Data on the physical, ecological, biogeochemical, and hydrological conditions collected at each of the 2021 wetlands are presented in this report.

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1. INTRODUCTION

1.1 PROJECT CONDITIONS

BC Hydro developed a Baseline and Construction Phase Wetland Monitoring Program (Native Plant Solutions (NPS) 2020) for the Site C Clean Energy Project (the Project) to address, in part, requirements outlined in the Federal Decision Statement (FDS) condition 11 and Environmental Assessment Certificate (EAC) condition 12.

> ***FDS condition 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.*
>
> ***FDS condition 11.4.3****. An approach to monitor and evaluate any changes to baseline conditions, as defined in condition 11.4.1 and identify improvements based on monitoring data.*
>
> ***EAC condition 12****. The EAC Holder must monitor construction and operation activities that could cause changes in wetland functions.*

1.2 PROJECT OVERVIEW

The Wetland Monitoring Program (the Program; NPS 2018) consists of two components:

1. Baseline wetland monitoring – gathers information (i.e., biogeochemical, hydrological, and ecological) on wetlands prior to construction activities, including verification of ecosystem mapping and wetland condition.
2. Construction and operations wetland monitoring – gathers information at two and five-year intervals after initiation of construction to evaluate changes from baseline conditions due to Project activities.

The Program is designed to allow for the following:

- collection of baseline data on the biogeochemical, hydrological, and ecological functioning of the wetlands and associated riparian habitat in the area affected by the Project;
- an evaluation of the change to baseline wetland conditions due to the Project;
- selection of mitigation measures for loss of wetland areas and functions, including reclamation, improvement, creation, and protection (BC Hydro 2015); and

- flexibility in the monitoring program to allow for further refinement in the characterization of baseline and affected wetlands, as data become available.

This 2021 annual report focuses on the continuation of the construction monitoring phase of the Project, with 43 of the 45 targeted wetlands previously sampled using the full BC Hydro Site C Vegetation and Wildlife Wetland Monitoring Program: Baseline and Construction Phase Wetland Monitoring (NPS 2020). The two wetlands that were previously sampled in 2016 were re-assessed during the 2021 field surveys using the full baseline methodology described by NPS (2020) applied to the existing data, instead of the construction phase monitoring methodology. Going forward, all future field surveys will be completed as per the construction phase monitoring methodology.

1.3 Study Area

The study area includes three distinct areas within the project activity zone (PAZ) and the downstream area of the dam site:

1. the reservoir footprint (the future inundation zone), which is composed of the Western Reservoir, Middle Reservoir, Eastern Reservoir, Lower Reservoir, and the Dam Site Area;
2. the transmission line, separated into Phase A and Phase B; and
3. the downstream area.

2. METHODS

2.1 SITE SELECTION

The 2021 field program included the first year of construction monitoring for wetlands that were initially sampled in 2019, as well as two wetlands that were sampled in 2016 that were not assessed in 2020 due to access constraints. A total of 45 construction phase wetlands were selected for 2021. Sites were selected based on the program sampling design of re-assessing (construction phase wetland monitoring) wetlands two years after the baseline data collection, and then every five years after that (NPS 2020). The wetlands selected for 2021 consisted of six wetland types (Table 2.1-1), with 42 wetlands last surveyed in 2019, two in 2016, and one last surveyed in 2020. A total of 40 wetlands on the 2021 target list were located along the transmission line, primarily within the cleared corridor, and five were located downstream.

Table 2.1-1. Target Number and Type of Construction Phase Wetlands for 2021

Wetland Type	Code	2021 Target
Black spruce-Labrador tea-sphagnum	BT	13
Shallow open water	OW	1
Sedge wetland	SE	18
Tamarack sedge	TS	7
Willow sedge wetland	WS	2
Willow herb	WH	4

2.2 FIELD METHODOLOGY

Field surveys were conducted to collect site-level information for site-level data categories (Table 2.2-1). The surveys used standardized methodologies to collect a wide range of physical and ecological characteristics of each wetland. Any observed changes or disturbances (such as vegetation removal, soil disturbance, dust deposition, and alterations to hydrology) were also described for each wetland using the condition assessment forms created by NPS (2020).

The following field data were collected through the 2021 field program:

- field plot data;
- spatial data of plot locations and wetland delineation;
- plot photographs;
- vegetation floristic quality index data;
- analytical data (laboratory analysis of water quality); and
- wetland condition assessments.

Comprehensive and detailed methods are provided in the BC Hydro Site C Wetland Monitoring Program Field Manual; Baseline and Construction Phase (Appendix D of NPS 2020). The two wetlands that were previously sampled in 2016 were completed before the development of the full baseline monitoring program. Therefore, data were collected for these two wetlands as per the Baseline Monitoring Phase (NPS 2020).

Table 2.2-1. Baseline and Construction Phase Wetland Monitoring Program: Data Categories and Parameters

Category	Parameter	Monitoring Phase [a]	Federal Condition 11.4.1
Site Information	Photo stations	B/C	–
	Site diagram	B/C	–
	Wetland ecosystem classification	B/C	–
Physical Parameters	Wetland delineation	B/C *	–
	Adjacent ecosystems	B/C *	–
	Slope position	B	–
Ecological Parameters	Cover type and percent open water	B/C	Biotic structure, biotic diversity
	Vegetation cover and communities present	B/C	Vegetation cover, biotic structure, biotic diversity
	Successional stage and structural stage	B/C	Biotic structure, biotic diversity
	Incidental wildlife observations	B/C	Biotic structure, biotic diversity
Biogeochemical Parameters	Water quality sampling	B/C *	Groundwater quality, surface water quality
	Soil profiles	B	–
Hydrological Parameters	*Hydrology*	B/C	–
	Water depth	B/C	Surface water quantity
	Inlets/outlets	B/C	–

[a] B = baseline field monitoring; C = construction phase monitoring;
* - reduced construction phase monitoring.
Italicized parameters indicate key parameters that will be used to define wetland types.
Source: NPS 2020.

2.3 Ecosystem Classification and Mapping

The existing Site C ecosystem mapping for the PAZ includes three distinct but related products: Terrestrial Ecosystem Mapping (TEM); broad habitat mapping; and Detailed Wetland Mapping (DWM). The existing ecosystem classification and mapping is based on *A Field Guide for Identification and Interpretation of Ecosystems of the Northeast Portion of the Prince George Forest Region* (DeLong et al. 1990), *Wetlands of*

British Columbia (MacKenzie and Moran 2004), and units created for the Project (2006 to 2012) by regional forest ecologists (Andrusiak and Simpson 2012).

In order to achieve the stated goals of the monitoring program and to satisfy the federal and provincial approval conditions for the Project, it is important that the wetland classification used is structured to accommodate the current (i.e., DeLong et al. 2011 and Mackenzie and Moran 2004) provincial classification. Therefore, Table 2.3-1 presents a crosswalk table that uses a “best fit” process to correlate existing PAZ ecosystem classification and current provincial classification system units. The crosswalk table was created by Tetra Tech and refined by EcoLogic for the wetland field program (NPS 2018). All wetlands were classified using the current Site Association descriptions to ensure a consistent mapping product.

Table 2.3-1. Crosswalk of Existing PAZ Ecosystem Classification and Current Provincial Ecosystem Mapping Codes

	Existing PAZ Ecosystem Units		Current Provincial Ecosystem Units	
Wetland Class	Wetland Type (Map Code)	Vegetation Community Description	Site Association	Vegetation Community Description
Bog	BT	Sb – Labrador tea – Sphagnum	Wb03	Black spruce – Lingonberry – Peat-moss
	BT	Assumed Wb05 included in BT	Wb05	Black spruce – Water sedge – Peat-moss
	TS	Tamarack - Sedge	Wb06	Tamarack – Water sedge – Fen moss
	BT	-	Wb08	Black spruce – Soft-leaved sedge – Peatmoss bog
	BT	-	Wb09	Black spruce – Common horsetail – Peat-moss
Fen	SE	Sedge Wetland	Wf00	Fen (unclassified)
	SE	Sedge Wetland	Wf01	Water sedge – Beaked sedge
	-	-	Wf02	Scrub birch – water sedge
Marsh	SE	Sedge Wetland	Wm00	Marsh (unclassified)
	SE	Sedge Wetland	Wm01	Beaked sedge – Water sedge
	SE	Sedge Wetland	Wm02	Swamp horsetail – Beaked Sedge
	SE	Sedge Wetland	Wm03	Awned sedge
	SE	Sedge Wetland	Wm04	Common spike-rush
	SE	Sedge Wetland	Wm05	Cattail
	SE	Sedge Wetland	Wm06	Great bulrush
	SE	Sedge Wetland	Wm15	Bluejoint – Beaked sedge
Swamp	-	-	Ws00	Swamp (unclassified)

Wetland Class	Existing PAZ Ecosystem Units		Current Provincial Ecosystem Units	
	Wetland Type (Map Code)	Vegetation Community Description	Site Association	Vegetation Community Description
	WS	Willow Sedge Wetland	Ws02	Mountain alder – Pink spirea – Sitka sedge
	WS	Willow Sedge Wetland	Ws03 (Ws14)	Bebb's willow – Bluejoint
	WS	Willow Sedge Wetland	Ws04	Drummond's willow – Beaked sedge
	WS	Willow Sedge Wetland	Ws05	MacCalla's willow – Beaker sedge
	WS	Willow Sedge Wetland	Ws06	Sitka willow – Sitka sedge
	-	-	Ws07	Spruce – Common horsetail – Leafy moss
	-	-	Ws15	SwSb – Labrador tea – Glow moss
Open Water	OW	Shallow open water	OW	Shallow Open Water (unclassified)
Floodplain	WH	Willow – Horsetail – Sedge – Riparian Wetland	Fl00	Low bench floodplain (unclassified)
	WH	Willow – Horsetail – Sedge – Riparian Wetland	Fl03	Pacific willow – Red-osier dogwood – Horsetail
	WH	Willow – Horsetail – Sedge – Riparian Wetland	Fl06	Sandbar willow
	-	-	Fm00	Mid bench floodplain (unclassified)
	Fm02 (09)[1]	ActSw - Red-osier dogwood	Fm02 (112)	Cottonwood – Spruce – Red-osier dogwood

2.4 FLORISTIC QUALITY INDEX

2.4.1 Introduction

To supplement the vegetation sampling methods outlined in Section 4.0 of the BC Hydro Site C Wetland Monitoring Program Field Manual, a vegetation monitoring technique was implemented that uses random sample plots to facilitate the calculation of the Floristic Quality Index (FQI) of wetlands. The FQI is a measurement of the quality of wetland vegetation communities and has been found to be a good indicator of plant conditions, habitat quality, and wetland health. The FQI was developed from a 2013 University of Alberta study titled the "Floristic Quality Assessment for Marshes in Alberta's Northern Prairie and Boreal Regions" (Wilson et al. 2013). Iterations of the FQI have been used as part of wetland monitoring protocols across Canada and the United States. FQI has been intensively researched and is

[1] Map codes do not exist for the floodplain site associations. The site series associated with the Fm02 changed from 09 to 112 in the updated field guide (DeLong et al. 2011).

now being used as an indicator across North America because it can be adapted to a region's unique vegetation assemblages (Washington 1984, Rooney and Rogers 2002, Bourdaghs et al. 2006).

Each wetland vegetation species identified within a wetland is assigned a coefficient of conservatism (CC) value; the CC value for each species is based on an average value between 0-10 that is assigned by a group of expert botanists. The CC value is an indicator of a species' tolerance to disturbance and specificity to a particular habitat type (e.g., species adapted to disturbed areas have a low CC value, whereas species with specific habitat requirements and are not tolerant of disturbance have higher CC values) (Cretini and Steyer 2011). The CC values used to analyze the 2019 and 2021 wetland data were obtained from a list of CC values compiled by the BC Wildlife Federation (2018). The CC values used are wetland specific and based on the plant communities found in British Columbia, east of the Cascade Mountains.

In general, the following categories and definitions were used for the CC values:

- **0** – non-native species and ruderal species growing on waste ground;
- **1–3** – species commonly found in a wide variety of conditions with a high tolerance to disturbance;
- **4–6** – species usually found within a specific plant community, but tolerant of moderate disturbance;
- **7–8** – species found in advanced stages of succession that tolerate minor disturbance; and
- **9–10** – species with very low tolerance to disturbance.

The FQI equation shown below was used to calculate FQI scores. The equation is unbiased by species richness and provides a measurement of wetland health:

$$\mathbf{FQI = Mean\ CC_N / 10 (\surd N / \surd S) * 100}$$

Where:
CC_N = Coefficient of Conservatism for all species
N = Number of native species
S = Total number of species

The FQI results for each wetland are compared across monitoring years to highlight consistencies and/or differences in the datasets, and ultimately to identify trends in wetland health over time.

2.4.2 FQI Standards and Field Protocols

The following standards and field protocols were used for vegetation FQI sampling:

- The standard seven-letter code naming system established for British Columbia (BC MOE and MOF 2010) was used for recording observed species. Naming conventions used for vegetation species were from the British Columbia Species and Ecosystem Explorer (BC CDC 2020);
- Floristic Quality Index plots were established and surveyed within each monitoring wetland. Three pairs of quadrats (six quadrats in total) were deployed randomly throughout each wetland. A

power analysis conducted as part of the study by Wilson et al. (2013) showed that six quadrats was sufficient to detect differences in species richness between monitored wetlands within the same type or class;

- Each wetland is broadly divided into thirds and one pair of quadrats is established within each of the three sampling areas. The quadrats are tossed in a randomly selected cardinal direction to add randomness to the location;
- Quadrat pairs were positioned directly beside each other;
- Each quadrat measures one square metre. Quadrats were measured in the field with a square PVC tube quadrat measuring 1 meter in length and width;
- Quadrat data were recorded on standard FQI field sheets using the standard naming convention established for the Wetland Monitoring Program;
- Within each of the quadrats, all herbaceous, shrub, and tree species and their percent cover were recorded. Percent cover estimations included overlapping vegetation and therefore the total percent cover could be greater than 100%. For example, if an overhead shrub species covered 100% of the quadrat, the percent cover of herbaceous species present in the understory were still recorded;
- Percent cover of live vegetation was estimated for each species present using the recording increment vegetation cover method shown in Table 2.3-2 and from the comparison charts for estimation of foliage cover from the 2010 Field Manual for Describing Terrestrial Ecosystems (BC MOE and MOF 2010).
- Photos of each quadrat were taken to further document the wetland vegetation community being monitored. Photos were taken using the Solocator Application (Civi Corp Pty Limited 2021) for iPhones, which records the cardinal direction the photo was taken in and the UTM location of the photo.

Table 2.3-2. Increments used for Recording Vegetation Cover for the Wetland FQI Quadrats as Adapted from the Ecological Land Survey Site Description Manual (ASRD 2003)

Cover Range	Recording Increment (%)	Examples (%)
A single plant	Exactly 0.1	0.1
Several plants	Exactly 0.5	0.5
1-10%	To the nearest 1	1, 2, 3, 5, 8
10-30%	To the nearest 5	10, 15, 25
30-100%	To the nearest 10	30, 40, 50, 60, 70, 80, 90

The wetland indicator status for each species was obtained from the United States Department of Agriculture (USDA 2020) Natural Resource Conservation Service (NRCS) Plants Database and is described below in Table 2.3-3. When available, the Alaska wetland region was used. In the event that the Alaska status was not provided, the wetland status for the Great Plains region was used as a substitute.

Table 2.3-3. Wetland Indicator Status Codes and Descriptions[1]

Indicator Code	Indicator Status	Description
OBL	Obligate Wetland	Almost always occur in wetlands
FACW	Facultative Wetland	Usually occur in wetlands, but may occur in non-wetlands
FAC	Facultative	Occur in wetlands and non-wetlands
FACU	Facultative Upland	Usually occur in non-wetlands, but may occur in wetlands
UPL	Obligate Upland	Almost never occur in wetlands

[1] Adapted from USDA Natural Resource Conservation Service Plants Database (USDA NRCS 2020).

3. RESULTS

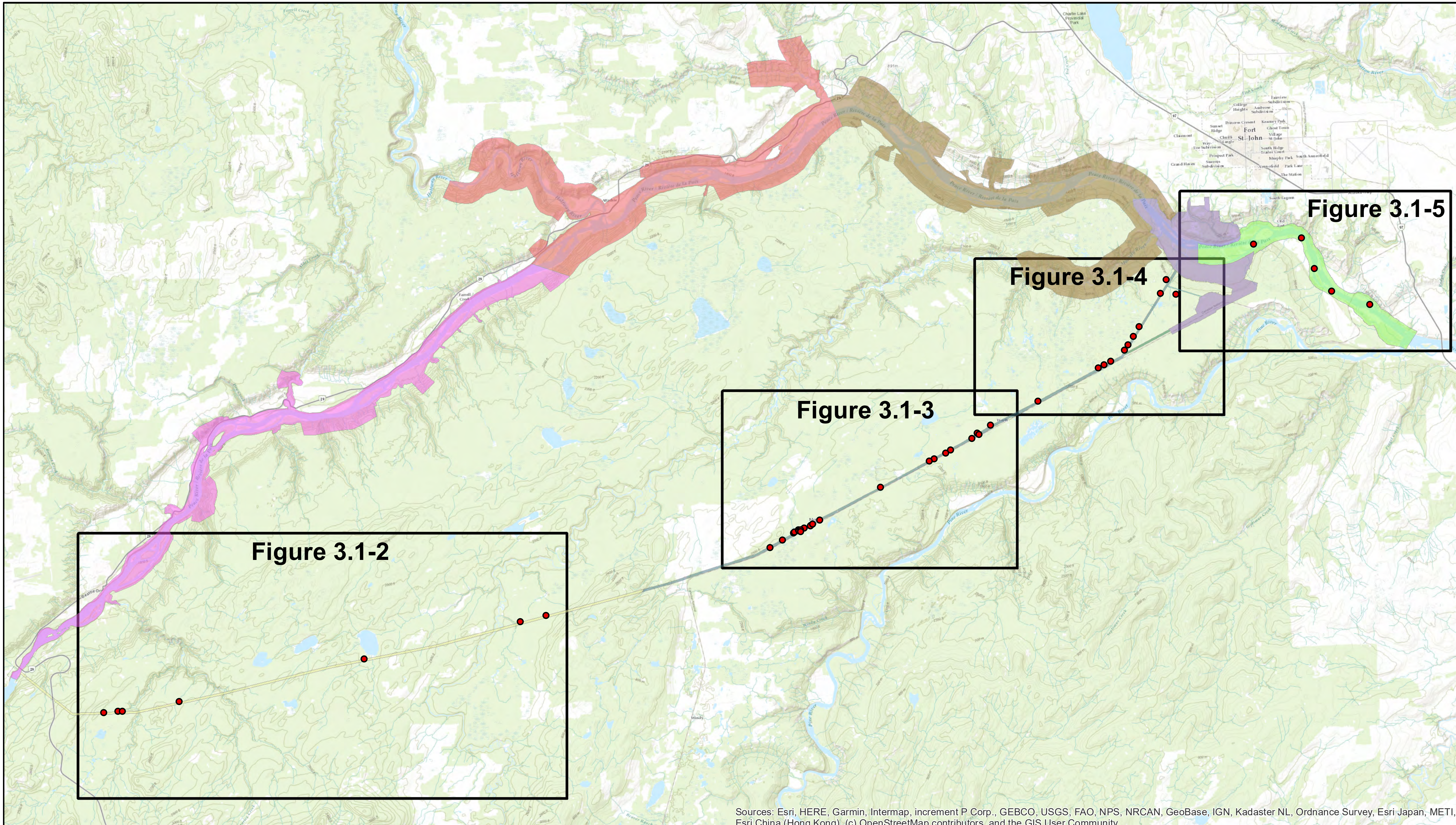
3.1 SUMMARY OF 2021 FIELD SURVEY EFFORT

Field surveys were completed from July 27 to August 3, 2021, along the transmission line and within the downstream area. A total of 45 wetlands were sampled, including all of the targeted wetlands as per the sampling plan (Tables 3.1-1; Figure 3.1-1).

Table 3.1-1. Summary of Wetlands Sampled in 2021

Plot	Wetland Class	Site Association	Wetland Type	Previous Sample Date(s)	Sampled in 2021
BR2	Fen	Wf01	SE	2019	y
MWL02	Fen	Wf02	SE	2016, 2019	y
MWL08	Marsh	Wm15	SE	2016, 2019	y
MWL09	Marsh	Wm15	SE	2016, 2019	y
MWL10	Marsh	Wm03	SE	2016, 2019	y
MWL12	Marsh	Wm03	SE	2016, 2019	y
MWL13	Bog	Wb08	BT	2016, 2019	y
MWL14	Marsh	Wm02	SE	2016, 2019	y
MWL18	Bog	Wb06	TS	2016, 2019	y
MWL19	Marsh	Wm00	SE	2016, 2019	y
MWL33	Marsh	Wm03	SE	2016, 2019	y
MWL58	Marsh	Wm01	SE	2016, 2019	y
MWL59	Shallow Open Water	OW	OW	2016, 2019	y
MWL62	Marsh	Wm03	SE	2016, 2019	y
MWL69	Swamp	Ws03	WS	2016, 2019	y
MWL72	Bog	Wb03	BT	2016, 2019	y
OWL11	Marsh	Wm15	SE	2016	y
OWL61	Marsh	Wm03	SE	2016	y
PI1	Marsh	Wm01	SE	2019	y
PI2	Marsh	Wm01	SE	2019	y
PI4	Fen	Wf01	SE	2019	y
PR	Fen	Wf01	SE	2019	y
WL104	Marsh	Wm01	SE	2016, 2018, 2020	y
WL200	Bog	Wb08	BT	2019	y

Plot	Wetland Class	Site Association	Wetland Type	Previous Sample Date(s)	Sampled in 2021
WL201	Bog	Wb08	BT	2019	y
WL202	Bog	Wb03	BT	2016, 2019	y
WL203	Swamp	Ws02	WS	2019	y
WL204	Floodplain	Fl06	WH	2019	y
WL205	Floodplain	Fl00	WH	2019	y
WL206	Floodplain	Fl06	WH	2019	y
WL207	Floodplain	Fl00	WH	2019	y
WL215	Bog	Wb03	BT	2016, 2019	y
WL216	Bog	Wb06	TS	2019	y
WL217	Bog	Wb03	BT	2019	y
WL218	Bog	Wb03	BT	2016, 2019	y
WL219	Bog	Wb08	BT	2016, 2019	y
WL220	Bog	Wb06	TS	2016, 2019	y
WL221	Bog	Wb08	BT	2016, 2019	y
WL222	Bog	Wb08	BT	2019	y
WL223	Bog	Wb08	BT	2019	y
WL224	Bog	Wb03	BT	2016, 2019	y
WL225	Bog	Wb06	TS	2016, 2019	y
WL226	Bog	Wb06	TS	2019	y
WL228	Bog	Wb06	TS	2016, 2019	y
WL229	Bog	Wb06	TS	2019	y



Site C Clean Energy Project

Location of 2021 Sample Sites

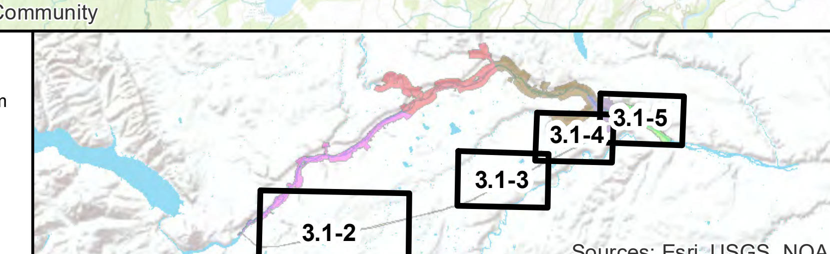
Figure 3.1-1

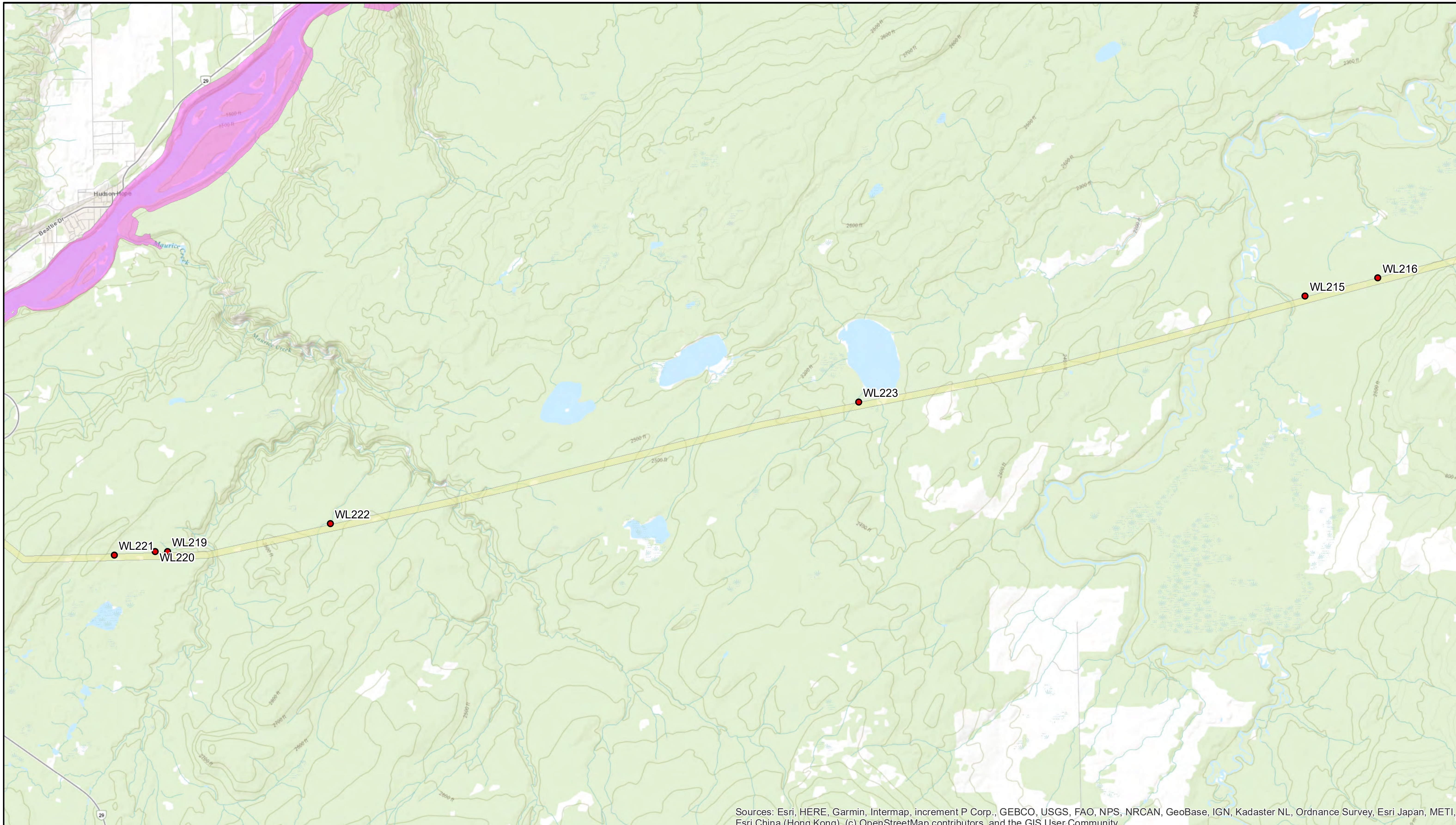
Date: 2022-01-14
Map Number: BCHWL-30
Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere
Projection: Mercator Auxiliary Sphere
Datum: WGS 1984

ECOLOGIC environmental consulting

Legend

- 2021Wetland Sample Sites
- Dam Site Area
- Downstream
- Eastern Reservoir
- Existing Right-of-Way
- Middle Reservoir
- Project Access Road
- TL Phase A
- TL Phase B
- Western Reservoir





Site C Clean Energy Project

Location of 2021 Sample Sites - TL Phase B

Figure 3.1-2

Date: 2022-01-14
Map Number: BCHWL-30
Coordinate System: NAD 1983 UTM Zone 10N
Projection: Transverse Mercator
Datum: North American 1983

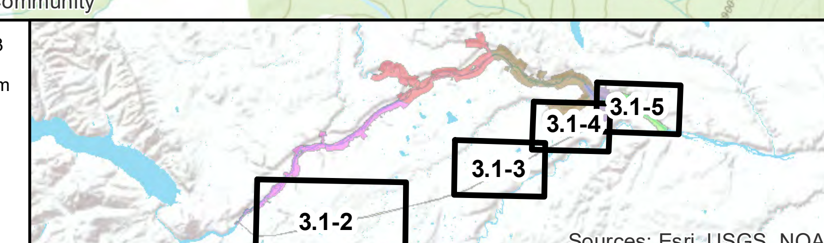
ECOLOGIC environmental consulting

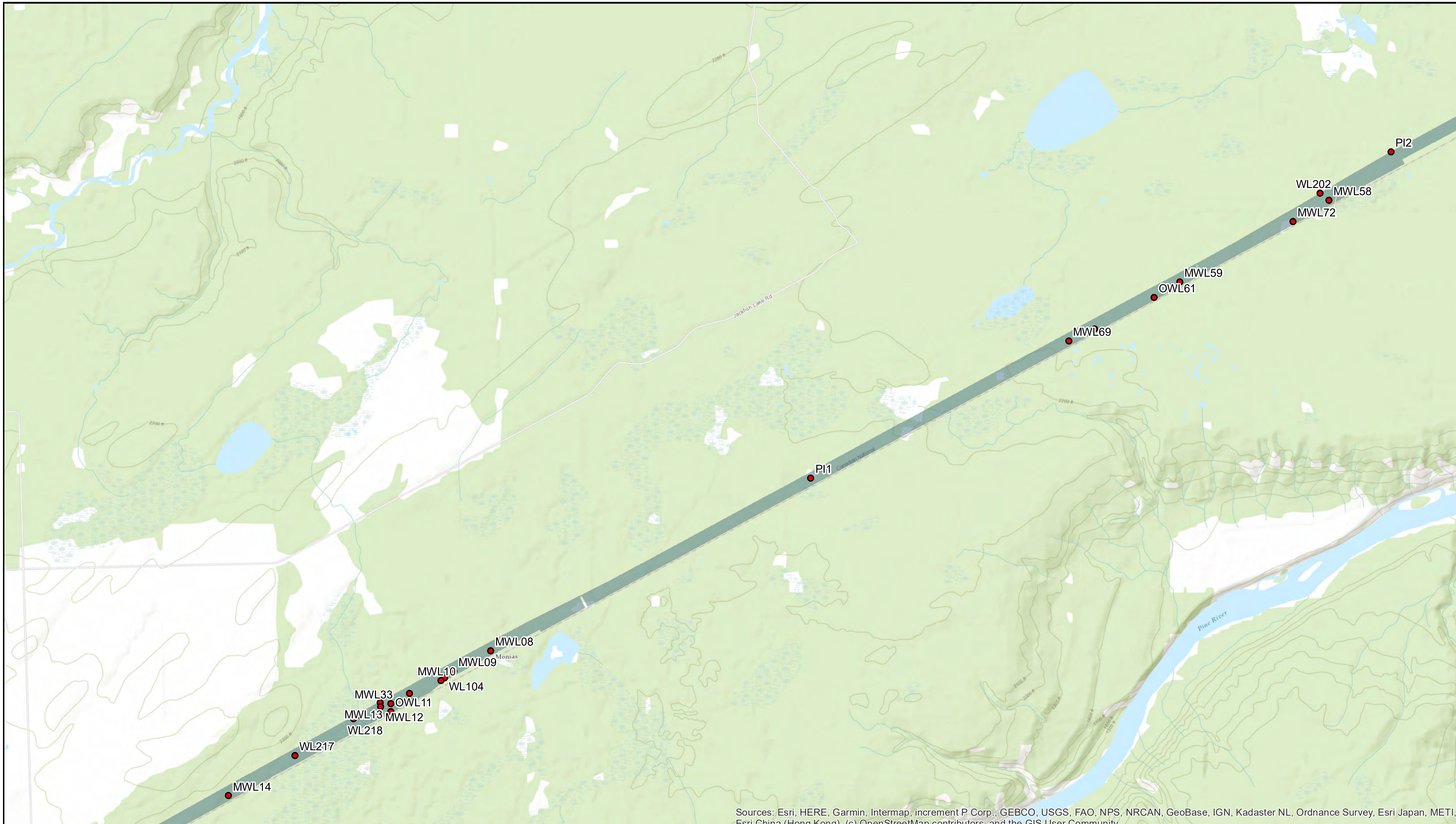
Legend

- 2021Wetland Sample Sites
- Dam Site Area
- Downstream
- Eastern Reservoir
- Existing Right-of-Way
- Middle Reservoir
- Project Access Road
- TL Phase A
- TL Phase B
- Western Reservoir

0 1 2 3 km

1:70,000





Site C Clean Energy Project

Location of 2021 Sample Sites - TL Phase A

Figure 3.1-3a

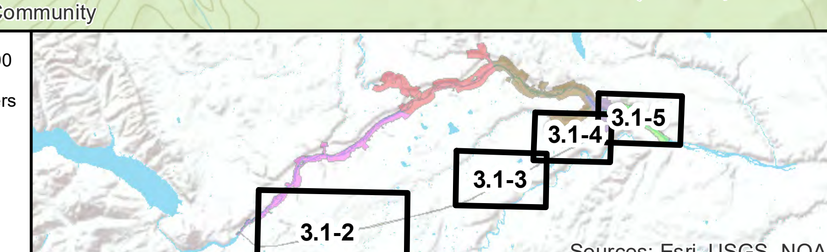
Date: 2022-01-14
Map Number: BCHWL-30
Coordinate System: NAD 1983 UTM Zone 10N
Projection: Transverse Mercator
Datum: North American 1983

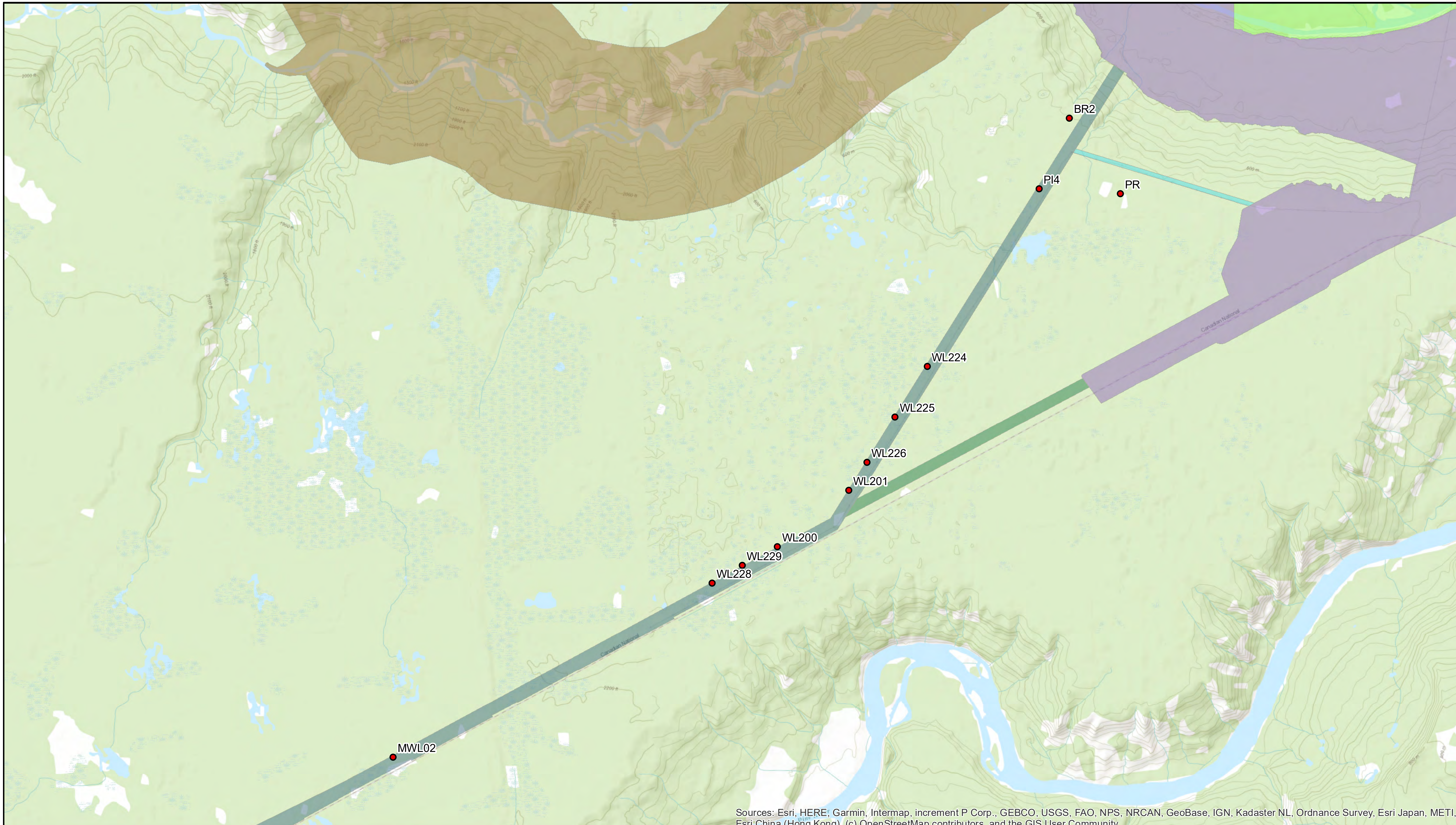
ECOLOGIC environmental consulting

Legend

- 2021Wetland Sample Sites
- Dam Site Area
- Downstream
- Eastern Reservoir
- Existing Right-of-Way
- Middle Reservoir
- Project Access Road
- TL Phase A
- TL Phase B
- Western Reservoir

0 500 1,000 1,500 Meters
1:38,000





Site C Clean Energy Project

Location of 2021 Sample Sites - TL Phase A

Figure 3.1-3b

Date: 2022-01-14
Map Number: BCHWL-30
Coordinate System: NAD 1983 UTM Zone 10N
Projection: Transverse Mercator
Datum: North American 1983

ECOLOGIC environmental consulting

Legend

- 2021Wetland Sample Sites
- Dam Site Area
- Downstream
- Eastern Reservoir
- Existing Right-of-Way
- Middle Reservoir
- Project Access Road
- TL Phase A
- TL Phase B
- Western Reservoir

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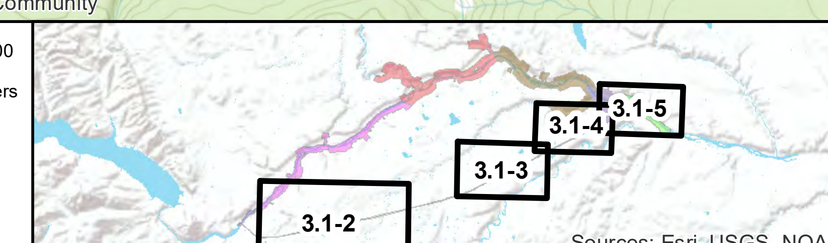
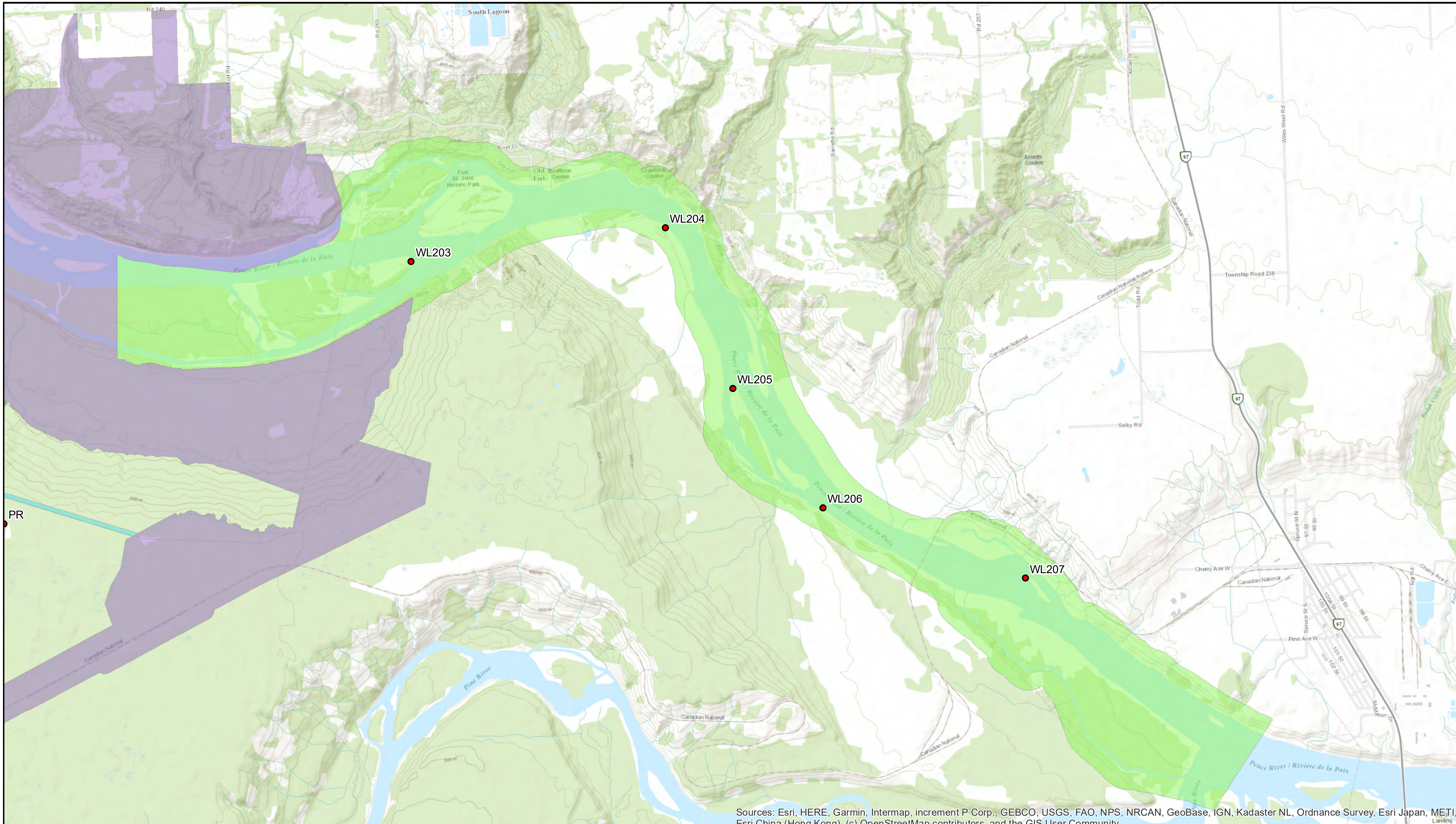
1:38,000





Site C Clean Energy Project

Location of 2021 Sample Sites - Downstream

Figure 3.1-4

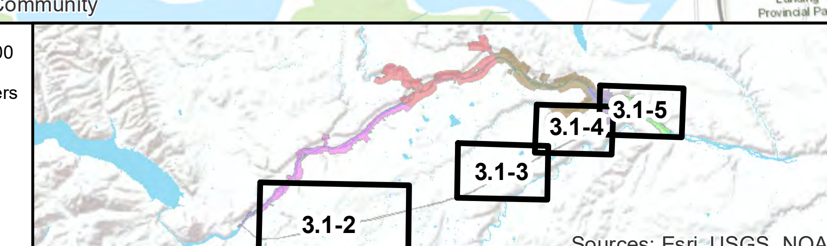
Date: 2022-01-14
Map Number: BCHWL-30
Coordinate System: NAD 1983 UTM Zone 10N
Projection: Transverse Mercator
Datum: North American 1983

ECOLOGIC environmental consulting

Legend

- 2021Wetland Sample Sites
- Dam Site Area
- Downstream
- Eastern Reservoir
- Existing Right-of-Way
- Middle Reservoir
- Project Access Road
- TL Phase A
- TL Phase B
- Western Reservoir

0 500 1,000 1,500
Meters
1:38,000



3.2 Ecosystem Classification and Mapping

Two wetlands were assessed in 2021 that were previously sampled in 2016. One of the wetlands, OWL61, was previously mapped as Field Truth Required (FTR) in the DWM indicating that the wetland classification was unknown. The other, OWL11, was mapped as SE. Both wetlands were updated as per the current provincial site associations (Table 3.2-1). These two wetlands were the last sites that required updating to the current ecosystem classification.

Table 3.2-1. Summary of Ecosystem Classification and Mapping Changes

Plot ID	DWM Wetland Type(s)	2021 Site Association	2021 Wetland Type	2021 Wetland Type Change
OWL11	SE	Wm15	SE	No
OWL61	FTR	Wm03	SE	Yes

3.3 Wetland Summaries

3.3.1 Bog Overview

Twenty bogs were sampled in 2021, comprising two wetland types (BT and TS) and three site associations (Table 3.3-1). All of the bogs were located in the transmission line right-of-way (ROW) and had been partially or entirely modified by clearing and/or grubbing from construction activities, and some had been modified by construction roads and tower pads. Initial regeneration was observed in most bogs with increased shrub and graminoid growth compared to the 2019 assessments, (Plates 3.3-1 to 3.3-6).

Table 3.3-1. Summary of Bogs Sampled in 2021

Wetland Class	Site Association	Wetland Type	Description	No. Sampled	Structural Stage(s)[(a)]	Successional Status(es)[(a)]	Hydrology
Bog	Wb03	BT	Black spruce - Lingonberry - Peat-moss	6	Low Shrub	Young Climax	Permanently to Semi-permanently Flooded
	Wb06	TS	Tamarack - Water sedge - Fen moss	7	Low Shrub, Tall Shrub	Young Seral	Permanently to Semi-permanently Flooded
	Wb08	BT	Black spruce - Soft-leaved sedge - Peat-moss	7	Graminoid, Low Shrub, Tall Shrub	Young Seral	Permanently to Semi-permanently Flooded
Total				**20**			

(a) See Appendix A for structural stage and successional status descriptions

Plate 3.3-1. Wb03 Black spruce - Lingonberry - Peat-moss bog at wetland WL251 along the transmission line in 2019.

Plate 3.3-2. Wb03 Black spruce - Lingonberry - Peat-moss bog at wetland WL251 along the transmission line in 2021.

Plate 3.3-3. Wb06 Tamarack - Water sedge - Fen moss bog at WL228 along the transmission line in 2019.

Plate 3.3-4. Wb06 Tamarack - Water sedge - Fen moss bog at WL228 along the transmission line in 2021.

Plate 3.3-5. Wb08 Black spruce - Soft-leaved sedge - Peat-moss bog at WL221 along the transmission line in 2019.

Plate 3.3-6. Wb08 Black spruce - Soft-leaved sedge - Peat-moss bog at WL221 along the transmission line in 2021.

3.3.2 Fen Overview

Two fens were sampled in 2021, comprising one wetland type (SE) and two site associations (Table 3.3-2). The fens ranged from largely undisturbed Wf01 pocket wetlands in the transmission line corridor and the groundwater well reference site (BR2) to highly disturbed (cleared and grubbed) and modified (hydrological alterations due to road construction) sites within the new transmission line corridor (Plates 3.3-7 to 3.3-10).

Table 3.3-2. Summary of Fens Sampled in 2021

Wetland Class	Site Association	Wetland Type	Description	No. Sampled	Structural Stage(s)[(a)]	Successional Status(es)[(a)]	Hydrology
Fen	Wf01	SE	Water sedge - Beaked sedge	3	Graminoid	Disclimax	Permanently to Semi-permanently Flooded
	Wf02	SE	Scrub birch-water sedge	1	Low Shrub	Young Seral	Permanently to Semi-permanently Flooded
Total				**4**			

(a) See Appendix A for structural stage and successional status descriptions

Plate 3.3-7. Wf01 Water sedge - Beaked sedge fen at PI4 along the transmission line in 2019.

Plate 3.3-8. Wf01 Water sedge - Beaked sedge fen at PI4 along the transmission line in 2021.

Plate 3.3-9. Wf02 Scrub birch - water sedge fen at MWL02 along the transmission line in 2019.

Plate 3.3-10. Wf02 Scrub birch - water sedge fen at MWL02 along the transmission line in 2021.

3.3.3 Marsh Overview

Fourteen marshes were sampled in 2021 (Table 3.3-3) along the transmission line, comprising one wetland type (SE) and five site associations (Plates 3.3-11 to 3.3-20). Due to the abnormally hot and dry summer, few of the marsh communities contained standing water in 2021. Most of the sampled marshes had minimal Project-related disturbances within the wetlands, but adjacent clearing, grubbing, construction roads, and tower sites were common.

Table 3.3-3. Summary of Marshes Sampled in 2021

Wetland Class	Site Association	Wetland Type	Description	No. Sampled	Structural Stage(s)[(a)]	Successional Status(es)[(a)]	Hydrology
Marsh	Wm00	SE	Marsh (unclassified)	1	Graminoid	Young Seral	Permanently to Semi-permanently Flooded
	Wm01	SE	Beaked sedge - Water sedge	4	Graminoid	Disclimax	Permanently to Semi-permanently Flooded
	Wm02	SE	Swamp horsetail - Beaked sedge	1	Graminoid	Disclimax	Permanently to Semi-permanently Flooded

Wetland Class	Site Association	Wetland Type	Description	No. Sampled	Structural Stage(s)[a]	Successional Status(es)[a]	Hydrology
	Wm03	SE	Awned sedge	5	Graminoid	Disclimax	Permanently to Semi-permanently Flooded
	Wm15	SE	Bluejoint - Beaked sedge	3	Graminoid	Disclimax	Permanently to Semi-permanently Flooded
Total				**14**			

(a) See Appendix A for structural stage and successional status descriptions

Plate 3.3-11. Wm00 Marsh (unclassified) at MWL19 along the transmission line in 2019.

Plate 3.3-12. Wm00 Marsh (unclassified) at MWL19 along the transmission line in 2021.

Plate 3.3-13. Wm01 Beaked sedge - Water sedge marsh at WL104 along the transmission line in 2018.

Plate 3.3-14. Wm01 Beaked sedge - Water sedge marsh at WL104 along the transmission line in 2021.

Plate 3.3-15. Wm02 Swamp horsetail - Beaked sedge marsh at MWL14 along the transmission line in 2019.

Plate 3.3-16. Wm02 Swamp horsetail - Beaked sedge marsh at WML14 along the transmission line in 2021.

Plate 3.3-17. Wm03 Awned sedge marsh at WML33 along the transmission line in 2019.

Plate 3.3-18. Wm03 Awned sedge marsh at WML33 along the transmission line in 2021.

Plate 3.3-19. Wm15 Bluejoint - Beaked sedge marsh at WML08 along the transmission line in 2019.

Plate 3.3-20. Wm15 Bluejoint - Beaked sedge marsh at MWL08 along the transmission line in 2021.

3.3.4 Shallow Open Water Overview

One shallow open water (OW wetland type) wetland was assessed in 2020 along the transmission line (Table 3.3-4). The shallow open water wetland had been modified due to Project construction activities (Plates 3.3-21 and 3.3-22).

Table 3.3-4. Summary of Shallow Open Water Sampled in 2021

Wetland Class	Site Association	Wetland Type	Description	No. Sampled	Structural Stage(s)[a]	Successional Status(es)[a]	Hydrology
Open Water	OW	OW	Shallow Open Water (unclassified)	1	Aquatic	NA	Permanently Flooded
Total				**1**			

(a) See Appendix A for structural stage and successional status descriptions

Plate 3.3-21. Shallow Open Water at MWL59 along the transmission line in 2019.

Plate 3.3-22. Shallow Open Water at MWL59 along the transmission line in 2021.

3.3.5 Swamp Overview

Two swamps (WS wetland type) were sampled in 2021, comprising two site associations (Table 3.3-5). The Ws02 association was located in the downstream portion of the Project area along the Peace River (Plates 3.3-24 and 3.3-25) and has not been directly affected by Project construction activities. The Ws03 association was located along the transmission line ROW and had minimal disturbance (some cutting and an adjacent temporary construction road) from construction activities (Plates 3.3-25 and 3.3-26).

Table 3.3-5. Summary of Swamps Sampled in 2021

Wetland Class	Site Association	Wetland Type	Description	No. Sampled	Structural Stage(s)[(a)]	Successional Status(es)[(a)]	Hydrology
Swamp	Ws02	WS	Mountain alder – Pink spirea – Sitka sedge	1	Tall Shrub	Young Seral	Seasonally to Intermittently Flooded
	Ws03	WS	Bebb's willow – Bluejoint	1	Tall Shrub	Young Seral	Seasonally to Intermittently Flooded
Total				**2**			

(a) See Appendix A for structural stage and successional status descriptions

Plate 3.3-23. Ws02 Mountain alder – Pink spirea – Sitka sedge swamp at WL203 in the downstream portion of the Peace River in 2019.

Plate 3.3-24. Ws02 Mountain alder – Pink spirea – Sitka sedge swamp at WL203 in the downstream portion of the Peace River in 2021.

Plate 3.3-25. Ws03 Bebb's willow - Bluejoint swamp at MWL69 along the transmission line in 2019.

Plate 3.3-26. Ws03 Bebb's willow - Bluejoint swamp at MWL69 along the transmission line in 2021.

3.3.6 Floodplain Overview

Four low bench floodplains were sampled in 2021 along the Peace River in the downstream Project area (Table 3.3-6), made up of two site associations that are both contained within the WH wetland type. All of the floodplain sites were outside of direct Project related construction activities but were subject to natural changes from scouring and deposition on a regular basis (Plate 3.3-27 to 3.3-30).

Table 3.3-6. Summary of Floodplains Sampled in 2021

Wetland Class	Site Association	Wetland Type	Description	No. Sampled	Structural Stage(s)[(a)]	Successional Status(es)[(a)]	Hydrology
Floodplain	Fl00	WH	Low bench floodplain (unclassified)	2	Low Shrub, Tall Shrub	Young Seral, Secondary Seral	Seasonally to Intermittently Flooded
	Fl06	WH	Sandbar willow	2	Tall Shrub	Young Seral	Seasonally to Intermittently Flooded
Total				**2**			

(a) See Appendix A for structural stage and successional status descriptions

Plate 3.3-27. Fl00 Low bench floodplain (unclassified) at WL207 in the downstream portion of the Peace River in 2019.

Plate 3.3-28. Recently scoured Fl00 Low bench floodplain (unclassified) at WL207 in the downstream portion of the Peace River in 2021.

Plate 3.3-29. Fl06 Sandbar willow low bench floodplain community at WL204 in the downstream portion of the Peace River in 2019.

Plate 3.3-30. Fl06 Sandbar willow low bench floodplain community at WL204 in the downstream portion of the Peace River in 2021.

3.4 FLORISTIC QUALITY INDEX

Each of the 2021 wetlands was assessed for species richness, distribution of CC values, percentage of wetland indicator species, percentage of non-native species, and FQI score. The data for 2019 is shown for reference.

3.4.1 Species Richness

Species richness was calculated for each wetland assessed in 2019 and 2021 individually (Figure 3.4-1) and then the data were combined, with average species richness calculated for each wetland type (Figure 3.4-2).

Species richness varied between individual wetlands and between monitoring years (Figure 3.4-1). In general, median species richness was found to be higher in bogs and floodplains than in fens, swamps, and marshes (Figure 3.4-2).

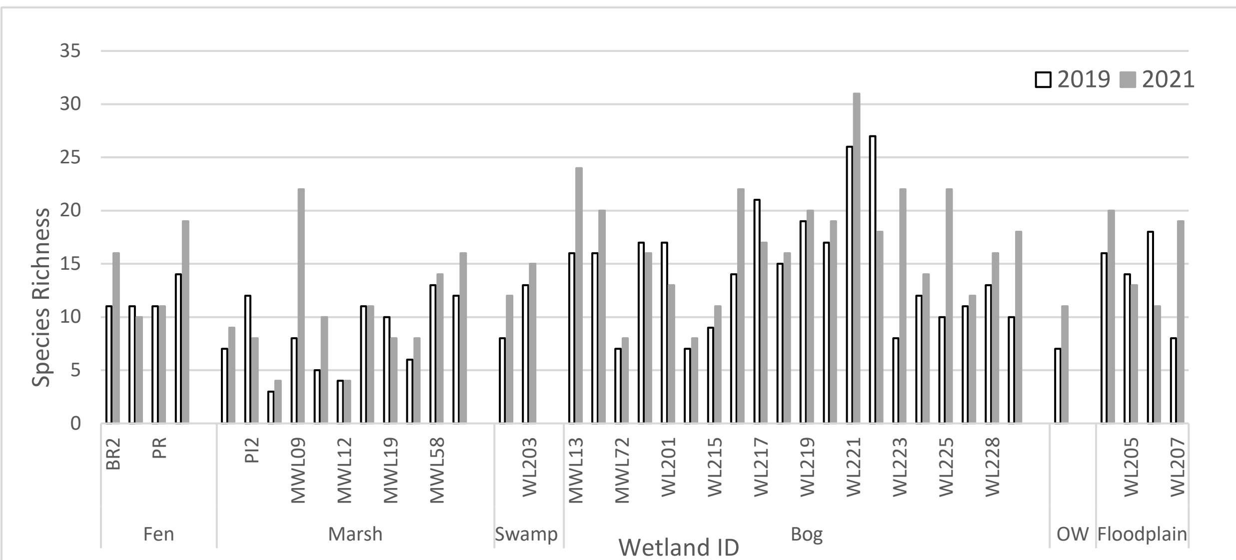


Figure 3.4-1. Individual Species Richness for Each Wetland Assessed in 2019 and 2021

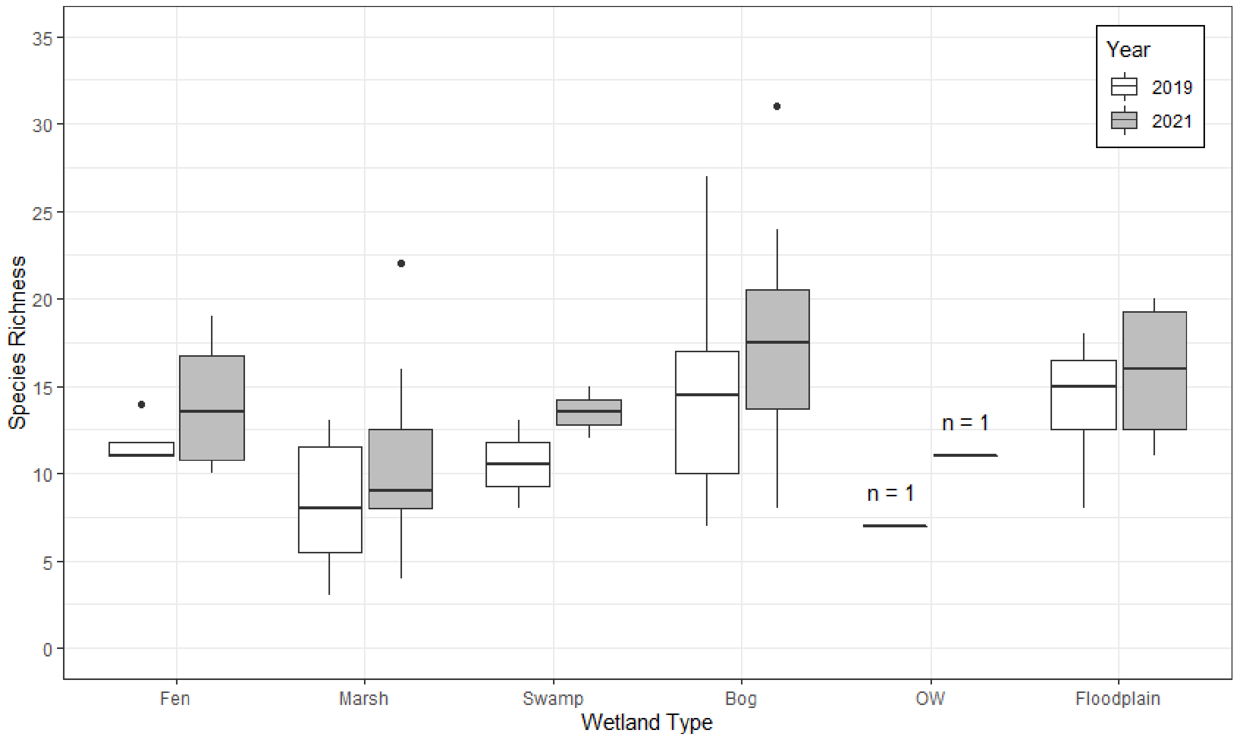


Figure 3.4-2. Comparison of Species Richness by Wetland (2019 and 2021)

3.4.2 Coefficient of Conservatism Values

The distribution of CC values assigned to the vegetation species found in each wetland type was plotted for 2019 and 2021 (Figures 3.4-3 to 3.4-8).

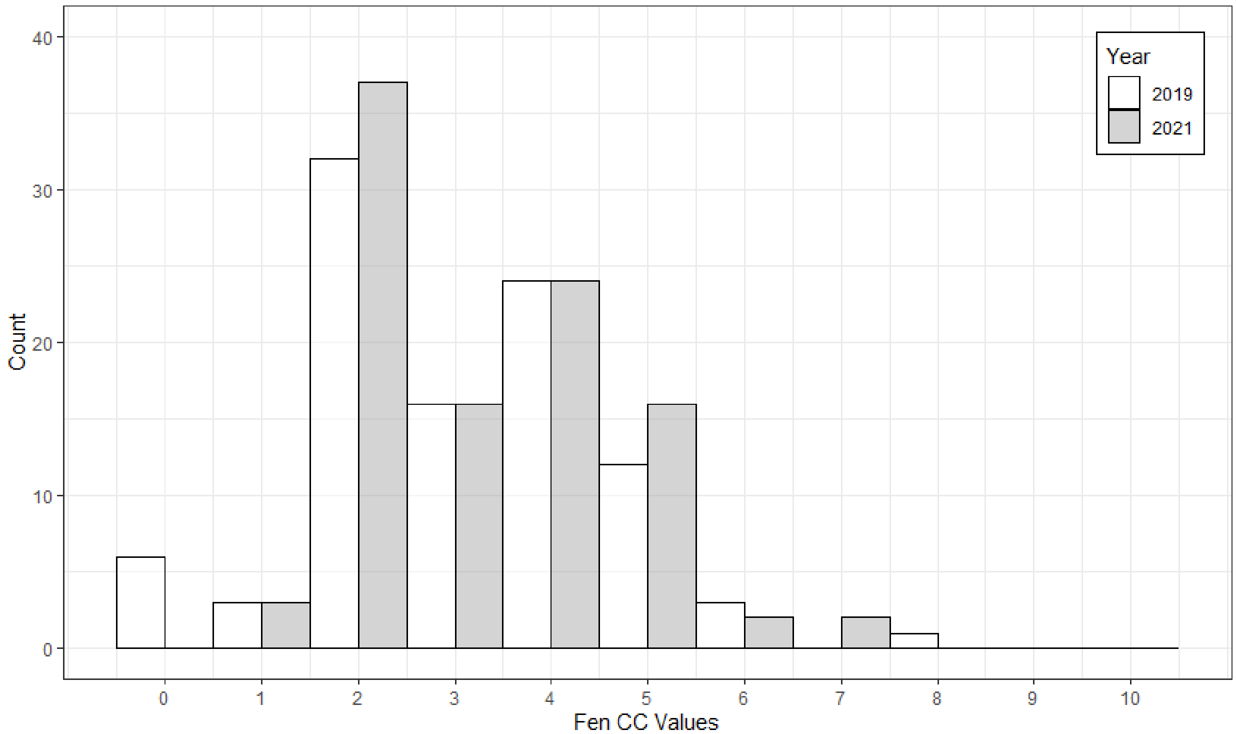


Figure 3.4-3. Coefficient of Conservatism Value Distribution for Fens Assessed in 2019 and 2021

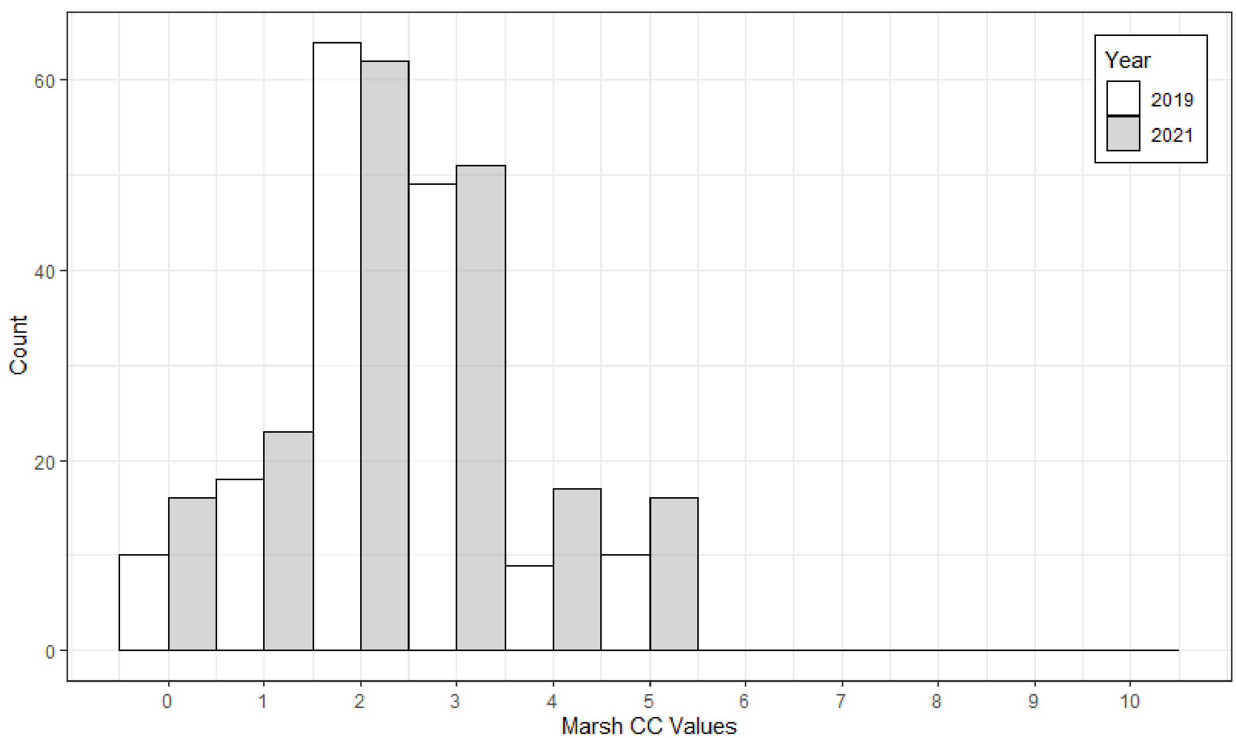


Figure 3.4-4. Coefficient of Conservatism Value Distribution for Marshes Assessed in 2019 and 2021

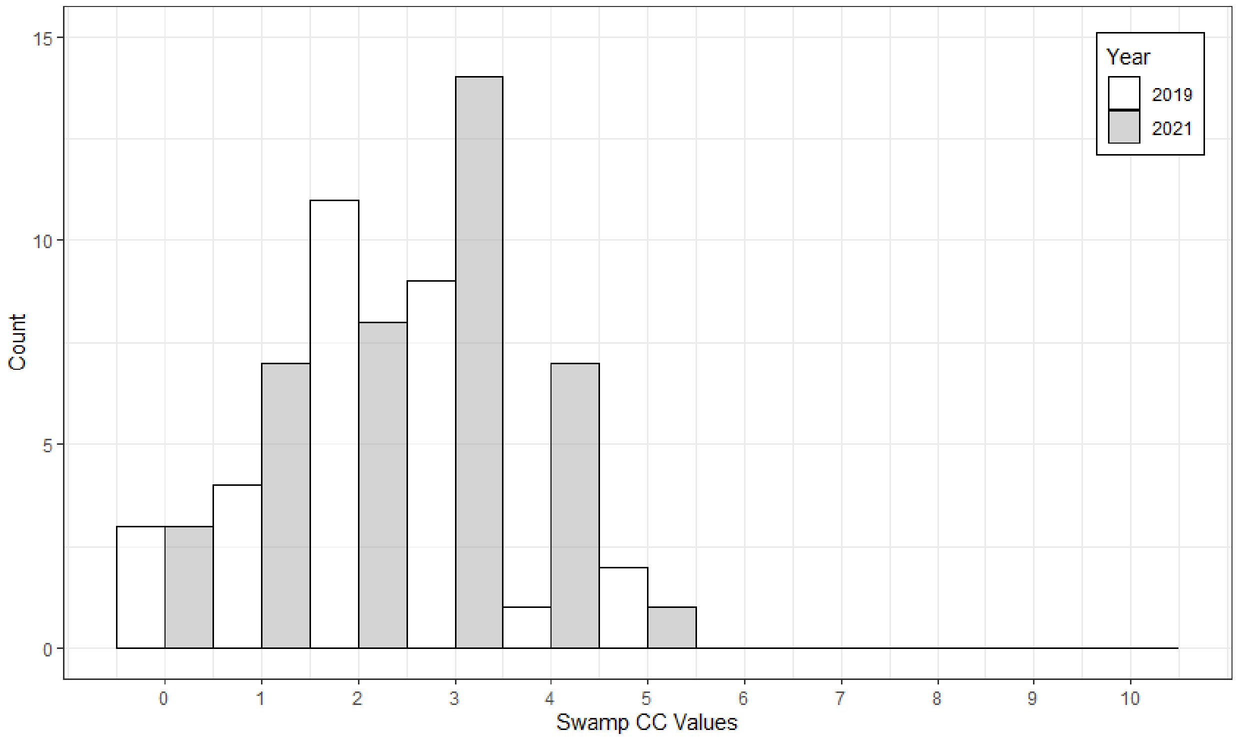


Figure 3.4-5. Coefficient of Conservatism Value Distribution for Swamps Assessed in 2019 and 2021

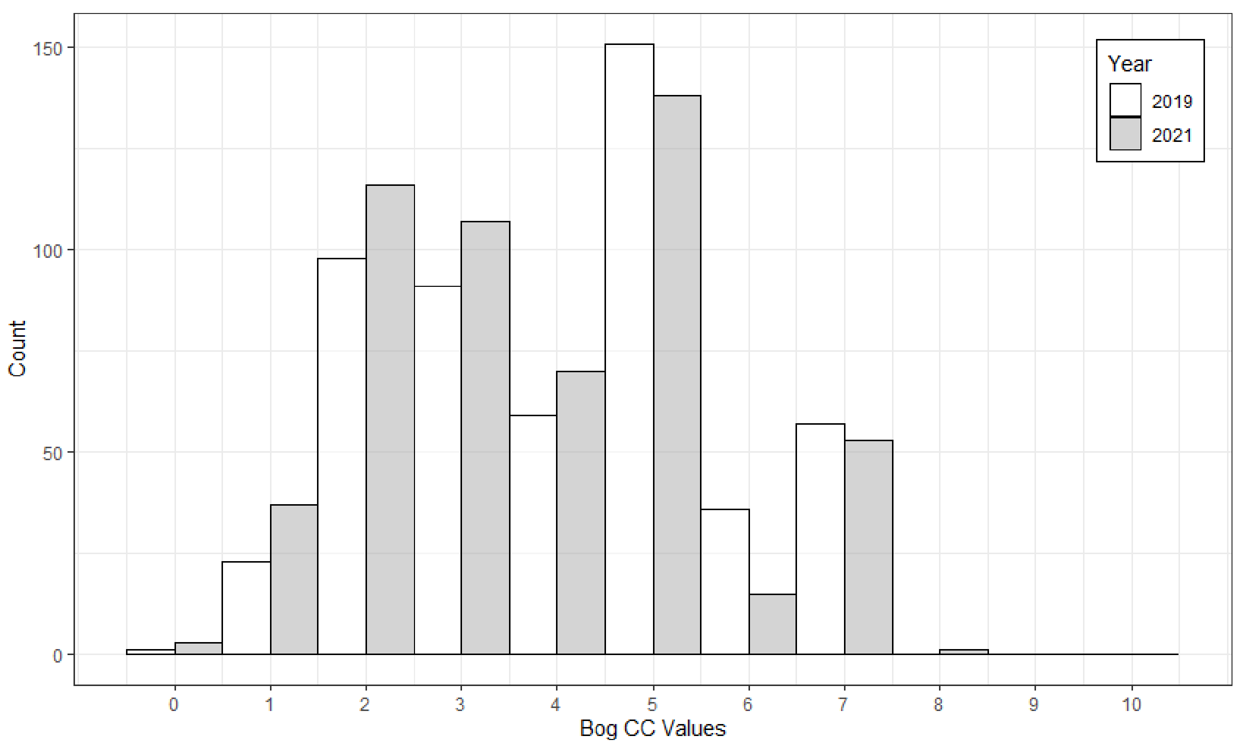


Figure 3.4-6. Coefficient of Conservatism Value Distribution for Bogs Assessed in 2019 and 2021

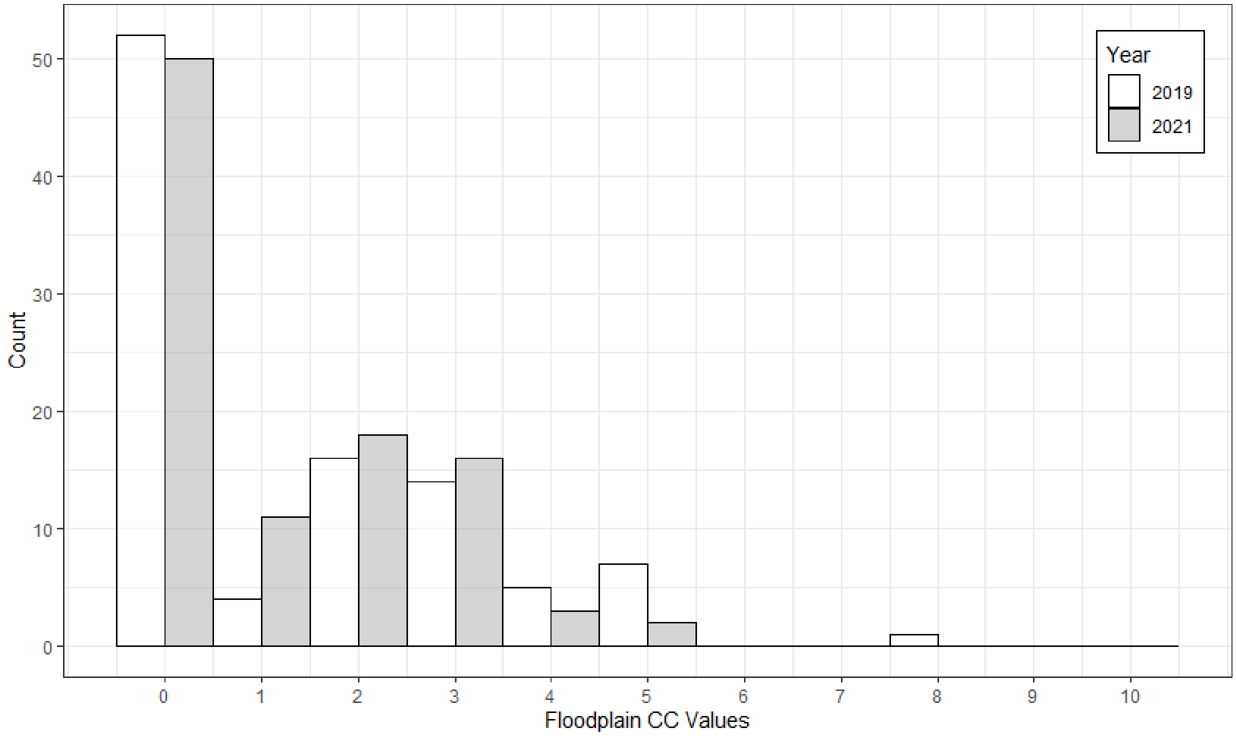


Figure 3.4-7. Coefficient of Conservatism Value Distribution for Floodplains Assessed in 2019 and 2021

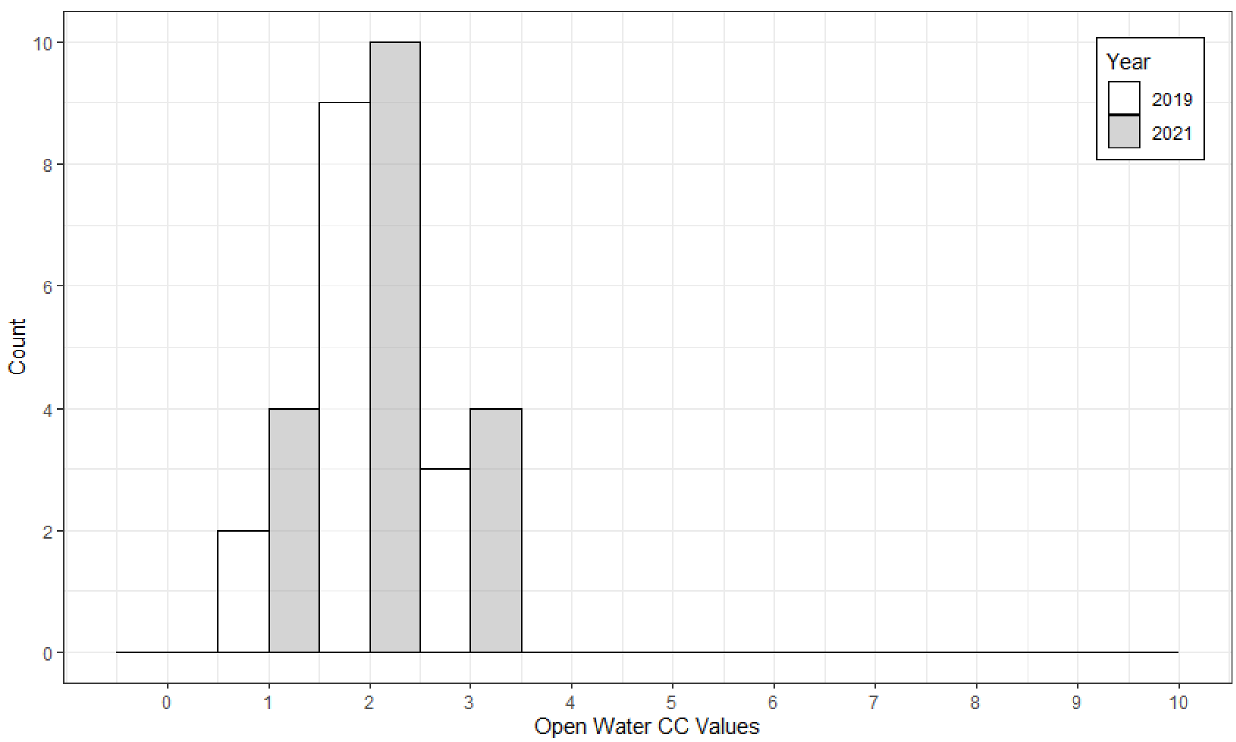


Figure 3.4-8. Coefficient of Conservatism Value Distribution for Open Water Wetlands Assessed in 2019 and 2021

The distribution of CC values within each wetland type was relatively similar between 2019 and 2021. Marsh, swamp, floodplain, and open water wetland types had a higher frequency of species with CC values between 0 and 3, and bog and fen wetlands had a higher frequency of species with CC values between 4 and 8. None of the wetlands contained species with CC values above 8. Out of all the wetland types, floodplains had the highest frequency of vegetation species with a CC value of 0.

3.4.3 Wetland Indicator Species

The wetland indicator status for each species was obtained from the United States Department of Agriculture (USDA) Natural Resource Conservation Service Plants Database (USDA NRCS 2020) and is described in Table 3.4-1. When available, the Alaska wetland region was used. In the event that the Alaska status was not provided, the wetland status for the Great Plains region was used as a substitute.

Table 3.4-1. Wetland indicator status codes and descriptions[1]

Indicator Code	Indicator Status	Description
OBL	Obligate Wetland	Almost always occur in wetlands
FACW	Facultative Wetland	Usually occur in wetlands, but may occur in non-wetlands
FAC	Facultative	Occur in wetlands and non-wetlands
FACU	Facultative Upland	Usually occur in non-wetlands, but may occur in wetlands
UPL	Obligate Upland	Almost never occur in wetlands

[1] Adapted from USDA Natural Resource Conservation Service Plants Database (USDA NRCS 2020).

The percentage of wetland indicator species identified during the 2019 and 2021 assessments was calculated for each wetland individually (Figure 3.4-9) and then the data were combined and plotted by wetland type (Figure 3.4-10).

The percentage of wetland indicator species varied between individual wetlands and between monitoring years (Figure 3.4-9). Floodplains had the lowest median percentage of wetland indicators when compared to the other wetland types, which all had relatively high median percentages of wetland indicators in both years (Figure 3.4-10).

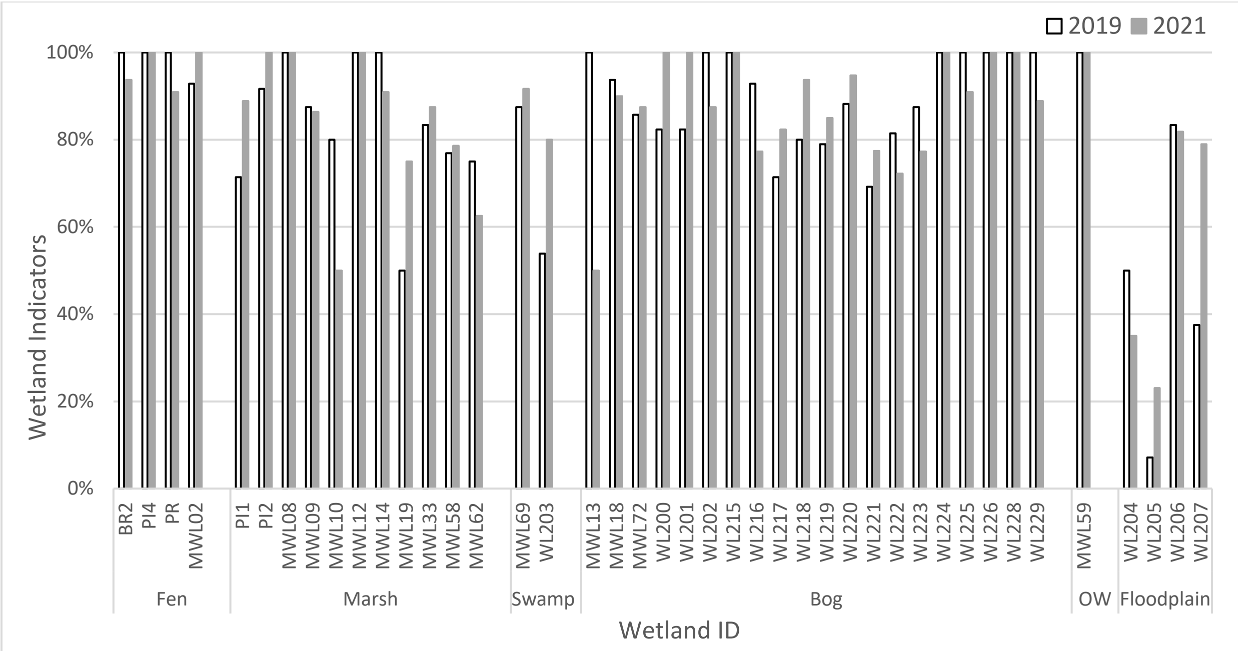


Figure 3.4-9. Percentage of Wetland Indicator Species Identified for Each Wetland Assessed in 2019 and 2021

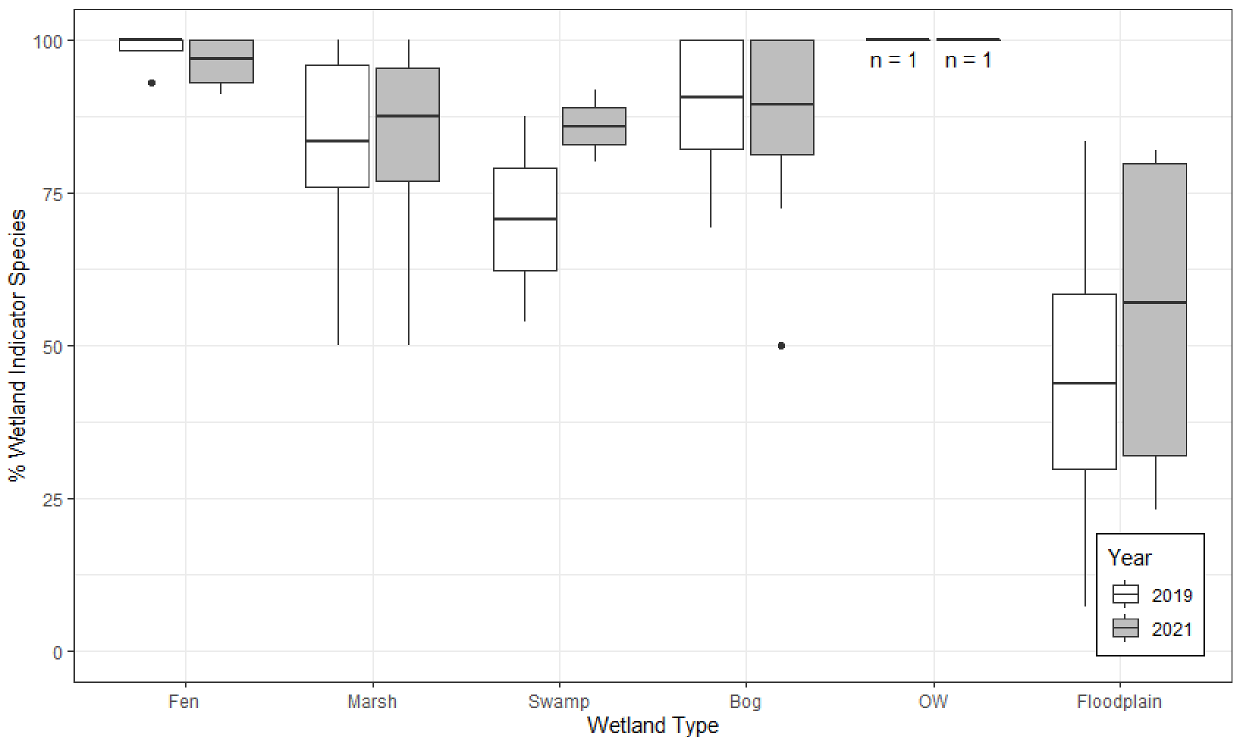


Figure 3.4-10. Comparison of Wetland Indicator Species by Wetland Type (2019 and 2021)

3.4.4 Non-Native Vegetation Species

The percentage of non-native vegetation species identified during the 2019 and 2021 assessments was calculated for each wetland individually (Figure 3.4-11) and then the data were combined and plotted by wetland type (Figure 3.4-12).

Non-native vegetation species were detected in 17 of the 42 wetlands, including at all four of the floodplains (Figure 3.4-11). Floodplains had the highest median percentage of non-native vegetation species. The median percentage of non-native vegetation species in fens, marshes, swamps, bogs and open water wetlands remained low (less than 15%) across both monitoring years (Figure 3.4-12).

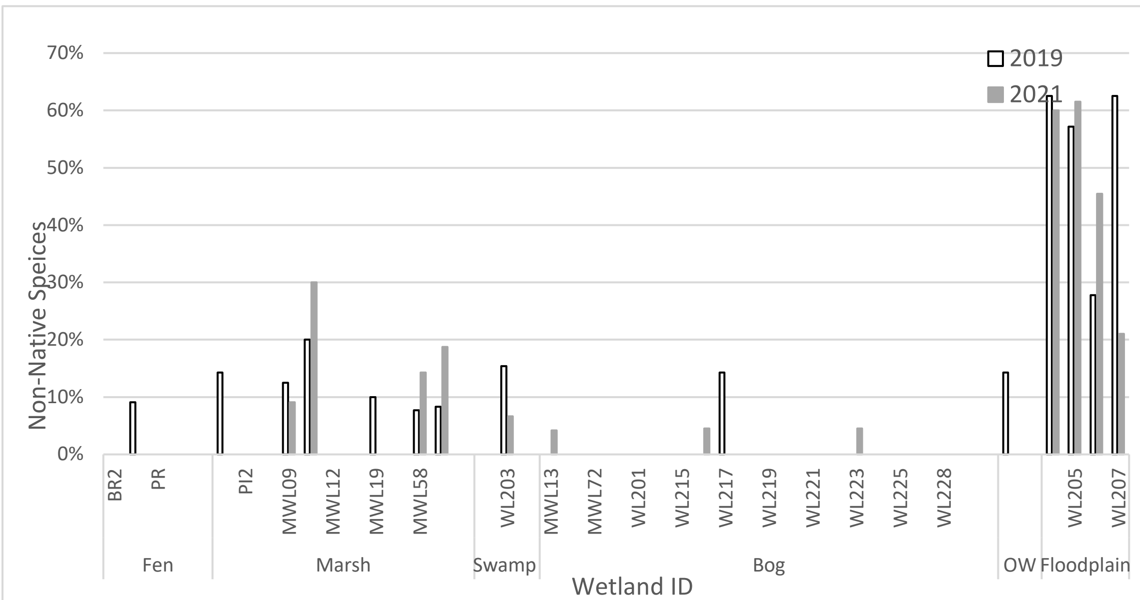


Figure 3.4-11. Comparison of Non-native Species by Wetland (2019 and 2021)

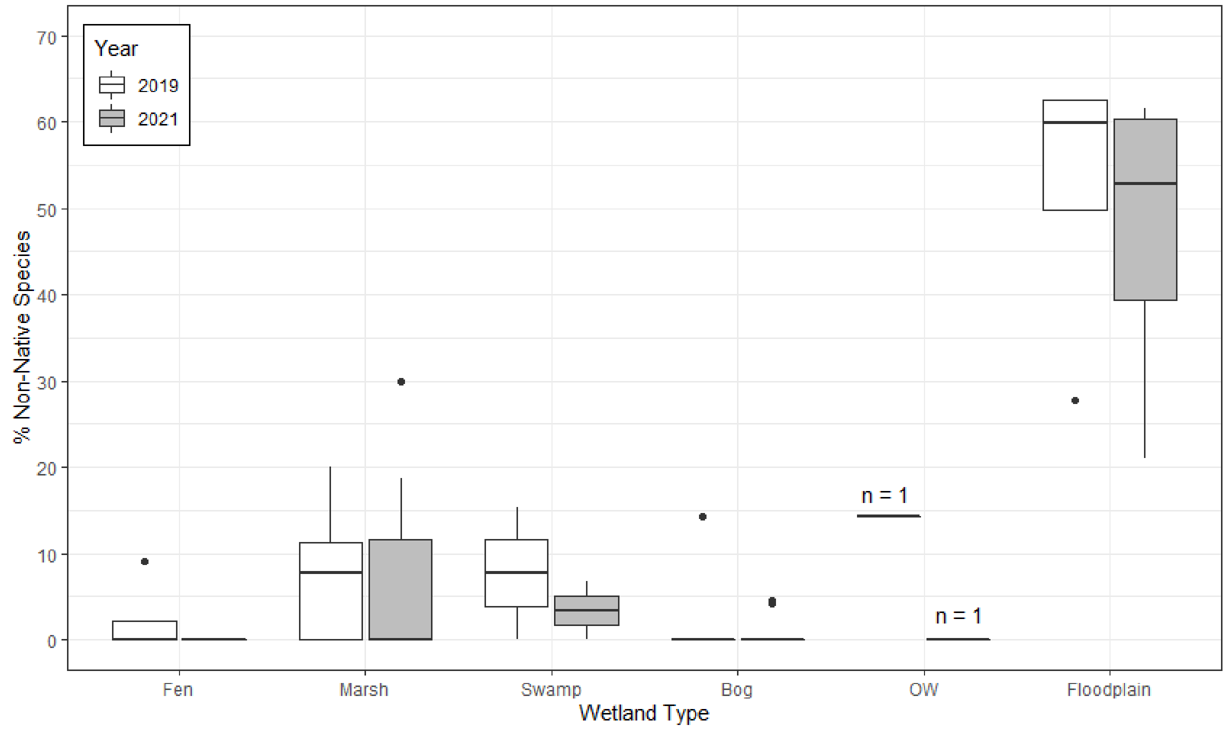


Figure 3.4-12. Percentage of Non-native Species Identified for Each Wetland Assessed in 2019 and 2021

3.4.5 FQI Score

FQI scores were calculated for each wetland assessed in 2019 and 2021 individually (Figure 3.4-13) and then the data were combined and plotted by wetland type (Figure 3.4-14).

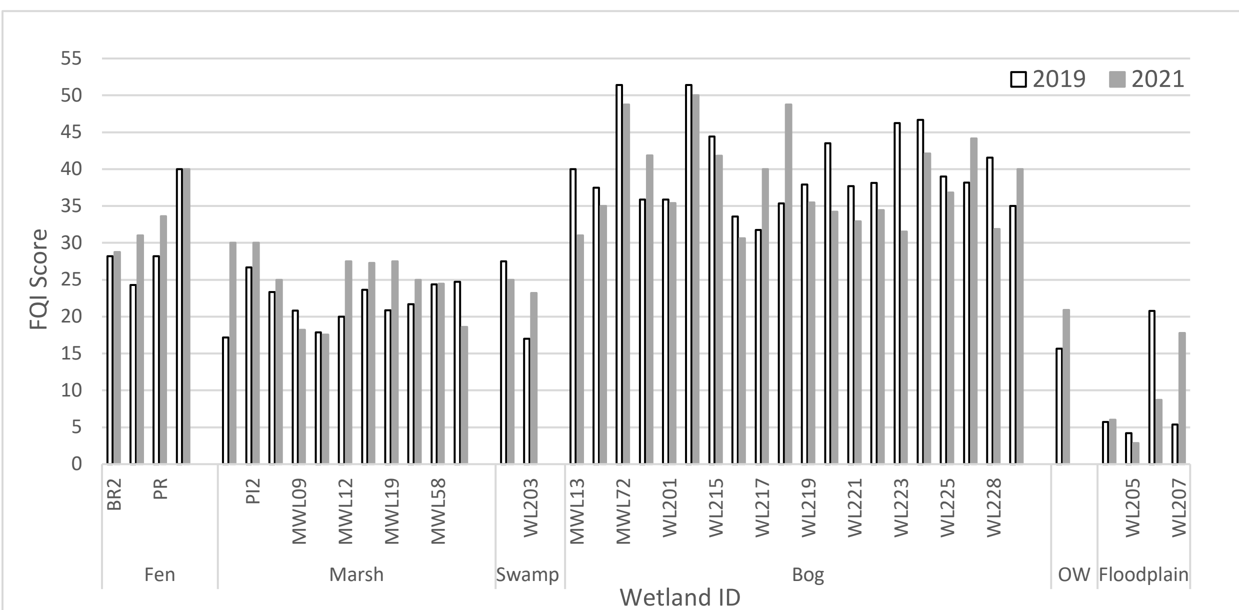


Figure 3.4-13. Individual FQI Scores for Each Wetland Assessed in 2019 and 2021

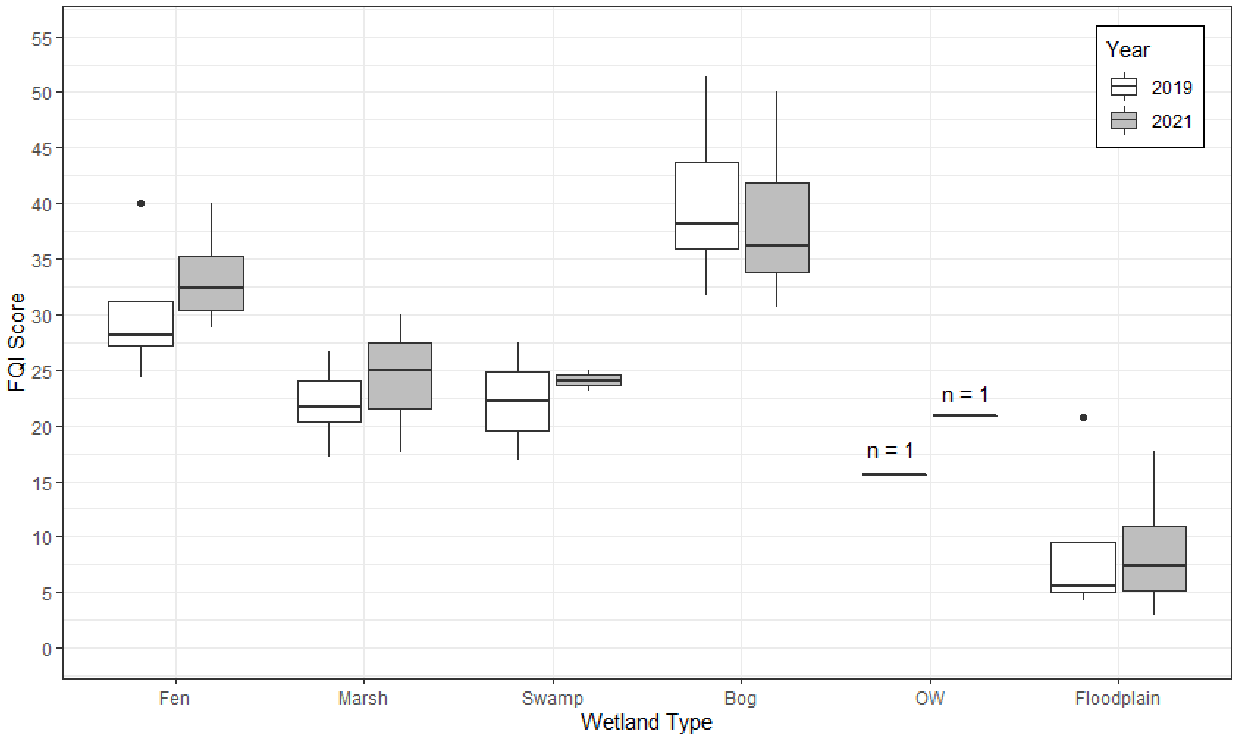


Figure 3.4-14. Comparison of FQI Scores by Wetland Type (2019 and 2021)

Individual FQI scores varied slightly between individual wetlands and between monitoring years (Figure 3.4-13). The median FQI scores are generally consistent between 2019 and 2021 for all of the wetland types. Overall, bogs had the highest median FQI score, and floodplains had the lowest median FQI score (Figure 3.4-14).

3.4.6 FQI Discussion

Overall, the results of the data analysis illustrated that the vegetation communities at the monitored wetlands were relatively consistent between 2019 and 2021. Slight variations between 2019 and 2021 are expected for species richness, distribution of CC values, percentage of wetland indicator species, and percentage of non-native vegetation species. Changes could be due to a number of factors, including differing weather patterns, wetland water levels, anthropogenic or project-related impacts, survey timing, and placement of quadrat locations. The 2021 data was collected during an abnormally dry and hot summer and therefore many of the wetlands surveyed were drier than had been observed in the past, including in 2019.

Non-native vegetation species were detected in 17 of the 42 wetlands. The median percentage of non-native vegetation species at floodplains was much higher (greater than 50%) than any other wetland type. The occurrence of non-native vegetation species in floodplain wetlands could be because this wetland type is located on a river system that can easily transport non-native plant fragments and seeds. Marshes are also more susceptible to establishment of non-native plants because marsh wetlands have more bare ground available for weed establishment as compared to open water wetlands, swamps, fens, and bogs.

In addition, marshes typically have less canopy cover, creating sunny conditions that are favorable for many weedy, non-native species, as compared to shady environments.

Species richness can easily be influenced by establishment of non-native or weedy vegetation species, and therefore is not always the best indicator of a healthy wetland. In addition, there are a number of naturally occurring wetland vegetation communities that have characteristically lower species richness but would still be considered healthy, intact, late succession wetland vegetation communities (e.g., poor fens). To adjust for the nuances that come with vegetation species richness in wetlands, we compared the distribution of CC values assigned to the vegetation species identified within the wetland types. Based on the two years of data available, bogs and fens appear to have more species that do not tolerate disturbance and are found in advanced stages of succession (higher CC values) compared to floodplains, marshes, and swamps.

FQI was found to be the highest in bogs and lowest in floodplains; these FQI scores are expected because bogs often contain a unique combination of plant species that are adapted to the acidic, nutrient-poor, stable water-level conditions typical of bogs (MacKenzie and Moran 2004) (e.g., a number of *Vaccinium* and *Drosera* species are often restricted to bogs). In addition, bog vegetation is often very slow growing, not tolerant of disturbances, and can be easily outcompeted if conditions, such as water level, change (MacKenzie and Moran 2004). Floodplains, on the other hand, have a higher potential for non-native species and often contain native species that are less specialized, more tolerant of disturbance and changing conditions, and that are often found in other environments.

4. SUMMARY OF WETLAND SAMPLING: 2016–2021

A total of 128 wetlands within the PAZ have been assessed since the beginning of the Program in 2016 (Table 4-1). Starting in 2018, with the development of a standard methodology (NPS 2020), wetlands surveyed in 2016 and 2017 were re-sampled so that all data were collected in a consistent manner.

Table 4-1. Summary of Wetland Sampling; 2016-2021

General Location	Pre-NPS Methodology		Baseline and/or Construction Monitoring			
	2016	2017	2018	2019	2020	2021
Downstream	-	-	-	5	-	5
Transmission Line	53	-	21	37	40	40
Reservoir	3	6	36	7	-	-
Total	**56**	**6**	**57**	**49**	**40**	**45**

Since 2018, all wetland sampling has been completed as per the *BC Hydro Site C Vegetation and Wildlife Wetland Monitoring Program: Baseline and Construction Phase Wetland Monitoring* (Appendix D of NPS 2020). The use of a current and standardized methodology allows for detailed classification of each wetland to the provincial Site Association level (Table 4-2). All wetlands assessed in 2022 and beyond will fall under the Construction Phase Monitoring portion of the project.

Table 4-2. Baseline and Construction Monitoring Wetlands Sampled from 2018 to 2021

Wetland Class	Site Association	Vegetation Community	No. Sampled			
			2018	2019	2020	2021
Reservoir Footprint						
Bog	Wb06	Tamarack – Water sedge – Fen moss	1			
Fen	Wf00	Fen (unclassified)	1			
Swamp	Ws00	Swamp (unclassified)	4			
	Ws02	Mountain alder – Pink spirea – Sitka sedge		1		
	Ws05	MacCalla's willow – Beaked sedge	1			
	Ws15	SwSb – Labrador tea – Glow moss	1			
Marsh	Wm00	Marsh (unclassified)	1			
	Wm02	Swamp horsetail – Beaked sedge	1			
	Wm03	Awned sedge	2			
	Wm04	Common spike-rush	1			
	Wm05	Cattail	1			

Wetland Class	Site Association	Vegetation Community	No. Sampled 2018	2019	2020	2021
	Wm06	Great bulrush	1			
Open Water	OW	Shallow Open Water (unclassified)	1			
Floodplain	Fl00	Low bench floodplain (unclassified)	8	1		
	Fl03	Pacific willow – Red-osier dogwood – Horsetail	1	1		
	Fl06	Sandbar willow	4	4		
	Fm00	Mid bench floodplain (unclassified)	2			
	Fm02	Cottonwood – Spruce – Red-osier dogwood	5			
		Reservoir Footprint Total	***36***	***7***	***0***	***0***
Downstream						
Swamp	Ws02	Mountain alder – Pink spirea – Sitka sedge		1		1
Floodplain	Fl00	Low bench floodplain (unclassified)		2		2
	Fl06	Sandbar willow		2		2
		Downstream Total		***5***		***5***
Transmission Line						
Bog	Wb03	Black spruce – Lingonberry – Peat-moss	1	6	1	6
	Wb05	Black spruce – Water sedge – Peat-moss	1		2	
	Wb06	Tamarack – Water sedge – Fen moss	3	7	4	7
	Wb08	Black spruce – Soft-leaved sedge – Peat-moss		7		7
	Wb09	Black spruce – Common horsetail – Peat-moss			1	
Fen	Wf01	Water sedge – Beaked sedge		3	1	3
	Wf02	Scrub birch – Water sedge	2	1	2	1
Swamp	Ws00	Swamp (unclassified)	1		2	
	Ws03	Bebb's willow – Bluejoint		1	2	1
	Ws04	Drummond's willow – Beaked sedge	1			
	Ws05	MacCalla's willow – Beaked sedge			3	
	Ws06	Sitka willow – Sitka sedge	1			
	Ws07	Spruce – Common horsetail – Leafy moss	1		2	
	Ws14	Mountain Alder – Bebb's Willow – Bluejoint	2		2	
Marsh	Wm00	Marsh (unclassified)		1	1	1
	Wm01	Beaked sedge – Water sedge	4	3	5	4
	Wm02	Swamp horsetail – Beaked sedge	1	1		1

Wetland Class	Site Association	Vegetation Community	No. Sampled			
			2018	2019	2020	2021
	Wm03	Awned sedge	1	4	8	5
	Wm05	Cattail	2		2	
	Wm15	Bluejoint – Beaked sedge		2		3
Open Water	OW	Shallow Open Water (unclassified)		1	2	1
		Transmission Line Total	***21***	***37***	***40***	***40***
		Grand Total	**57**	**49**	**40**	**45**

5. WETLAND SAMPLING PLAN: 2022–2027

As per *BC Hydro Site C Vegetation and Wildlife Wetland Monitoring Program: Baseline and Construction Phase Wetland Monitoring* (NPS 2020), wetlands are sampled two years after the initial baseline assessment, then every five years after that.

A summary of the total number of wetlands that have been sampled to date are presented in Table 5-1. This includes: 1) wetlands that have been re-assessed after the baseline visit; and 2) the expected number of wetlands to be sampled from 2022 to 2027. The first year that the two- and five-year construction monitoring assessments will be completed for all wetlands in the study will be 2027.

Table 5-1. Summary of Wetlands Sampled from 2016 to 2021 and Planned Construction Monitoring for 2021 to 2027

	Pre-NPS Methodology		Baseline and/or Construction Monitoring			Construction Monitoring						
General Location	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**
Downstream	-	-	-	5	-	5	-	-	-	-	5	-
Transmission Line	53	-	21	37	40	40	22	-	-	20	38	22
Reservoir	3	6	36	7	-	-	-	-	-	-	-	-
Total	**56**	**6**	**57**	**49**	**40**	**45**	**22**	**0**	**0**	**20**	**43**	**22**

The specific wetland sites that were sampled from 2016 to 2021, and those that will be sampled from 2022 to 2027, are presented in Table 5-2. Wetlands located within the reservoir area are not included in the construction monitoring, as they will be inundated as the reservoir is filled.

Table 5-2. Wetlands Sampled from 2016 to 2021 and Planned Construction Monitoring for 2021 to 2027

		Pre-NPS Methodology				Baseline and/or Construction Monitoring				Construction Monitoring			
General Location	**Site**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**
Downstream	WL203				x		x					x	
	WL204				x		x					x	
	WL205				x		x					x	
	WL206				x		x					x	
	WL207				x		x					x	
Reservoir	WL001			x									
	WL002	x		x									
	WL003			x									
	WL004	x		x									

General Location	Site	Pre-NPS Methodology				Baseline and/or Construction Monitoring				Construction Monitoring			
		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Reservoir (cont'd)	WL005			x									
	WL006	x		x									
	WL007			x									
	WL008			x									
	WL009			x									
	WL010			x									
	WL011			x									
	WL012			x									
	WL013			x									
	WL014			x									
	WL015			x									
	WL016			x									
	WL017			x									
	WL018			x									
	WL019			x									
	WL022			x									
	WL023			x									
	WL024			x									
	WL025			x									
	WL026			x									
	WL027			x									
	WL028			x									
	WL029			x									
	WL030			x									
	WL031			x									
	WL032			x									
	WL033			x									
	WL034			x									
	WL035			x									
	WL036			x									
	WL037			x									
	WL038			x									
	WL208				x								

General Location	Site	Pre-NPS Methodology				Baseline and/or Construction Monitoring				Construction Monitoring			
		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Reservoir (cont'd)	WL209				x								
	WL210				x								
	WL211				x								
	WL212				x								
	WL213				x								
	WL214				x								
Transmission Line	BR2				x		x					x	
	MWL02	x			x		x					x	
	MWL08	x			x		x					x	
	MWL09	x			x		x					x	
	MWL10	x			x		x					x	
	MWL12	x			x		x					x	
	MWL13	x			x		x					x	
	MWL14	x			x		x					x	
	MWL18	x			x		x					x	
	MWL19	x			x		x					x	
	MWL33	x			x		x					x	
	MWL58	x			x		x					x	
	MWL59	x			x		x					x	
	MWL62	x			x		x					x	
	MWL69	x			x		x					x	
	MWL72	x			x		x					x	
	OWL001	x				x		x					x
	OWL011	x					x	x					x
	OWL021	x				x		x					x
	OWL026	x				x		x					x
	OWL027	x				x		x					x
	OWL030	x				x		x					x
	OWL032	x				x		x					x
	OWL034	x				x		x					x
	OWL035	x				x		x					x
	OWL053	x				x		x					x
	OWL060	x				x		x					x

General Location	Site	Pre-NPS Methodology				Baseline and/or Construction Monitoring				Construction Monitoring			
		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Transmission Line (cont'd)	OWL061	x					x	x					x
	OWL063	x				x		x					x
	OWL067	x				x		x					x
	OWL070	x				x		x					x
	OWL071	x				x		x					x
	OWL073	x				x		x					x
	OWL102		x			x		x					x
	OWL103		x			x		x					x
	OWL107		x			x		x					x
	OWL109		x			x		x					x
	OWL110		x			x		x					x
	PI1				x		x					x	
	PI2				x		x					x	
	PI4				x		x					x	
	PR				x		x					x	
	WL020	x		x		x					x		
	WL021	x		x		x					x		
	WL100			x		x					x		
	WL101	x		x		x					x		
	WL102	x		x		x					x		
	WL103	x		x		x					x		
	WL104	x		x		x	x					x	
	WL105	x		x		x					x		
	WL106	x		x		x					x		
	WL107			x		x					x		
	WL108	x		x		x					x		
	WL109			x		x					x		
	WL110			x		x					x		
	WL111			x		x					x		
	WL112			x		x					x		
	WL113			x		x					x		
	WL114			x		x					x		
	WL115	x		x		x					x		

General Location	Site	Pre-NPS Methodology				Baseline and/or Construction Monitoring				Construction Monitoring			
		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Transmission Line (cont'd)	WL116	x		x		x					x		
	WL117		x	x		x					x		
	WL118	x		x		x					x		
	WL200				x		x					x	
	WL201				x		x					x	
	WL202	x			x		x					x	
	WL215	x			x		x					x	
	WL216				x		x					x	
	WL217				x		x					x	
	WL218	x			x		x					x	
	WL219	x			x		x					x	
	WL220	x			x		x					x	
	WL221	x			x		x					x	
	WL222				x		x					x	
	WL223				x		x					x	
	WL224	x			x		x					x	
	WL225	x			x		x					x	
	WL226				x		x					x	
	WL228	x			x		x					x	
	WL229				x		x					x	

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APPENDIX A. DEFINITION OF STRUCTURAL STAGES AND SUCCESSIONAL STATUS CODES

Structural stage codes and structural stage modifiers are used to describe the vegetation structure and appearance in each ecosystem unit. Structural stage codes describe the relative age of a given ecosystem (i.e., shrub-dominated vs. old-growth forest) while the modifiers are used to provide additional descriptions of structural stages (BC MOE and MOF 2010). Note that while the successional status has been included in the summary tables for each wetland class, it has been loosely applied as the codes used to describe successional status in British Columbia were developed for forested communities and are not directly applicable to non-forested wetlands.

Structural Stage

Structural Stage	Description
Post-disturbance stages or environmentally induced structural development	
1 Sparse/bryoid	Initial stages of primary and secondary succession; bryophytes and lichens often dominant, can be up to 100%; time since disturbance less than 20 years for normal forest succession, may be prolonged (50–100+ years) where there is little or no soil development (bedrock, boulder fields); total shrub and herb cover less than 20%; total tree layer cover less than 10%.
1a Sparse	Less than 10% vegetation cover.
Stand initiation stages or environmentally induced structural development	
2 Herb	Early successional stage or herbaceous communities maintained by environmental conditions or disturbance (e.g., snow fields, avalanche tracks, wetlands, grasslands, flooding, intensive grazing, intense fire damage); dominated by herbs (forbs, graminoids, ferns); some invading or residual shrubs and trees may be present; tree layer cover less than 10%, shrub layer cover less than or equal to 20% or less than 1/3 of total cover, herb-layer cover greater than 20%, or greater than or equal to 1/3 of total cover; time since disturbance less than 20 years for normal forest succession; many herbaceous communities are perpetually maintained in this stage.
2a Forb-dominated	Herbaceous communities dominated (greater than 1/2 of the total herb cover) by non-graminoid herbs, including ferns.
2b Graminoid-dominated	Herbaceous communities dominated (greater than 1/2 of the total herb cover) by grasses, sedges, reeds, and rushes.
2c Aquatic	Herbaceous communities dominated (greater than 1/2 of the total herb cover) by floating or submerged aquatic plants; does not include sedges growing in marshes with standing water (which are classed as 2b).
3 Shrub/Herb	Early successional stage or shrub communities maintained by environmental conditions or disturbance (e.g., snow fields, avalanche tracks, wetlands, grasslands, flooding, intensive grazing, intense fire damage); dominated by shrubby vegetation; seedlings and advance regeneration may be abundant;

Structural Stage	Description
	tree layer cover less than 10%, shrub layer cover greater than 20% or greater than or equal to 1/3 of total cover.
3a Low shrub	Communities dominated by shrub layer vegetation less than 2 m tall; may be perpetuated indefinitely by environmental conditions or repeated disturbance; seedlings and advance regeneration may be abundant; time since disturbance less than 20 years for normal forest succession.
3b Tall shrub	Communities dominated by shrub layer vegetation that are 2–10 m tall; may be perpetuated indefinitely by environmental conditions or repeated disturbance; seedlings and advance regeneration may be abundant; time since disturbance less than 40 years for normal forest succession.
Stem exclusion stages	
4 Pole/Sapling	Trees greater than 10 m tall, typically densely stocked, have overtopped shrub and herb layers; younger stands are vigorous (usually greater than 10–15 years old); older stagnated stands (up to 100 years old) are also included; self-thinning and vertical structure not yet evident in the canopy - this often occurs by age 30 in vigorous broadleaf stands, which are generally younger than coniferous stands at the same structural stage; time since disturbance is usually less than 40 years for normal forest succession; up to 100+ years for dense (5,000–15,000+ stems per hectare), stagnant stands.
5 Young Forest	Self-thinning has become evident, and the forest canopy has begun differentiation into distinct layers (dominant, main canopy, and overtopped); vigorous growth and a more open stand than in the pole/sapling stage; time since disturbance is generally 40–80 years but may begin as early as age 30, depending on tree species and ecological conditions.
Understory re-initiation stage	
6 Mature Forest	Trees established after the last disturbance have matured; a second cycle of shade-tolerant trees may have become established; understories become well developed as the canopy opens up; time since disturbance is generally 80−250 years.
Old-growth stage	
7 Old Forest	Old, structurally complex stands composed mainly of shade-tolerant and regenerating tree species, although older seral and long-lived trees from a disturbance such as fire may still dominate the upper canopy; snags and coarse woody debris in all stages of decomposition typical, as are patchy understories; understories may include tree species uncommon in the canopy, due to inherent limitations of these species under the given conditions; time since disturbance generally greater than 250 years.

Structural Stage Modifiers are used to describe the overstorey structure of a forested stand, often related to disturbance history or edaphic conditions (BC MOE and MOF 2010).

Structural Stage Modifiers

Modifier	Description
s single storied	Closed forest stand dominated by the overstory crown class (dominant and co-dominant trees); intermediate and suppressed trees account for less than 20% of all crown classes combined, advance regeneration in the understory is generally sparse.
t two storied	Closed forest stand co-dominated by distinct overstory and intermediate crown classes; the suppressed crown class is lacking or accounts for less than 20% of all crown classes combined, advance regeneration is variable.
m multistoried	Closed forest stand with all crown classes well represented; each of the intermediate and suppressed classes account for greater than 20% of all crown classes combined, advance regeneration is variable.
o open	Forest stand with very open main and intermediate crown classes (totaling less than 25% cover); substantial understorey light levels commonly result in well-developed shrub and/or herb understorey.

Stand composition modifiers are used to provide additional descriptions of structural stages 3–7 and indicate the dominance of the stand by broadleaf, conifers, or a mixed forest (BC MOE and MOF 2010).

Stand Composition Modifiers

Modifier	Description
C - coniferous	Greater than 3/4 of total tree layer cover is coniferous.
B - broadleaf	Greater than 3/4 of total tree layer cover is broadleaf.
M - mixed	Neither coniferous nor broadleaf account for greater than 3/4 of total tree layer cover.

Successional status describes a temporal stage of a given ecosystem type in relation to its expected stable state for a given environment (BC MOE and MOF 2010). It is generally used to describe the development of a community after a large-scale disturbance (natural or human). The successional system was developed for forested ecosystems, but can be generally applied to other communities to describe the current status of the community relative to what is expected to occur on the site (BC MOE and MOF 2010).

Successional Status

Successional Status	Description
NV – Non-vegetated	Due to substrate or disturbance, vegetation cover is absent or less than five percent.
PS – Pioneer Seral	Initial stages of re-vegetation after disturbance.

Successional Status	Description
YS – Young Seral	Early successional community where competition has not created structural complexity. Often a mix of pioneer and early successional species. Forested stands are even-aged, and less than 60 years old.
MS – Maturing Seral	Early successional tree species that have gone through natural self-thinning. Overstorey and understory of trees present, with understory species including shade tolerant trees. Trees of mature age, generally 60–140 years old.
OS – Overmature Seral	Overstorey seral tree species are dying, usually older than 140 years.
YC – Young Climax	Young stand with trees species typical of climax expected for site. Composition and structure are underdeveloped.
MC – Maturing Climax	Mature (80–120 years old) stand of climax species that has undergone natural thinning, with few seral species remaining. Vertical structure is developed.
OC – Old Climax	Old (greater than 250 years) and composed of expected climax species. Vertical structure is well developed, including canopy gaps, and large woody debris is common on forest floor.
DC – Disclimax	Persistent community that does not reflect the expected species composition due to disturbance (historic or repeated). Used for species conditions where processes or events are holding natural succession from moving forward.