Nose Creek Watershed
Wetland Inventory and Valuation Project

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Executive Summary

The purpose of this project is to complete a wetland inventory map in the Nose Creek Watershed and to identify wetlands in the watershed of highest value for retention in a natural state (protection) or altered state (restoration). The new 2020 wetland inventory is based on the best available digital elevation and remote sensing data from 2018 and 2019. The 2020 wetland valuation is based on the Alberta Wetland Relative Value Evaluation Tool-Estimator (ABWRET-E) defined by the Government of Alberta. The relative wetland value is a single score that captures the combined functions of a wetland relative to all other wetlands within the watershed. The following scenarios were used to combine the functions: (1) equal weighting of hydrological health (HH), water quality (WQ), and ecological health (EH); (2) equal weighting of HH, WQ, and EH with the top 10% of scores in each function group reserved for conservation of "highest functioning" wetlands in all categories; (3) hydrologic health (HH) priority (0.8 weighting of HH, 0.1 weighting each of WQ and EH); (4) water quality (WQ) priority (0.8 weighting of WQ, 0.1 weighting each of HH and EH); and (5) ecological health (EH) priority (0.8 weighting of EH, 0.1 weighting each of HH and WQ). For each scenario, the score has four categories of a, b, c, and d assigned to wetlands based on their rank order of relative wetland value within the watershed, with categories assigned from distributions of normalized relative wetland value scores from d to a at the 40th, 70th and 90th percentiles respectively.

Introduction

The Nose Creek Watershed Partnership (hereafter "Partnership") is seeking to protect wetlands and their functions in mitigating flood and drought impacts, improving water quality, and supporting biodiversity in the Nose Creek watershed (hereafter "Watershed") of southwestern Alberta. To this end, the Partnership engaged Irena Creed (hereafter "Creed") to deliver an accurate (> 85%) and up-to-date high-resolution (3-meter) inventory of existing wetlands in the watershed and to estimate the values of these wetlands for retention or restoration purposes.

This report serves as a supplement to the wetland inventory and wetland value estimates delivered by Creed to the Partnership as a geodatabase ("NCWP_NoseCreek_2020_inventories.gdb"; see Appendix A: Geodatabase Description), outlining the methods used to generate the deliverables and provide a description of the geodatabase attributes.

1 WETLAND INVENTORY (TASK 1)

The current wetland inventory in widespread use in Alberta is the Alberta Merged Wetland Inventory (AMWI)[1] updated in 2020 to depict wetlands in the Province between 1998 and 2017. As with most current wetland inventories, the AMWI is a generalized composite of inventories from multiple sources using different types of source data from different years and different wetland mapping methods. The AMWI for much of the area of the Watershed is developed from the Rockyview inventory prepared by Ducks Unlimited for Alberta Environment and Parks in 2006[2]; this inventory is currently 14 years out of date.

Creed delivered to the Partnership a standardized high-resolution (3-meter) 2015 wetland inventory derived from 2014 digital elevation and satellite image data for Task 1 of the Nose Creek Watershed Wetland Inventory and Valuation Project (hereafter "Project"). The 2015 wetland inventory had a minimum mapping unit (MMU) of 0.02 ha (200 m^2). The boundary of the Nose Creek Watershed was taken from a provincial dataset that did not include the lower reach of the watershed within the City of Calgary, including the reach upstream of the confluence with the Bow River. The wetlands were generated using digital terrain analysis and object-based segmentation and classification approaches to delineate wetlands from a combination of light-detection-and-ranging (LiDAR) digital elevation data and remote sensing imagery (high resolution SPOT satellite multispectral images). The original contract between Creed and the Partnership was based on the use of this 2015 wetland inventory.

The Partnership requested that a new inventory be generated with a revised Watershed boundary and more recently acquired digital elevation data. Creed agreed to generate a new standardized high-resolution (3-meter) 2020 wetland inventory. The 2020 wetland inventory had a MMU of 0.09 ha (900 m^2). Partnership jurisdictions made available their most up-to-date

[1] https://geodiscover.alberta.ca/geoportal/rest/metadata/item/bfa8b3fdf0df4ec19f7f648689237969/html
[2] https://maps.ducks.ca/cwi/

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(2018 and 2019) LiDAR digital elevation models (DEMs) to Creed for this purpose. There were no current LiDAR DEMs available for a large portion of Rocky View County and the Partnership approved to use the 2014 LiDAR DEM acquired by Creed for this area. A list of data layers used to generate the new high-resolution inventory is given in **Table 1**; areal coverage of the DEMs used is shown in **Figure 1**.

The revised map was completed to provide the Partnership with the most current data available for wetland management.

Table 1. Data layers used to generate new wetland inventory.

Data layer	Resolution /Scale	Source data year(s)	Creator/Source
Calgary LiDAR DEM	0.5 m	2019	City of Calgary
Airdrie LiDAR DEM	1.0 m	2018	City of Airdrie
Crossfield LiDAR DEM	1.0 m	2019	Town of Crossfield
Rocky View LiDAR DEM	1.0 m	2018	Rocky View County
Nose Creek Watershed LiDAR DEM	1.0 m	October 14, 17, 2014	Airborne Imaging Inc.
SPOT Near-Infrared (NIR) images	1.5 m	2019	Map & Data Distribution Centre, Alberta Environment and Sustainable Resource Development
Access and Facility Roads, Railroads	1:50,000	2016, 2020	AltaLIS Ltd.

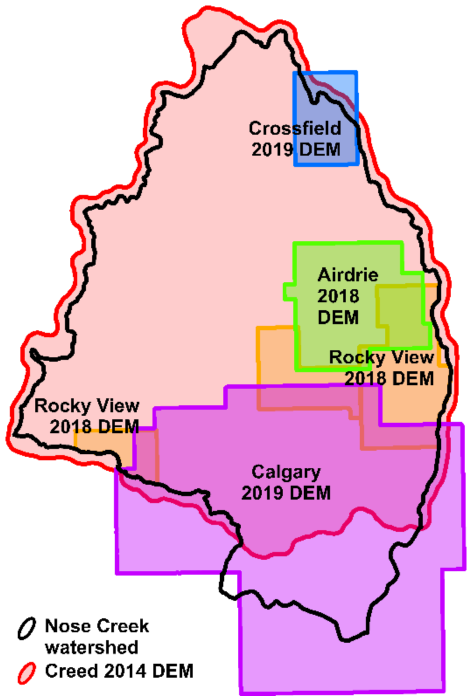

Figure 1. DEMs used to generate the new high-resolution wetland inventory.

The methods used to generate the 2020 wetland inventory follow the methods used for the 2015 wetland inventory (see Serran & Creed (2015) and Waz & Creed (2017)). However, the methods were modified for different data inputs (i.e., the lack of "full-feature" digital surface models (DSMs) for most of the Watershed) and different software capabilities (i.e., the use of ArcGIS software for object-based segmentation and classification). The methods, with each step outlined below, were performed in ArcGIS 10.8 unless otherwise noted.

1.1 Seamless watershed DEM

DEMs listed above in **Table 1** were re-projected using bilinear resampling to the NAD 1983 10TM Alberta Forest coordinate system and then resampled to 3-meter resolution using bilinear resampling; 3-meter resolution is considered by Creed based on previous experiments to be optimal for potential wetland mapping (1-meter resolution DEMs produce a large number of non-wetland artifacts). The resampled DEMS were mosaicked together with the mosaic operator set to use elevation values from (1) Airdrie, Calgary, and Crossfield DEMs first, (2) Rocky View DEM next, and (3) the 2014 LiDAR DEM acquired by Creed last.

1.2 Seamless watershed SPOT NIR image

Four NIR tiles from the Government of Alberta 2019 SPOT mosaic (NTS grids O8201, O8208, O82P04, and O82P05) were re-projected using bilinear resampling to the NAD 1983 10TM Alberta Forest coordinate system and then resampled to 3-meter resolution using bilinear resampling. The resampled tiles were mosaicked together with the mosaic operator set to use NIR values in order from O8201, O8208, O82P04, and O82P05 tiles.

1.3 Depression probability mapping

Potential wetlands were identified in part from topographic depressions. Depression probability (P_{dep}) mapping takes into account uncertainty from (varying) DEM vertical accuracy and errors (Lindsay & Creed, 2005, 2006) and has been used to identify wetlands in a variety of landscapes, including shallow wetlands in both arid and forested landscapes (Serran & Creed, 2016). P_{dep} mapping uses Monte Carlo simulations in which random error terms are added to each DEM cell selected from a normal distribution of random error terms with a standard deviation equal to the root mean square error (rmse; i.e., vertical accuracy) of the DEM. The Planchon & Darboux (2001) depression filling algorithm is then applied to the error-added DEM, and cells that are filled are flagged as depressions. This process is iterated 100-1000 times and the final output for each cell is a P_{dep} value [0-1], calculated as the proportion of times each cell was flagged as a depression per the number of iterations.

P_{dep} mapping through 100 iterations was performed on the seamless watershed DEM using the WhiteboxR package[3] (Lindsay, 2016) in R 4.0.3. The vertical accuracy of the seamless DEM was unknown because it was mosaicked from different data sources with different or unreported vertical accuracies. Several rmse values (0.15, 0.3, 0.5, and 1.0) were tested and rmse = 1.0 produced the most realistic results per visual assessment; this P_{dep} map (rmse = 1.0) was selected for further use.

1.4 Image segmentation

The Segment Mean Shift tool in ArcGIS 10.8 was used to merge adjacent P_{dep} and SPOT NIR cells into segments of relative P_{dep} or SPOT NIR homogeneity. Spectral and spatial detail parameters [2-20] are used to control the degree of spectral (P_{dep} or SPOT NIR) homogeneity and the size and smoothing of the segments, respectively. (This function is conceptually similar to the multi-resolution segmentation algorithm implemented in eCognition software that was

[3] https://github.com/giswqs/whiteboxR

formerly used by in Serran & Creed (2015) and Waz & Creed (2017); parameterization of spectral and spatial detail is not the same, however, and a departure from the parameters selected for the Watershed by Waz & Creed (2017) was required.) Several combinations of spectral and spatial detail parameters were tested and the following combinations were selected by visual assessment:

(1) spatial detail = 5; spectral detail = 5; minimum segment size = 4 (cells) for P_{dep};
(2) spatial detail = 20; spectral detail = 5; minimum segment size = 4 (cells) for P_{dep};
(3) spatial detail = 5; spectral detail = 5; minimum segment size = 4 (cells) for SPOT NIR.

Resulting raster segments were converted to polygons ("seg$P_{dep0505}$", "seg$P_{dep2005}$", and "segNIR_{0505}", respectively).

1.5 Segment Pdep classification and post-processing

Prior to segment classification, features from a road and railway vector polyline layer buffered 15 meters on each side were erased from the segment polygons. A 15-meter buffer was used because most roads (e.g., gravel roads, paved roads, multi-lane highways, etc.) fell entirely within this buffered area.

Mean P_{dep} [0-1] was calculated for each feature in "seg$P_{dep0505}$" and "seg$P_{dep2005}$" layers, and mean NIR [0-255] was calculated for each feature in "seg$P_{dep0505}$". Features in "seg$P_{dep0505}$" where mean $P_{dep} < 0.52$ and features in "seg$P_{dep2005}$" where mean $P_{dep} < 0.45$ were removed (thresholds taken from Waz & Creed (2017)). The remaining features from both "seg$P_{dep0505}$" and "seg$P_{dep2005}$" layers were dissolved to form contiguous features. Area (m^2), perimeter length (m), and the ratio of perimeter length to area (length:area) were calculated for each feature, and features with area < 36 m^2 were removed.

The remaining features were classified as "developed" within the boundaries of Calgary, Airdrie, and Crossfield (and within the developed areas between Calgary and Airdrie), and "undeveloped" intersecting the area outside these boundaries. Developed features were removed and these areas were treated separately in subsequent steps (see next section). Undeveloped features adjacent to the 15-meter road and railway buffer and with length:area > 0.7 and area < 91 m^2 were identified as linear road- or rail-side ditch drainage features and removed; the remaining features were classified as wetlands.

1.6 Segment NIR classification and post-processing

NIR segmentation and classification was included to improve the inventory of wetlands by adding inundated areas in areas where topography alone is insufficient for capturing wetland boundaries; i.e., developed area where stretches of flat areas such as subdivisions and parking lots were classified as wetlands.

Inundated segments were classified separately for developed and undeveloped area because these features were (1) used to replace wetlands delineated through P_{dep} segmentation and classification in developed areas, and (2) used as supplementary information to wetlands in undeveloped areas. Features in the "$segNIR_{p0505}$" layer were classified as "developed" intersecting the areas within the boundaries of Calgary, Airdrie, and Crossfield (and within the developed areas between Calgary and Airdrie), and "undeveloped" outside these boundaries. Area (m^2), perimeter length (m), and length:area were calculated for each feature. The following inundated segment features classified as developed were removed: mean NIR > 29 OR area < 36 m^2 OR (feature adjacent to 15-meter road and railway buffer AND length:area > 0.7 AND area < 91 m^2). The following inundated segment features classified as undeveloped were also removed: mean NIR > 40 OR area < 36 m^2 OR (feature adjacent to 15-meter road and railway buffer AND length:area > 0.7 AND area < 91 m^2). (Mean NIR thresholds were taken from Waz & Creed (2017).) The remaining inundated segments were then added to the wetland inventory.

Finally, AMWI features adjacent to the 15-meter road and railway buffer were compared with high-resolution aerial photographs and added to the wetland inventory where these could be visually confirmed as wetlands.

1.7 Wetland inventory

Wetland inventory features with area < 900 m^2 were removed to conform with Ducks Unlimited's inventory MMU standard (0.09 ha)[4]. The decision to apply this MMU was made after review of a previous version of the wetland inventory in which features with area < 81 m^2 (an area equivalent to a 3 × 3 window of 3-meter grid cells) were removed found numerous and unevenly distributed small ambiguous features in some agricultural areas.

The 2020 wetland inventory contains 6,413 wetlands with a total area of 6,401.8 ha, 6.6% of the watershed's total area of 97,290.7 ha (**Figure 2**; **Table 2**). The average area of wetlands is 1.00 ha;

[4] https://geodiscover.alberta.ca/geoportal/rest/metadata/item/bfa8b3fdf0df4ec19f7f648689237969/html

a smaller median area of 0.29 ha is driven by a positive skew in the distribution of wetlands by area (**Figure 3**). 2020 wetland inventory features are provided in the "NCWP_NoseCreek_2020 inventories.gdb" geodatabase (see Appendix A: Geodatabase Description).

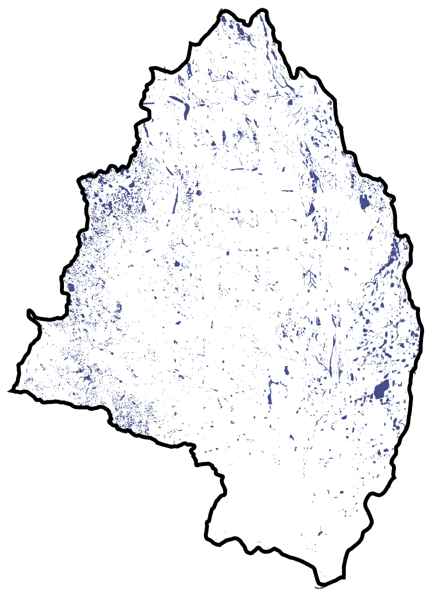

Figure 2. 2020 wetland inventory.

Table 2. Wetlands per jurisdiction by number and area (some wetlands intersect both a municipal jurisdiction boundary and Rocky View county jurisdiction boundary (excluding Calgary, Airdrie, and Crossfield); these wetlands are counted in both jurisdictions).

	Number of wetlands	Total wetland area (ha)	Average wetland area (ha)	Median wetland area (ha)
Calgary (within watershed only)	584	631.03	1.08	0.39
Airdrie	276	617.37	2.24	0.51
Crossfield (within watershed only)	64	98.21	1.53	0.31
Rocky View (excluding Calgary, Airdrie, Crossfield)	5,525	4,984.72	0.90	0.27

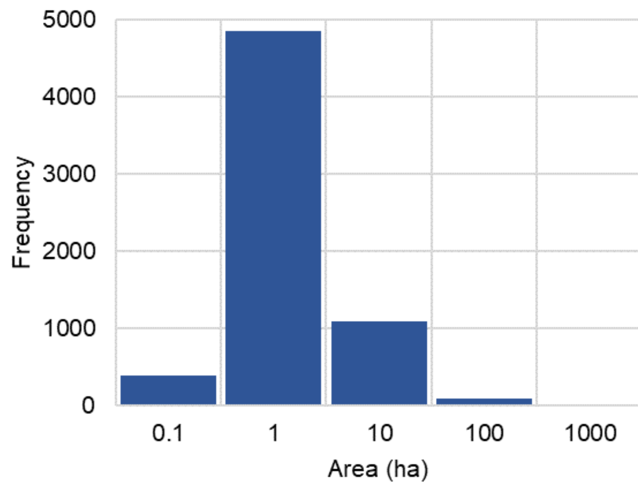

Figure 3. Distribution of wetlands currently existing by size (area).

1.8 Inventory validation

The 2020 wetland inventory was validated through visual assessment of high-resolution aerial photographs provided by (1) City of Calgary, (2) City of Airdrie, (3) Town of Crossfield, and (4) Rocky View County. Visual assessment was used for validation because the Covid-19 pandemic made the planned (one week) field validation untenable. Visual validation required 40 hours because (1) air photos required pre-processing to conform to standardized formats and coordinate systems, and (2) visual validation is more cumbersome given the difficulty of identifying indicative wetland vegetation patterns in small shallow wetlands.

Forty wetland inventory features were randomly selected throughout the boundaries of each of (1), (2), (3), and that portion of (4) outside the boundaries of (1), (2), and (3). The selected features were inspected for commission errors (i.e., features incorrectly identified as wetlands). Twelve random 300-meter × 300-meter grids throughout the watershed were also selected, classified as (1), (2), (3), or (4), and inspected for commission and omission errors (i.e., wetland features > not identified). Errors within the grids were identified by generating 12 random points within each grid which were buffered to create circles with an average area equal to the average area of wetland features (9,983 m^2) and inspecting each circle for the presence or absence of wetlands.

Validation results for each jurisdiction and overall are presented in **Table 3**. Overall accuracy was 95.5%, above the expected 85% accuracy; 95.6% of inventory wetland features were correctly identified, and 4.7% of non-wetland features were incorrectly identified as wetlands.

Table 3. Inventory validation results.

		Total	Correct identification	Incorrect identification	Error (%)	Accuracy (%)
Calgary	Wetland	40	39	1	2.5	97.5
	Non-wetland	12	12	0	0.0	100.0
	Total	52	51	1	1.9	98.1
Airdrie	Wetland	40	38	2	5.0	95.0
	Non-wetland	9	9	0	0.0	100.0
	Total	49	47	2	4.1	95.9
Crossfield	Wetland	40	39	1	2.5	97.5
	Non-wetland	6	6	0	0.0	100.0
	Total	46	45	1	2.2	97.8
Rocky View*	Wetland	40	37	3	7.5	92.5
	Non-wetland	37	34	3	8.1	91.9
	Total	77	71	6	7.8	92.2
Overall	Wetland	160	153	7	4.4	95.6
	Non-wetland	64	61	3	4.7	95.3
	Total	224	214	10	4.5	95.5

*excluding Calgary, Airdrie, Crossfield

1.9 Drained wetland inventory

Restorable wetlands in the Watershed were identified by Waz & Creed (2017) and provided to the Partnership in the "NCWP_NoseCreek_2020 inventories.gdb" geodatabase (see Appendix A: Geodatabase Description). Waz & Creed (2017) identified drainage as one of the most common mechanisms of wetland loss in the Prairies and the plugging of drainage ditches as the most cost-effective mechanism of wetland restoration; their inventory of ditch-drained wetlands is therefore described as an inventory of easily restorable wetlands.

The inventory of ditch-drained wetlands was generated using digital terrain analysis techniques on the 2014 Nose Creek Watershed LiDAR DEM (see **Table 1**) using the provincial boundary of the Watershed that did not include the lower reach of the watershed within the City of Calgary. The decision to provide this inventory instead of generating a new inventory of ditch-drained wetlands was made because (1) the hours required for a new analysis were not available, and (2) the Partnership agreed that drained wetlands in the Watershed have decreased in number since 2015.

The original ditch-drained wetland inventory (MMU = 0.02 ha) contained 1,571 intersecting the Watershed with an overall accuracy as reported by Waz & Creed (2017) of 76.0%; 65.0% of features classified as ditch-drained were correctly identified, and 13.0% of non-drained features were incorrectly identified as drained.

Ditch-drained wetland inventory features with area < 900 m^2 were removed to conform with the MMU of the 2020 wetland inventory. The ditch-drained wetland inventory contains 822 wetlands with a total area of 1,175.4 ha, 1.2% of the watershed's total area of 97,290.7 ha (**Figure 4**). The average area of drained wetlands is 1.43 ha; the smaller median area of 0.30 ha is driven by a positive skew in the distribution of wetlands by area (**Figure 5**). 398 ditch-drained wetlands (48.4%) with an average area of 2.4 ha intersect at least a portion of a feature in the 2020 wetland inventory because the ditch-drained wetland features were extracted from features in the 2015 wetland inventory that was generated using similar methods and from the same DEM data in the Rocky View County portion of the Watershed as the 2020 wetland inventory. The presence of an intersecting ditch-drained wetland feature may indicate that a portion of a wetland feature was drained.

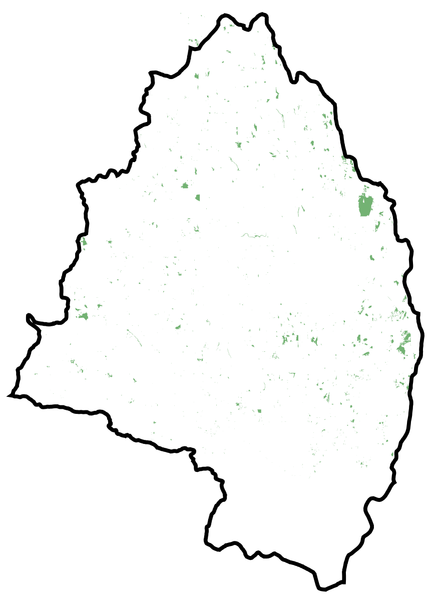

Figure 4. 2015 ditch-drained wetland inventory.

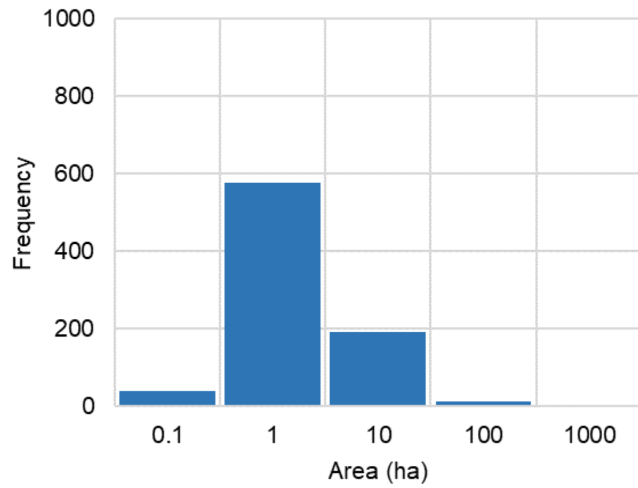

Figure 5. Distribution of ditch-drained wetlands by size (area).

2 Wetland Valuation (Task 2)

Wetland value scores were developed based on the Government of Alberta (hereafter "GOA") 2013 wetland policy as well as Partnership priorities.

The GOA 2013 wetland policy shifted the focus of previous policy from protection of wetland area to wetland function in recognition that different wetlands function differently and that wetland areas are not of equal value. The GOA further recognized that land developers and watershed managers needed accessible information about the functions and values of wetlands, and commissioned Creed to develop the Alberta Wetland Relative Value Evaluation Tool-Estimator (ABWRET-E) to deliver off-site estimates of relative value for all wetlands in the White Area of Alberta. This tool is built from the logical foundation employed in the ABWRET-Actual (-A) designed by Dr. Paul Adamus (Oregon State University, Corvallis, OR, United States) and Creed but uses Geographic Information Systems (GIS) instead of field assessments, allowing simultaneous and automated assessment of potentially thousands or millions of wetlands at the landscape level.

The GOA identified three major function groups provided by wetlands to be assessed:

(1) Hydrologic Health (HH): the water storage and delay function provided by wetlands for impeding and desynchronizing the downslope movement of peak flows.

(2) Water Quality (WQ): the retention or removal of sediment or nutrients provided by wetlands for purifying receiving waters.
(3) Ecological Health (EH): the habitats for aquatic and terrestrial plants and animals provided by wetlands for enhancing biodiversity.

A fourth function group, Human Use (HU) describing the multiple human activities that are supported by wetlands including recreation and education as well as the importance of wetlands to historical and current culture, was also implemented in ABWRET-E but not included in the Project. On April 3, 2020, the Partnership discussed including HU as a management lever, but time was unavailable to implement calculations of HU indicators and values. The Partnership acknowledges that HU is an important consideration and will be further explored.

Wetland functions are estimated from 73 indicators identified from and combined using models derived from expert opinion and extensive literature review. GIS methods and layers identified by searching provincial, national and international databases are used to extract each indicator and indicator values are combined into sub-function scores from 0 to 1 (where 1 indicates the best sub-function performance in the watershed using a combination of scaling, weighted average and "if-else" statements according to sub-function models). Indicators for each wetland are provided in the "NCWP_NoseCreek_2020 inventories.gdb" geodatabase (see Appendix A: Geodatabase Description).

Wetland HH is derived from a combination of water storage and stream flow support sub-functions.

Wetland WQ is derived from a combination of water cooling, sediment retention, phosphorus retention, and nitrate removal sub-functions.

Wetland EH is derived from a combination of organic nutrient export, fish habitat, invertebrate habitat, amphibian habitat, water bird nesting habitat, songbird, raptor and mammal habitat, and plant and pollinator habitat sub-functions.

Sub-functions are combined into functions, function scores are normalized to 0-1 range using **Equation (1),** and the functions then aggregated into value scores from 0 to 1 (**Figure 6**).

$$y_i = \frac{x_i - \min_i}{\max_i - \min_i} \qquad (1)$$

where y is the normalized score for function i, x is the observed score, and min and max are the minimum and maximum scores from all wetlands within the watershed. Sub-function scores (normalized and before normalization) for each wetland are provided in the "NCWP_NoseCreek_2020 inventories.gdb" geodatabase (see Appendix A: Geodatabase Description).

Relative wetland value scores were calculated for each wetland by using a weighted average of the three standardized function scores, where weights are assigned by the priorities of the user. Relative wetland value scores for each wetland are provided in the "NCWP_NoseCreek_2020 inventories.gdb" geodatabase (see Appendix A: Geodatabase Description).

For this project, Creed had several meetings with the Partnership (April and May 2020) and presented to the Partnership (May 28, 2020) and subsequently received from the Partnership a final set of strategies for scenario implementation on the 2020 wetland inventory.

Specifically, the Partnership requested the following scenarios:

(1) Equal weighting of HH, WQ, and EH;
(2) Equal weighting of HH, WQ, and EH with top 10% of scores in each function group reserved for conservation of "highest functioning" wetlands in all categories;
(3) Hydrologic health (HH) priority (0.8 weighting of HH, 0.1 weighting each of WQ and EH);
(4) Water quality (WQ) priority (0.8 weighting of WQ, 0.1 weighting each of HH and EH); and
(5) Ecological health (EH) priority (0.8 weighting of EH, 0.1 weighting each of HH and WQ).

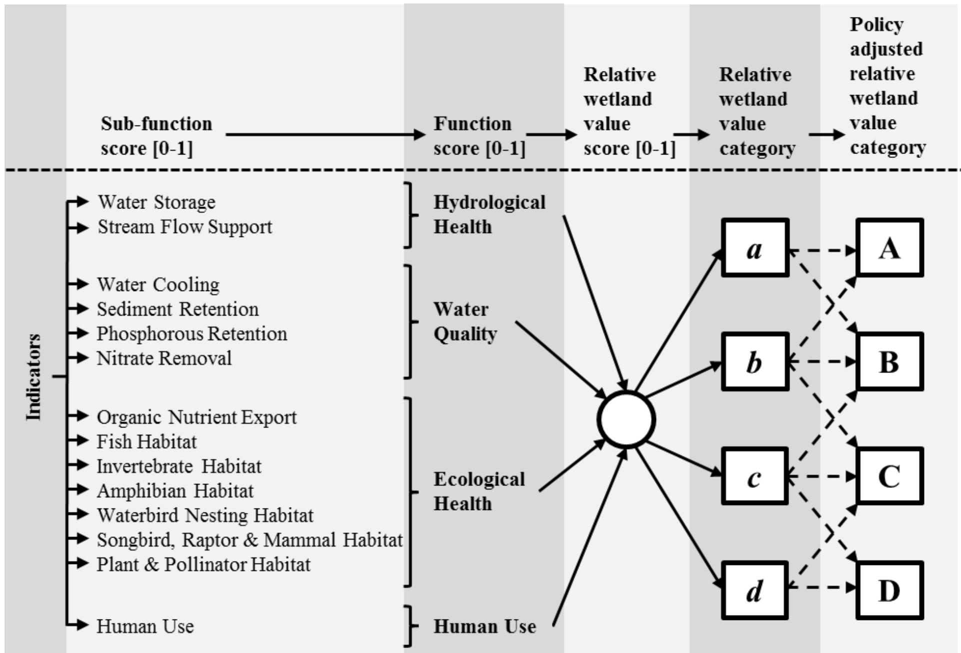

Figure 6. ABWRET-E combines indicators to wetland sub-function and function scores and bundles function scores to produce wetland scores.

Finally, four categories of a, b, c and d are assigned to wetlands based on their rank order of wetland value scores. Categories are assigned from the distribution of normalized wetland value scores from d to a at the 40th, 70th and 90th percentiles respectively (i.e., the top 10% of normalized wetland value scores are categorized as "a," the next top 20% are categorized as "b," the next top 30% are categorized as "c," and the remaining are categorized as "d"). Ditch-drained wetlands are scored relative to each other and not to features in the 2020 wetland inventory following the recommendation of Creed and agreed upon by the Partnership.

The numbers of wetlands in each category for each weighting scheme are shown in **Table 4** and the numbers of ditch-drained wetlands in each category for each weighting scheme are shown in **Table 5**. Owing to the use of percentiles for categorization, the number of wetlands in each category will be approximately the same for each weighting scheme unless the distribution of wetland value scores is highly skewed. Normalized HH and WQ function scores are strongly negatively skewed (**Table 6**, **Table 7**), resulting in 70th and 90th percentiles of these function scores equaling 1; therefore, HH priority and WQ priority weighting schemes produce the same categorizations of wetlands. The same skewing results in almost all wetlands categorized as "a" when the top 10% of function scores are reserved for this category.

Table 4. Number of wetlands in each value category (a,b,c,d) in each jurisdiction (jurisdiction totals do not equal wetland inventory total because some wetlands intersect more than one jurisdiction and are counted in each).

Value Category - equal weighting of HH, WQ, and EH; HH priority; and WQ priority					
Wetland Value Category	**Total**	**Airdrie**	**Calgary**	**Crossfield**	**Rocky View**
a	642	6	24	4	615
b	1,282	19	83	3	1,183
c	1,924	66	92	12	1,765
d	2,565	185	385	45	1,962
Value Category - equal weighting of HH, WQ, and EH (top 10% of function scores reserved for "a")					
Wetland Value Category	**Total**	**Airdrie**	**Calgary**	**Crossfield**	**Rocky View**
a	5,871	217	461	49	5,174
b	0	0	0	0	0
c	0	0	0	0	0
d	542	59	123	15	351
Value Category - EH priority					
Wetland Value Category	**Total**	**Airdrie**	**Calgary**	**Crossfield**	**Rocky View**
a	642	7	40	5	602
b	1,282	11	55	2	1,219
c	1,924	57	114	6	1,761
d	2,565	201	375	51	1,943

Table 5. Number of ditch-drained wetlands in each value category (a,b,c,d) in each jurisdiction (jurisdiction totals do not equal wetland inventory total because some wetlands intersect more than one jurisdiction and are counted in each).

Wetland Value Category	Total	Airdrie	Calgary	Crossfield	Rocky View
Value Category - equal weighting of HH, WQ, and EH; HH priority; and WQ priority					
a	83	0	9	0	74
b	164	16	17	1	129
c	246	9	54	1	182
d	329	30	71	7	220
Value Category - equal weighting of HH, WQ, and EH (top 10% of function scores reserved for "a")					
a	814	55	149	9	599
b	0	0	0	0	0
c	0	0	0	0	0
d	8	0	2	0	6
Value Category - EH priority					
a	83	0	8	0	75
b	164	16	17	1	129
c	246	11	57	2	176
d	329	28	69	6	225

Table 6. Average function and value scores for all wetlands and per value category.

	Normalized HH Function Score	Normalized WQ Function Score	Normalized EH Function Score	Value Score - equal weighting	Value Score - HH priority	Value Score - WQ priority	Value Score - EH priority
All wetlands	0.87	0.91	0.34	0.71	0.82	0.85	0.45
a	1.00	1.00	0.60	0.87	0.96	0.96	0.68
b	1.00	1.00	0.34	0.78	0.93	0.93	0.47
c	1.00	1.00	0.28	0.76	0.93	0.93	0.42
d	0.69	0.77	0.32	0.59	0.66	0.72	0.40

Table 7. Average function and value scores for all ditch-drained wetlands and per value category.

	Normalized HH Function Score	Normalized WQ Function Score	Normalized EH Function Score	Value Score - equal weighting	Value Score - HH priority	Value Score - WQ priority	Value Score - EH priority
All wetlands	0.96	0.98	0.19	0.71	0.89	0.90	0.35
a	1.00	1.00	0.60	0.87	0.96	0.96	0.68
b	1.00	1.00	0.23	0.74	0.92	0.92	0.38
c	1.00	1.00	0.14	0.71	0.91	0.91	0.31
d	0.91	0.95	0.11	0.66	0.83	0.86	0.28

Wetland value categories are not distributed evenly throughout the watershed (**Figure 7**, **Figure 8**, **Figure 9**); "a" wetlands are primarily found in the western reaches of the watershed using equal weighting, HH priority, and WQ priority weighting schemes (**Figure 7**) and in the western reaches and along streams using the EH priority weighting scheme (**Figure 9**).

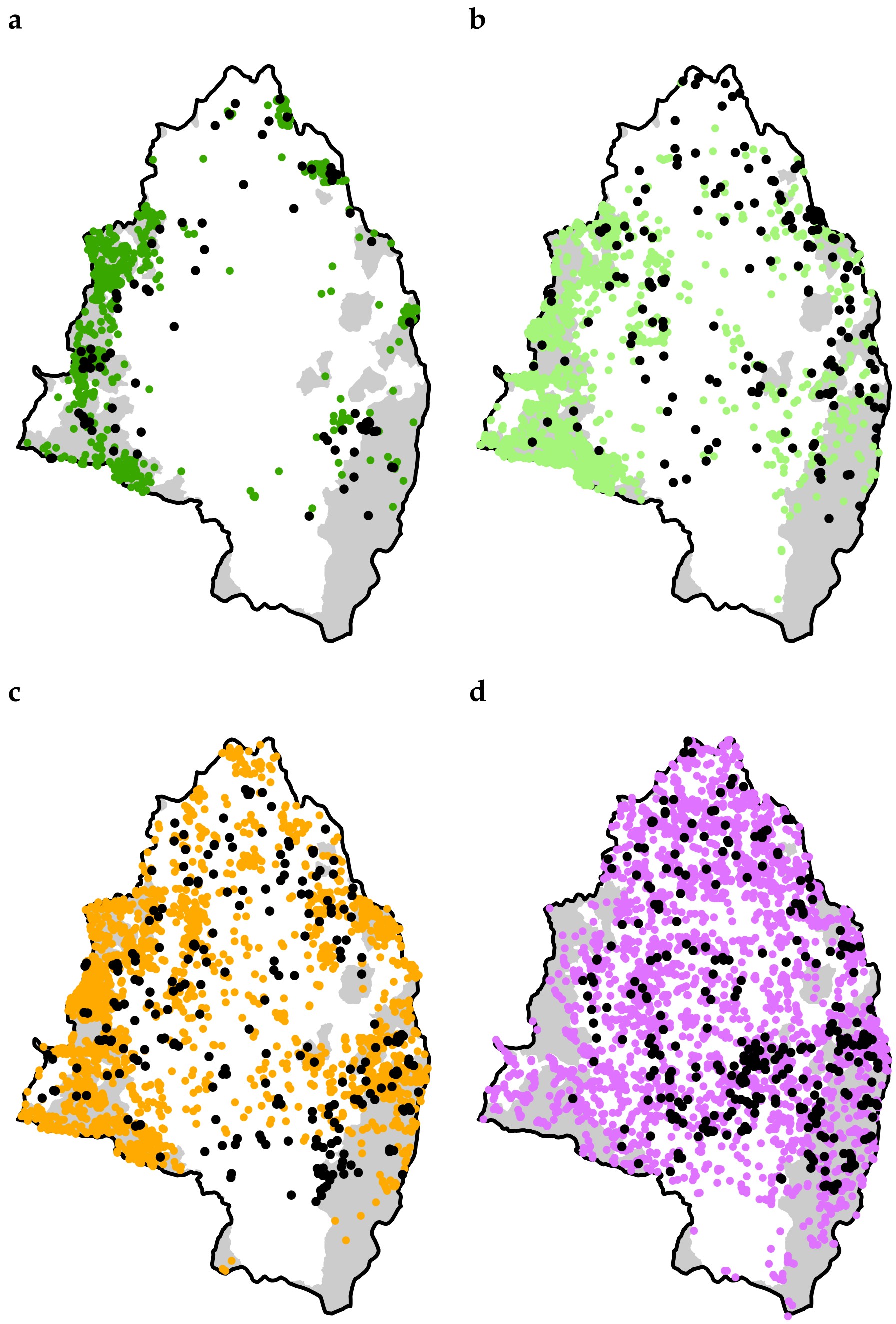

Figure 7. Location of "a" (top left, dark green), "b" (top right, light green), "c" (bottom left, orange), and "d" wetlands (bottom right, purple) categorized using equal weighting of HH, WQ, and EH, HH priority, and WQ priority weighting schemes (IDAs shown in grey). Ditch-drained wetlands in each category are shown as black circles.

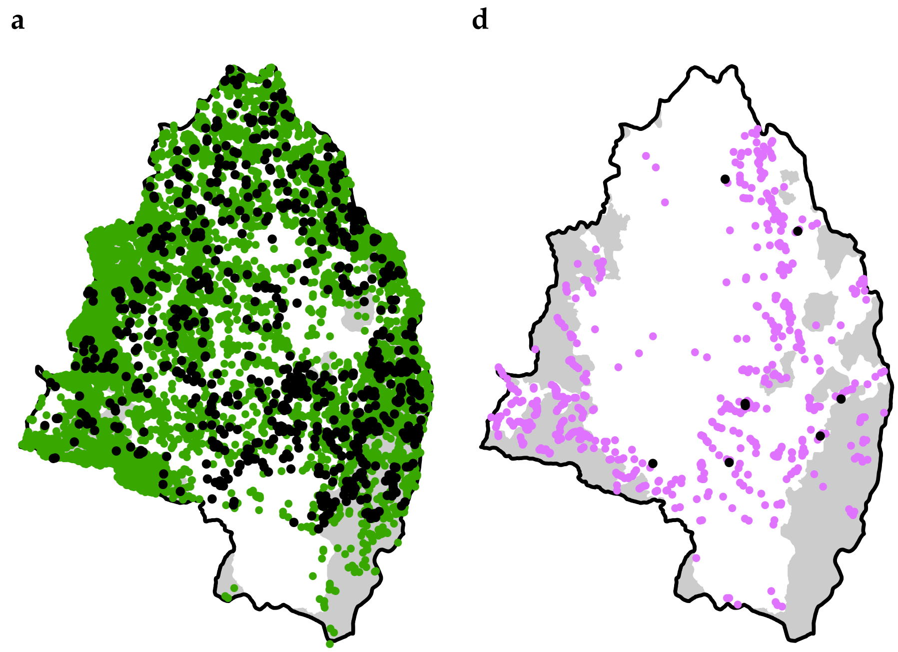

Figure 8. Location of "a" (left, dark green) and "d" wetlands (right, purple) categorized using equal weighting of HH, WQ, and EH function scores with the top 10% of scores in each function group reserved for “a” (IDAs shown in grey). Ditch-drained wetlands in each category are shown as black circles.

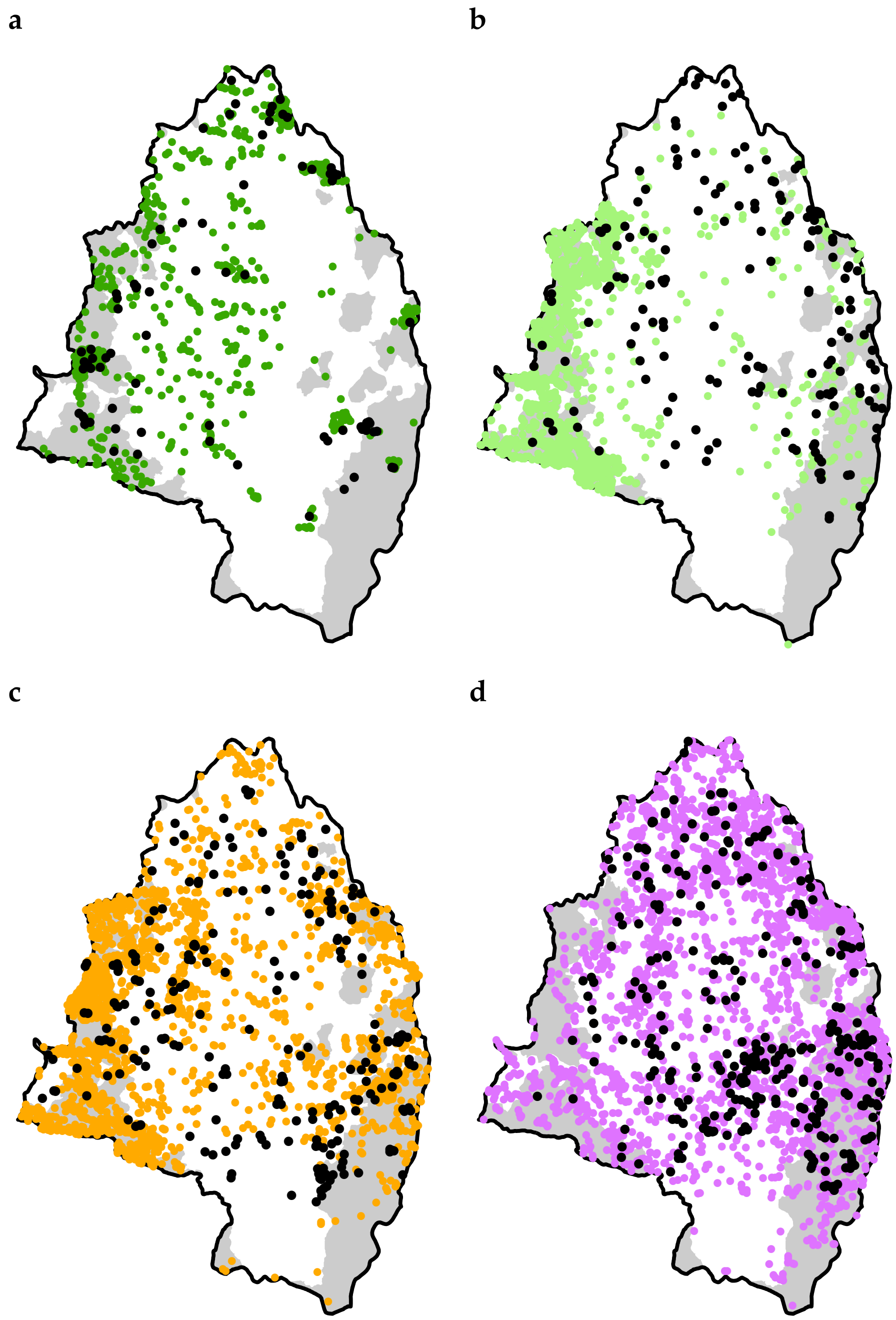

Figure 9. Location of "a" (top left, dark green), "b" (top right, light green), "c" (bottom left, orange), and "d" wetlands (bottom right, purple) categorized using the EH priority weighting scheme (IDAs shown in grey). Ditch-drained wetlands in each category are shown as black circles.

The Partnership requested metrics of connectivity and identification of wetland complexes. Two rudimentary metrics of connectivity for each 2020 wetland inventory feature are provided in the "NCWP_NoseCreek_2020 inventories.gdb" geodatabase (see Appendix A: Geodatabase Description):

(1) the presence of an intersection with a stream[5].
(2) the presence of an uninterrupted natural cover corridor to another wetland within 1 km.

A rudimentary metric of the possibility that a wetland is a part of a wetland complex is provided in the geodatabase as the distance to the nearest wetland.

3 DECISION-MAKING OPPORTUNITIES USING WETLAND INVENTORY AND VALUATION TOOL – GEODATABASE AND MAPS (TASK 3)

Digital maps indicating wetlands and priorities are provided to the Partnership in .pdf formats and in an ArcGIS file geodatabase for use in development planning and decision-making and project implementation. The geodatabase ("NCWP_NoseCreek_2020 inventories.gdb") contains the following layers:

(1) "nose_creek_wetlands_2020_nad8310tmaepforest", "nose_creek_wetlands_2020_subfunction_function_scores_nad8310tmaepforest", and "nose_creek_wetlands_2020_indicators_nad8310tmaepforest" (2020 wetland inventory)
(2) "nose_creek_wetlands_2015_nad8310tmaepforest" (2015 wetland inventory)
(3) "nose_creek_drained_wetlands_2015_nad8310tmaepforest" (2015 ditch-drained wetland inventory)
(4) "internal_drainage_areas_ID" (internal drainage areas with ID field to link to "IDA" field in 2020 wetland inventory).

Attributes provided in the 2020 wetland inventory include value scores and value categories using the different weighting schemes; definitions of the attributes are given in **Table 8**.

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[5] Alberta Environment and Parks Base Stream and Flow Representation; https://geodiscover.alberta.ca/geoportal/rest/metadata/item/a8739420b43f467ebde0b1618a177409/html

Table 8. Field attributes in "nose_creek_2020_nad8310tmaepforest" geodatabase layer.

Attribute	Definition
WetID	unique identifier for each wetland
Muni1	jurisdiction to which wetland intersects
Muni2	second jurisdiction to which wetland intersects (if applicable)
IDA	internal drainage area to which wetland intersects
WetArea	area of wetland (m^2)
WetPerim	length of wetland perimeter (m)
OW_area	area of open water in wetland (m^2)
OW_number	number of open water segments in wetland (m^2)
MR_area	area of marsh in wetland (m^2)
Stream	presence of intersection of wetland with stream[6] (connectivity measure); 1 = yes, 0 = no
DistWet	distance to nearest wetland (connectivity measure) (m)
NatConn1k	presence of uninterrupted natural cover[7] corridor to another wetland within 1 km (connectivity measure); 1 = yes, 0 = no
normHH	normalized HH score
normWQ	normalized WQ score
normEH	normalized EH score
valeq	value score using equal weighting
valHH	value score using HH priority weighting scheme
valWQ	value score using WQ priority weighting scheme
valEH	value score using EH priority weighting scheme
cateq	value category (a,b,c,d) using equal weighting
cateq10	value category (a,b,c,d) using equal weighting and reserving top 10% of all function scores to "a"
catHH	value category (a,b,c,d) using HH priority weighting scheme
catWQ	value category (a,b,c,d) using WQ priority weighting scheme
catEH	value category (a,b,c,d) using EH priority weighting scheme

[6] Alberta Environment and Parks Base Stream and Flow Representation; https://geodiscover.alberta.ca/geoportal/rest/metadata/item/a8739420b43f467ebde0b1618a177409/html
[7] Agriculture and Agri-Food Canada (AAFC) 2013 Crop Mapping

Additional attributes provided in the 2015 ditch-drained wetland inventory are given in **Table 9**.

Table 9. Additional field attributes in "nose_creek_drained_wetlands_2015_nad8310tmaepforest" geodatabase layer.

Attribute	Definition
DrainID	unique identifier for each ditch-drained wetland
DrainArea	area of ditch-drained wetland (m^2)
DrOWAr	area of open water in ditch-drained wetland (m^2)
DrMRAr	area of marsh in ditch-drained wetland (m^2)

Maps of priority ("a") wetlands within internal drainage areas for equal weighting, HH priority, and WQ priority weighting schemes for the EH priority weighting scheme are shown in **Figure 10**.

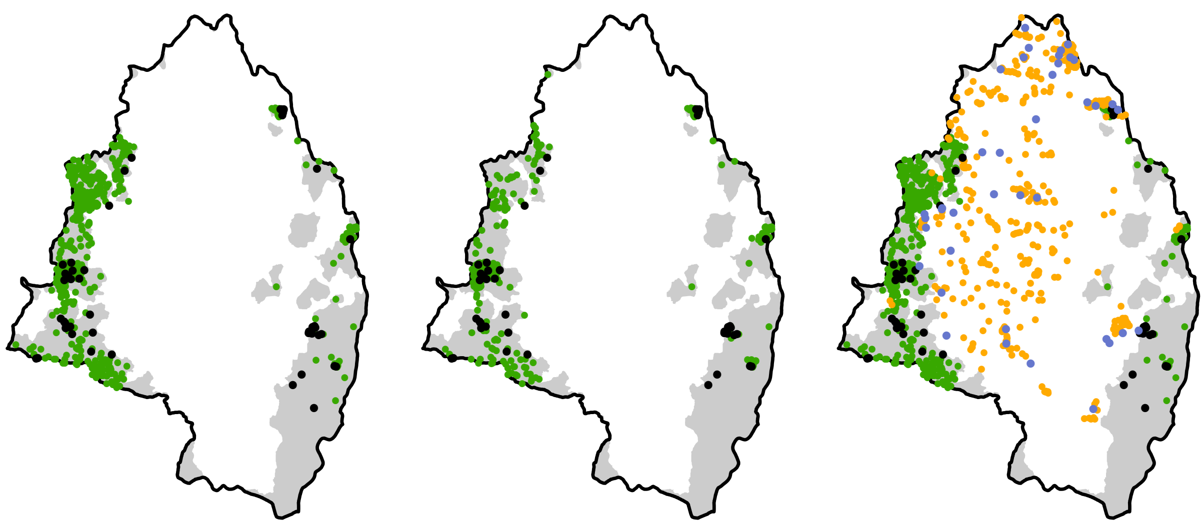

Figure 10. Location of "a" wetlands (dark green) and ditch-drained wetlands (black) within internal drainage areas (grey) categorized using (left) equal weighting of HH, WQ, and EH function scores, and (middle) the EH priority weighting scheme. The map on the right shows location of "a" wetlands and ditch-drained wetlands within internal drainage areas categorized using equal weighting of HH, WQ, and EH function scores and "a" wetlands (orange) and ditch-drained wetlands (blue) outside internal drainage areas categorized using the EH priority weighting scheme.

4 Literature Cited

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APPENDIX A: GEODATABASE DESCRIPTION

The ArcGIS file geodatabase ("NCWP_NoseCreek_2020 inventories.gdb") provided to the Partnership contains the following layers projected to a common NAD 1983 10TM AEP Forest coordinate system:

(1) "nose_creek_wetlands_2020_nad8310tmaepforest" (2020 Watershed wetland inventory features; MMU = 0.09 ha)
(2) "nose_creek_wetlands_2020_subfunction_function_scores_nad8310tmaepforest" (2020 Watershed wetland inventory features; MMU = 0.09 ha)
(3) "nose_creek_wetlands_2020_indicators_nad8310tmaepforest" (2020 Watershed wetland inventory features; MMU = 0.09 ha)
(4) "nose_creek_wetlands_2015_nad8310tmaepforest" (2015 Watershed wetland inventory features; MMU = 0.02 ha)
(5) "nose_creek_drained_wetlands_2015_nad8310tmaepforest" (2015 Watershed ditch-drained wetland inventory features; MMU = 0.02 ha)
(6) "internal_drainage_areas_ID" (Watershed internal drainage areas with ID field to link to "IDA" field in 2020 wetland inventory).

The layers can be queried in an ArcGIS environment by attribute, by location, or by spatial reference to queries in different layers using "Select by Attribute" and "Select by Location" tools.

The "nose_creek_wetlands_2020_nad8310tmaepforest" layer contains 6,413 Watershed features in the 2020 wetland inventory developed by Creed from 2014, 2018 and 2019 digital elevation and 2019 satellite image data. Each feature contains the following attributes meant for use in decision making:

Attribute	Definition
WetID	unique identifier for each wetland
Muni1	jurisdiction to which wetland intersects
Muni2	second jurisdiction to which wetland intersects (if applicable)
IDA	internal drainage area to which wetland intersects
WetArea	area of wetland (m^2)
WetPerim	length of wetland perimeter (m)
OW_area	area of open water in wetland (m^2)
OW_number	number of open water segments in wetland (m^2)
MR_area	area of marsh in wetland (m^2)
Stream	presence of intersection of wetland with stream[8] (connectivity measure); 1 = yes, 0 = no
DistWet	distance to nearest wetland (connectivity/wetland complex measure) (m)
NatConn1k	presence of uninterrupted natural cover[9] corridor to another wetland within 1 km (connectivity measure); 1 = yes, 0 = no
normHH	normalized HH score
normWQ	normalized WQ score
normEH	normalized EH score
valeq	value score using equal weighting
valHH	value score using HH priority weighting scheme
valWQ	value score using WQ priority weighting scheme
valEH	value score using EH priority weighting scheme
cateq	value category (a,b,c,d) using equal weighting
cateq10	value category (a,b,c,d) using equal weighting and reserving top 10% of all function scores to "a"
catHH	value category (a,b,c,d) using HH priority weighting scheme
catWQ	value category (a,b,c,d) using WQ priority weighting scheme
catEH	value category (a,b,c,d) using EH priority weighting scheme

[8]Alberta Environment and Parks Base Stream and Flow Representation; https://geodiscover.alberta.ca/geoportal/rest/metadata/item/a8739420b43f467ebde0b1618a177409/html
[9]Agriculture and Agri-Food Canada (AAFC) 2013 Crop Mapping

The "nose_creek_wetlands_2020_subfunction_function_scores_nad8310tmaepforest" layer provides sub-function scores for each of the 6,413 Watershed features in the 2020 wetland inventory. This layer includes the following additional attributes:

Attribute	Definition
WS Score	Surface Water Storage sub-function score
SFS Score	Stream Flow Support sub-function score
HH Function Score	non-normalized HH function score (combination of WS and SFS scores)
WC Score	Water Cooling sub-function score
SR Score	Sediment & Toxicant Retention & Stabilization sub-function score
PR Score	Phosphorus Retention sub-function score
NR Score	Nitrate Nitrogen Removal sub-function score
WQ Function Score	non-normalized WQ function score (combination of WC, SR, PR, and NR scores)
OE Score	Organic Nutrient Export sub-function score
FR Score	Resident Fish Habitat sub-function score
INV Score	Invertebrate Habitat sub-function score
AM Score	Amphibian Habitat sub-function score
WB Score	Waterbird Nesting Habitat sub-function score
SRM Score	Songbird, Raptor, and Mammal Habitat sub-function score
PH+POL Score	Native Plant and Pollinator Habitat sub-function score
EH Function Score	non-normalized EH function score (combination of OE, FR, INV, AM, WB, SRM, and PH+POL scores)

The "nose_creek_wetlands_2020_indicators_nad8310tmaepforest" layer provides indicator scores for each of the 6,413 Watershed features in the 2020 wetland inventory. Indicator values are calculated in a GIS environment using different vector and raster input layers; a comprehensive list of indicators and their corresponding GIS methods and input layers can by obtained by contacting Creed. The "nose_creek_wetlands_2020_indicators_nad8310tmaepforest" layer includes the following additional attributes:

Attribute	Definition
Aspect	Aspect of Wetland's 100 m Upslope Buffer (1 = North (315° to 45°), -1 = South (135° to 225°), 0 = Other)
BioDivZone	Key Wildlife Biodiversity Zone (1 = Yes, 0 = No)
ChanConn	Channel Connection (1 = Yes, 0 = No)
ClumpHerbWood	Clumpiness Index for Herbaceous and Woody Vegetation in the Wetland
ClumpWater	Clumpiness Index for Vegetation and Water
CodeClassAB	Class A or B (Alberta Water Act Codes of Practice Streams) (1 = Yes, 0 = No)
Dist2DevCrop	Distance from Wetland to Nearest Developed Land or Annual Cropland
Dist2Road	Distance from Wetland to Nearest Road (no value if > 5 km)
ElevPctileHUC8	Elevation Percentile In HUC8 (Watershed)
FenBogMarshPct	Percent Fen, Bog, or Marsh
FenPct	Percent Fen
FenSwampMarshPct	Percent Fen, Swamp, or Marsh
FWRipArea	Floodways or Riparian Area (1 = Yes, 0 = No)
GrowDD	Growing Degree Days (1971-2000)
IBArea	Important Bird Area (1 = Yes, 0 = No)
LGIndex	Hydrologic Detention Time (Flow Length/Flow Gradient) (only wetlands ≥ 100 ha)
MarshPct	Percent Marsh
NatCover1k	Percent Natural Cover Within 1 km
NatCoverConn1k	Habitat Connectivity to Other Wetlands within 1 km (1 = Yes, 0 = No)
OWArea	Open Water Area (m^2)
OWDens1k	Wetland Density (Open Water Only) within 1 km (percentage)
OWPct	Percent Open Water
PerimNatCov	Percent Perimeter Adjoined By Natural Cover
PPET	P-PET (1971-2000)
RaptorNest	Sensitive Raptor Nesting Area (1= Yes, 0 = No)
RareBirdUse	Nesting Bird Colony, Piping Plover Water Body or Trumpeter Swan Use Area (1 = Yes, 0 = No)
RarePlantRange	Rare Plant Species Range (1 = Yes, 0 = No)
RoadDens1k	Road Density in 1 km Buffer (ratio of road lengths to 1 km buffer area)

Attribute	Definition
SBStaging	Shorebird Staging Wetland (1 = Yes, 0 = No)
SensAM	Sensitive Amphibian Range (1= Yes, 0 = No)
Slope500	Slope In 500 m Buffer (percent)
SoilOrgCont	Soil Organic Content (percent)
SoilTex	Soil Texture
SpringGWD	Springs or Other Groundwater Discharge Area (300 m radius) (1 = Yes, 0 = No)
Sub0Days	Subzero Days (1971-2000)
SwampMarshPct	Percent Swamp or Marsh
SwanArea	Trumpeter Swan Area (1 = Yes, 0 = No)
UndevOpenL1k	Percent Undeveloped Openlands Within 1 km
UniqClass	Linear Scaling of Maximum of UniqFenMarsh (see below)
UniqFenMarsh	Uniqueness of Fen and Marsh Classes (ratio of total Fen and Marsh class areas to total Wet Area within 1 km buffer (percentage))
UniqFenMarshSwamp	Uniqueness of Fen, Swap, and Marsh Classes (ratio of total Fen, Swamp, and Marsh class areas to total Wet Area within 1 km buffer (percentage))
WatProb	Water Permanence Probability
WBStaging	Waterfowl Staging Wetland (1 = Yes, 0 = No)
WetArea	Wetland Area
WetClassRich	Internal Wetland Type Richness (number of unique wetland classes within wetland feature)
WetClassRich1k	Wetland Type Richness within 1 km (number of unique wetland classes within 1 km buffer)
WetDens1k	Wetland Density within 1 km (ratio total wetland area within 1 km buffer to 1 km buffer area (percent))
WetDens1k_NoBog	Wetland Density within 1 km (ratio total wetland area excluding bog area within 1 km buffer to 1 km buffer area (percent))
WetPctHUC8	Wetland Size Percentile In HUC8
WetPerim2Area	Perimeter-Area Ratio
WetVegArea	Wetland Vegetated Area (non-Open Water area)
WetWood	Percent Wooded (Forest and Swamp)
WindSum	Wind Intensity – Summer (W/m^2)
WindWin	Wind Intensity - Winter (W/m^2)

The “nose_creek_wetlands_2015_nad8310tmaepforest” layer contains 12,260 Watershed features in the 2015 wetland inventory developed by Creed from 2014 digital elevation and satellite image data and previously supplied to the Partnership. This layer is included in the geodatabase for spatial comparison purposes and does not include attributes.

The "nose_creek_drained_wetlands_2015_nad8310tmaepforest" contains 1,587 Watershed features in the 2015 ditch-drained wetland inventory features developed by Creed from 2014 digital elevation and satellite image data. This layer is included in the geodatabase for the purpose of identifying easily restorable wetlands in the Watershed. Each feature contains the following attributes meant for use in decision making:

Attribute	Definition
DrainID	unique identifier for each ditch-drained wetland
Muni1	jurisdiction to which wetland intersects
IDA	internal drainage area to which wetland intersects
DrainArea	area of ditch-drained wetland (m^2)
DrOWAr	area of open water in ditch-drained wetland (m^2)
DrMRAr	area of marsh in ditch-drained wetland (m^2)
normHH	normalized HH score
normWQ	normalized WQ score
normEH	normalized EH score
valeq	value score using equal weighting
valHH	value score using HH priority weighting scheme
valWQ	value score using WQ priority weighting scheme
valEH	value score using EH priority weighting scheme
cateq	value category (a,b,c,d) using equal weighting
catHH	value category (a,b,c,d) using HH priority weighting scheme
catWQ	value category (a,b,c,d) using WQ priority weighting scheme
catEH	value category (a,b,c,d) using EH priority weighting scheme

The "internal_drainage_areas_ID" layer was provided to Creed by the Partnership and is included in the geodatabase for querying purposes. The Partnership is especially concerned with wetland protection and restoration in the internal drainage areas. Thirty internal drainage areas identified by the Partnership are provided with unique integer identifiers in an "ID" field. Features in the "nose_creek_wetlands_2020_nad8310tmaepforest" and "nose_creek_drained_wetlands_2015_nad8310tmaepforest" layer are identified where they intersect with a unique internal drainage area feature in an "IDA" attribute that corresponds to "ID" attributes in the "internal_drainage_areas_ID" layer.