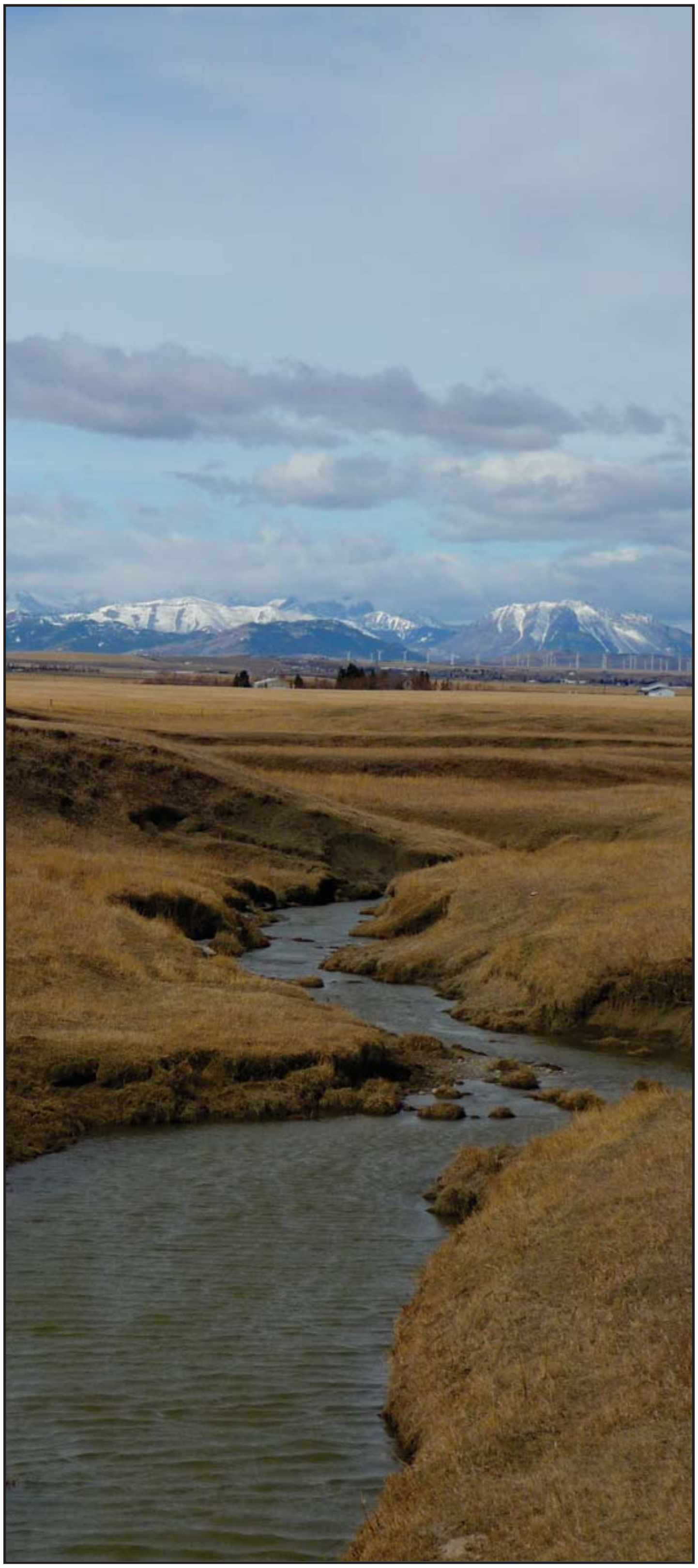
SECTION 9
APPENDICES



Appendix 1. Water Analysis Quality Assurance and Quality Control during the Switch of Laboratories

Introduction

Water samples were collected and analyzed from 2007 to 2009 by ALS Canada Limited using scientific methods previously described in Olson and Kalischuk (2008, 2009) for the Nutrient Beneficial Management Practices Evaluation Project. In January 2010, a new request for proposal for water analysis services was issued in order to comply with new legislation (The Trade, Investment, Labour Mobility Agreement and the Agreement of Internal Trade) in Alberta. The end result was a new contract for water analysis was awarded to Exova Canada Incorporated until December 2012. In order to ensure the continuous scientific integrity of water analysis for the project, it was critical that the same methods, minimum detection limits, and laboratory processing times were used for water quality comparisons for the length of the project. This was true for most parameters except for total Kjeldahl nitrogen (TKN). Due to the toxicity of the chemical used in the TKN analysis (wet chemical oxidation method), Exova uses the less hazardous TN method (catalytic high temperature oxidation chemiluminescence), which also is a more acceptable method.

The information presented here documents the quality-control data of the ALS Laboratory, inter-laboratory quality assurance samples, and blind reference samples throughout the contracting period.

Methods

In 2008, seven duplicate samples (collected on the same days and at the same water quality monitoring stations) were analyzed by the Alberta Agriculture and Rural Development (ARD) and ALS laboratories. Sixteen reference samples, containing known amounts of N and P, were also submitted to the ALS laboratory from 2008 to 2009.

Replicate water samples (126 total) collected from the field were analyzed for pH, electrical conductivity (EC), chloride (Cl), nitrate nitrogen (NO_3-N), ammonia nitrogen (NH_3-N), total nitrogen (TN), orthophosphate (PO_4-P), total dissolved phosphorus (TDP), total phosphorus (TP), and total suspended solids (TSS) by ALS and Exova laboratories during the laboratory transition period from January 13 to May 12, 2010. In addition, a 37-sample sub-set of the 126 water samples were analyzed by the Alberta ARD laboratory. An evaluation of TN measurements by the three laboratories, in the post-ALS contract phase, was completed in order to document any shifts in TN concentrations that could be due to the change in TN methods that occurred during the laboratory transition.

Statistical Definitions

Analysis of variance. Analysis of variance (ANOVA) is a general technique that can be used to test the hypothesis that the means among two or more groups are equal, under the assumption that the sampled populations are normally distributed.

Concordance correlation coefficient. The concordance correlation coefficient (r_c) (Lin 1989) evaluates the degree to which pairs of observations fall on the 45-degree line through the origin.

Control chart. The individual analytical values in a series are plotted and evaluated against control limits. The limits are calculated as the mean historic target value ±3 standard deviations of historic target value as upper and lower control limits.

Control limit. The individual analytical values in the series are plotted and evaluated against control limits. The control limits are calculated as the mean historic target of percent recovery ±3 standard deviations of percent recovery as upper and lower control limits.

Correlation coefficient. The correlation coefficient (r) is a measure of the degree of linear relationship between two variables. The correlation coefficient is a value between -1 and +1. If one variable tends to increase as the other decreases, the correlation coefficient is negative. Conversely, if the two variables tend to increase together the correlation coefficient is positive.

Relative standard deviation. Relative standard deviation (% RSD) is calculated from repeated analysis [(standard deviation ÷ mean value of replicate observed values) × 100].

Two-samples t-test. Hypothesis test for two population means to determine whether they are significantly different. This procedure uses the null hypothesis that the difference between two population means is equal to a hypothesized value (H_0: $m_1 - m_2 = m_0$), and tests it against an alternative hypothesis, which can be left-tailed ($m_1 - m_2 < m_0$), right-tailed ($m_1 - m_2 > m_0$), or two-tailed ($m_1 - m_2 \neq m_0$).

Quality Control Chart Evaluation for ALS and Exova Laboratories

There were no laboratory blank failures from 2007 to 2009 for the ALS laboratory (Table 1.1A) or for the Exova laboratory in 2010 (Table 1.2A). The quality control results from the ALS laboratory resulted in six TKN control sample failures and one TSS control sample failure from 2007 to 2009. There was one Cl, five TDP/TP, and two TSS control samples failures at the Exova laboratory in 2010. Exova had tighter control limits for the control samples and this may be the reason why there were more failures than at the ALS laboratory (Tables 1.1A and 1.2A). There were also more failures in Exova duplicate samples compared with ALS, but the RSD levels were stricter for Cl, NH_3-N, NO_3-N, TN, and TSS at Exova. Control and duplicate samples were re-ran when they were outside of the laboratory control limits and were not passed until the values were within the control limits. The laboratories reported the original failure values and the re-run values.

Table 1.1A. ALS Laboratory quality-control data assessment from 2007 to 2009.

	Control samples				Lab blank	Duplicate samples			Spike samples		
Parameter	Sets	Historic run mean	Historic run control limit	Sets failed	Sets failed	Sets	% RSD	Sets failed	Sets	Control limit	Sets failed
EC	188	99.9%	90-108%	0	0	120	9.8	1			
Cl	258	102.2%	90-111%	0	0	258	13	2	39	80-113%	0
NH_3-N	179	100.6%	86-113%	0	0	466	10	0	246	77-121%	0
NO_3-N	179	99.9%	89-109%	0	0	557	16	5	100	76-117%	0
TKN (Nicotinic)	201	97.1%	81-114%	6	0	174	17	0	156	61-140%	0
TKN (NH_4)	269	99.8%	69-131%	0	0						
TKN (Glyceine)	269	99.6%	83-118%	2	0						
PO_4-P	174	99.3%	85-123%	0	0	307	6.5	0	133	72-111%	5
TDP/TP	150	99.7%	63-138%	0	0	272	9.5	1			
TSS	166	96.5%	72-111%	1	0	385	12	3			

Table 1.2A. Exova Laboratory quality-control data assessment in 2010.

	Control samples					Lab blank	Duplicate samples		
Parameter	Sets	Level	Historic run mean	Historic run control limit	Sets failed	Sets failed	Sets	% RSD	Sets failed
EC	106	Low	100.00%	92.11-107.89%	0	0	101	10	0
	110	High	100.00%	95.62-104.38%	0				
Cl	84	Low	99.60%	90.01-109.99%	0	0	110	10	2
	92	High	100.55%	94.10-107.00%	1				
NH_3-N	98	Low	98.75%	91.25-106.25%	0	0	74	10	1
	100	High	100.32%	92.34-100.32%	0				
NO_3-N	109	Low	100.00%	90.01-109.99%	0	0	83	10	4
	57	High	100.00%	95.10%-104.90%	0				
TN	101	Trace	104.50%	86.00%-123.00%	0	0	101	10	3
	55	Mid	100.27%	90.27%-110.27%	0				
	95	High	98.83%	87.19-110.47%	0				
PO_4-P	59	Trace	100.00%	79.99%-120.01%	0	0	86	10	2
	80	Low	96.88%	80.00%-113.76%	0				
TDP/TP	58	Low	100.00%	79.99-120.01%	0	0	83	10	3
	44	Mid	100.00%	90.01-109.99%	5				
TSS	90	Low	97.50%	75.00%-120.00%	0	0	89	10	11
	92	High	99.49%	94.36-104.62%	2				

Inter-Laboratory Quality Control Assessment (ALS contract period)

The correlation coefficient (r) for the duplicate sample TN and TP measurements showed agreement between the ARD and ALS laboratories, the concordance coefficient (r_c) showed that the slope of the regression closely fell on the 1:1 line through the origin between both laboratories, and the two-sample t-test showed no significant difference between the two laboratories (Table 1.3A).

Table 1.3A. Collaborative laboratories evaluation of duplicate samples analyzed by Alberta Agriculture and Rural Development (ARD) and ALS laboratories in 2008.

		ARD Laboratory		ALS Laboratory		Two-sample t-test (without pooling variances)					
Parameter	n	Mean Rd.	SE	Mean Rd.	SE	DF	t	P^{z}	Significant difference	r	Concordance coefficient $(r_c)^{y}$
NH_3-N	7	<0.10		<0.05							
NO_3-N	7	<0.10		<0.05							
TN	7	0.571	0.0565	0.597	0.068	11	0.28	0.783	NO	0.850	0.824
PO_4-P	7	<0.010		<0.005							
TDP	7	<0.010		<0.005							
TP	7	0.0607	0.0103	0.065	0.010	11	0.31	0.766	NO	0.999	0.982

[z] Significance level of 0.05 was used.
[y] Lin 1989, 2000.

Results from blind reference-sample analyses indicated that 100% of the samples analyzed for NH_3-N, PO_4-P, TDP, and TP were within control limits (Figure 1.1A). One out of 16 analyzed for NO_3-N exceeded the laboratory control limits and one out of 15 analyzed for TN exceeded control limits.

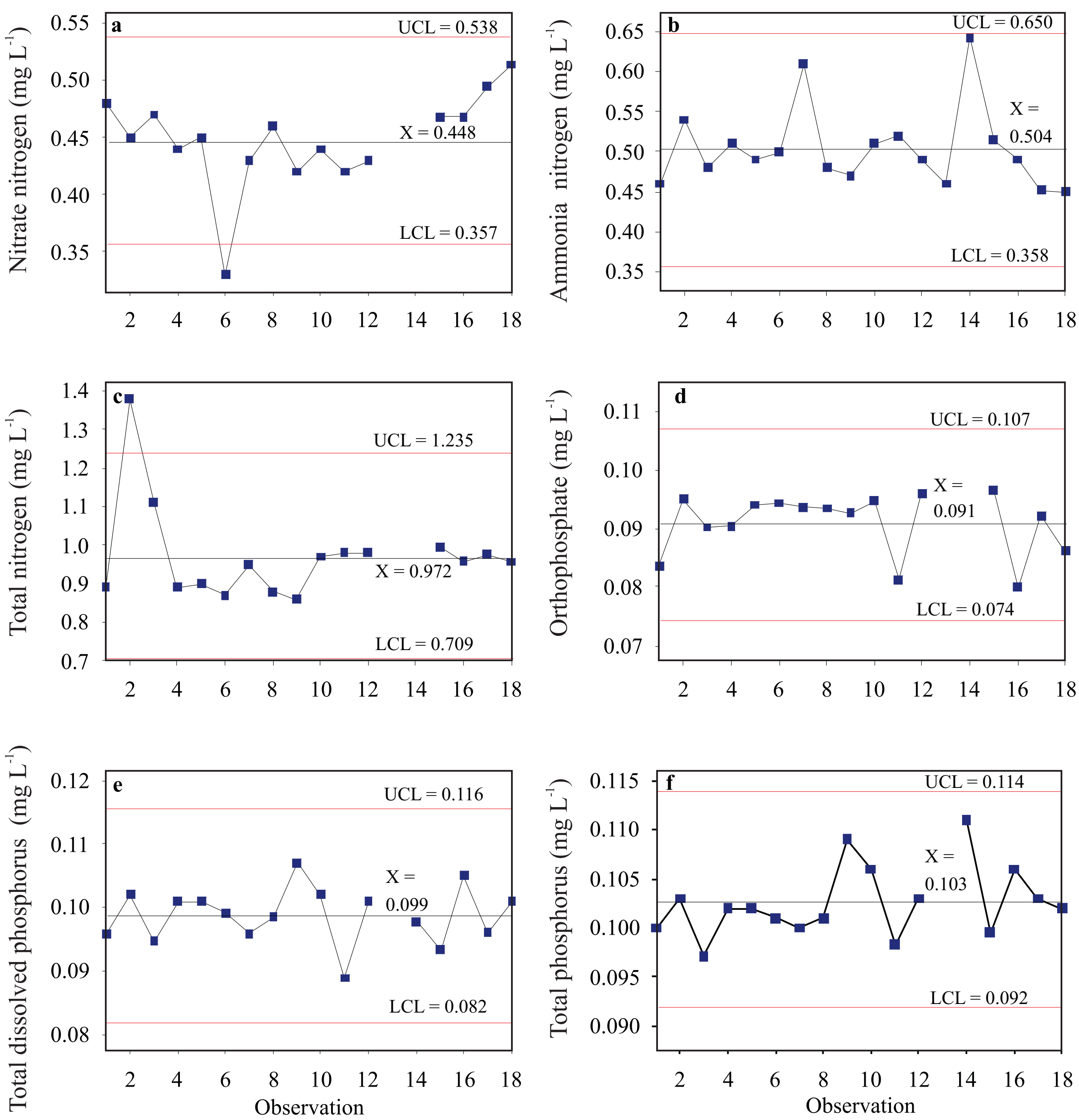


Figure 1.1A. Control chart of certified blind reference sample results from ALS Laboratory from 2008 to 2009 for (a) nitrate nitrogen, (b) ammonia nitrogen, (c) total nitrogen, (d) orthophosphate, (e) total dissolved phosphorus, and (f) total phosphorus. UCL = upper control limit, X = mean, and LCL = lower control limit.

Inter-laboratory Quality Control Assessment during Post-ALS Contract Period from January to March 2010

The ANOVA test at the 5% level showed there were no significant differences among the three laboratories for all parameters, except for pH (Table 1.4A). The TN analytical method passed the ANOVA test among the three laboratories and this suggests that the ARD, ALS, and Exova measurements are comparable and interchangeable in the post-ALS contract phase.

Table 1.4A. Collaborative laboratories evaluation of triplicate samples among the Alberta Agriculture and Rural Development (ARD), Exova, and ALS laboratories.

		ARD Laboratory		Exova Laboratory		ALS Laboratory				
Parameter	n	Mean Rd.	SE	Mean Rd.	SE	Mean Rd.	SE	df1/df2	F value	Significant difference between labs at 5% level (ANOVA)
pH	37	8.28	0.023	7.78	0.032	8.05	0.030	2/108	75.09	YES
EC	37	0.923	0.078	0.879	0.782	0.875	0.074	2/108	0.12	NO
Cl	37	24.82	2.76	23.72	2.687	24.00	2.715	2/108	0.04	NO
NH_3-N	37	1.334	0.258	1.373	0.264	1.326	0.251	2/90	0.01	NO
NO_3-N	37	2.644	0.796	2.577	0.791	2.478	0.709	2/84	0.01	NO
TN	37	5.402	0.716	5.396	0.731	7.125	0.688	2/108	1.96	NO
PO_4-P	37	1.228	0.189	1.252	0.198	1.154	0.177	2/105	0.07	NO
TDP	37	1.247	0.188	1.231	0.192	1.257	0.192	2/108	0.00	NO
TP	37	1.528	0.197	1.521	0.198	1.508	0.196	2/102	0.00	NO
TSS	37	65.34	32.56	55.31	26.19	37.34	11.75	2/75	0.32	NO

Examination of Total Nitrogen Analytical Methods in other Studies

The TN method using the Shimadzu TOC Instrument with TNM-1 Unit (TNs) is accurate and reliable for surface water samples when compared to calculating TN by a summation of TKN, NO_3-N, and NO_2-N (TNk) (Westerhoff et al. 2003; Au et al. 2005).

The regression equations between TNk and TNs established by ARD (Au et al. 2005) and Arizona State University (ASU) Laboratory (Westerhoff et al. 2003) showed very strong agreement (Table 1.5A), i.e., both methods were accurate and gave comparable and reliable measurements of TN in surface water samples.

Table 1.5A. TNk versus TNs relationship results from the Alberta Agriculture and Rural Development (ARD; Au et al. 2005) and Arizona State University (ASU; Westerhoff et al. 2003) laboratories.					
	n		r	r_c	Year
ARD Laboratory (TNk vs. TNs)	105	TNk = 0.0074 + 1.0405 × TNs	0.990	0.986	2005
ASU Laboratory (TNk vs. TNs)	110	TNk = -0.0384 + 0.9893 × TNs	0.995	N/A	2003

Examination of Total Nitrogen Analytical Methods between Three Laboratories during the Post-ALS Contract Period

The regression equations of TN between laboratories showed very strong relationships (Table 1.6A). However, the intercept values showed that the ALS method overestimated the TN values compared with ARD and Exova values in the post-ALS contract phase. The strongest relationship existed between the ARD and Exova Laboratory TN measurements, and this was similar to the ARD and ASU TN measurement relationship (Table 1.5A). This suggests that ARD and Exova TN measurements are comparable and interchangeable in the post-ALS contract phase.

Table 1.6A. Regression relationship between laboratories (post-ALS contract period from January 2010 to May 2010).				
	n		r	r_c
ALS(TNk) vs. ARD(TNs)	37	ALS(TNk) = 2.2855 + 0.90 × ARD(TNs)	0.932	0.859
ARD(TN_S) vs. Exova(TN_S)	54	ARD(TNk) = 0.01733 + 1.01 × Exova(TNs)	0.997	0.997
ALS(TNk) vs. Exova(TN_S)	126	ALS(TNk) = 1.46804 + 0.93 × Exova (TN_S)	0.967	0.951

Summary and Conclusions

There was good agreement between the ALS laboratory and ARD laboratory duplicate sample TN and TP concentrations and the blind reference samples were generally within the ALS control limits during the ALS contract period. There were no significant differences between the three laboratories for all parameters, except pH, in the post-ALS contract period. The TN regression relationships were strong for all three laboratories in the post-ALS contract period. The strongest relationship was between the ARD and Exova Laboratory TN measurements, and this relationship was similar to those found in other studies. These findings suggest that the change in the TN method upon switching laboratories from ALS to Exova did not result in a shift in the TN concentrations and this is evident when viewing the historical and current TN data at the outlet of Indianfarm Creek (Figure 1.2A). Therefore, the laboratory switchover was successful and the TN data does not require modifications in the post-ALS contract period.

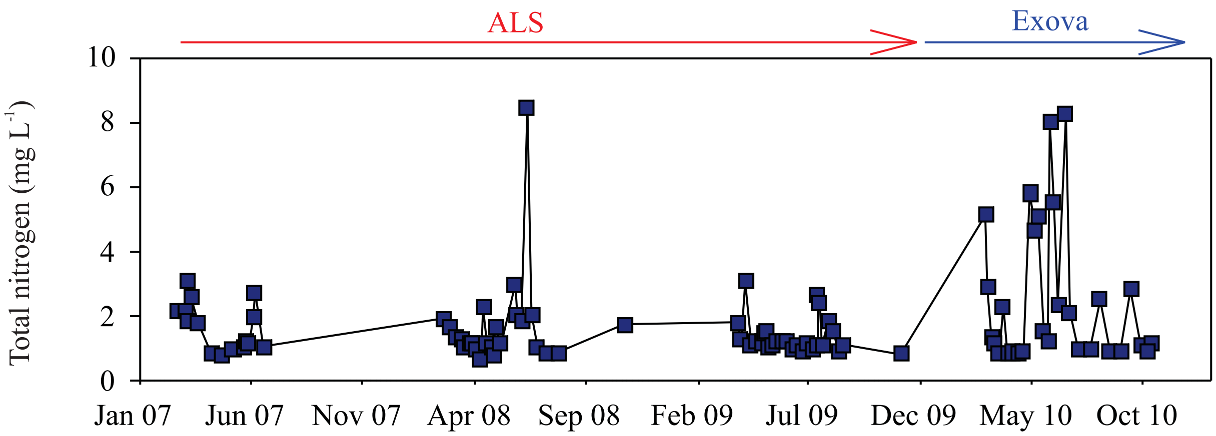


Figure 1.2A. Indianfarm Creek outlet total nitrogen (TN) concentration from 2007 to 2010. ALS Laboratory TN data are shown from 2007 to 2009 and Exova TN data are shown for 2010.

Appendix 2. Riparian Control Transect Data

Background

The establishment of the four riparian control transects is described in Section 2.5.1.5. The control transects were surveyed on July 7, 2010. The plant species found within the control transects are shown in Table 2.1A. The transect diversity is shown in Table 2.2A. The control transects will be surveyed again in 2011 to provide a reference to the riparian transects at the Impoundment, Pasture, and Wintering beneficial management practices sites. These reference transects will provide insight into the year-to-year natural variability of species presence and diversity.

Table 2.1A. Average species percent cover (%) and number of quadrats the species was present at the riparian control transects in 2010.

Species	Average % cover ± standard deviation	Number of quadrats species present[z]
Achillea millefolium	3 ± 2.8	2
Agropyron smithii	15 ± 10	4
Artemisia sp.	5 ± 0	2
Aster sp.	4 ± 4.3	9
Bromus inermis	29 ± 22.1	22
Carex sp.	30	1
Cirsium arvense	4 ± 1.3	4
Elaeagnus commutata	9 ± 3.8	5
Equisetum arvense	1 ± 0	3
Fragaria virginiana	2 ± 1.7	5
Geranium viscosissimum	3 ± 0.7	2
Juncus balitcus	15	1
Linaria vulgaris	7	1
Phleum pretense	3 ± 1.7	4
Poa pratensis	29 ± 11	7
Rosa acicularis	22 ± 17.3	23
Rumex sp.	6 ± 6.4	2
Salix exigua	8 ± 9.9	2
Smilecina stellata	7 ± 2.4	4
Solidago canadensis	8 ± 4.2	7
Symphoricarpos occidentalis	31 ± 15.8	24
Taraxacum officinale	3 ± 2.8	2
Trifolium sp.	40	1
Vicia americana	2 ± 1.6	6

[z] Total number of quadrats was 32 in 2010.

Table 2.2A. Shannon Diversity Index (H) value for the riparian control transects in 2010.

Transect	H-value 2010
1a	-2.21
1b	-2.20
2a	-2.19
2b	-2.24
3a	-2.14
3b	-1.56
4a	-2.12
4b	-2.59

Appendix 3. Scientific and common names for riparian and range vegetation at the Impoundment, Pasture, and Wintering beneficial management practices sites in the Indianfarm Creek Watershed.

Scientific name	Common name
Achillea millefolium	Western yarrow
Agropyron cristata	Crested wheatgrass
Agropyron dasystachyum	Northern wheat
Agropyron intermedium	Intermediate wheatgrass
Agropyron smithii	Western wheatgrass
Antennaria aprica	Low everlasting
Arnica fulgens	Shining arnica
Artemisia frigida	Fringed sage
Artemisia ludoviciana	Prairie sage
Aster ericoides	White prairie aster
Aster falcatus	Tufted white aster
Astragulus americanus	American vetch
Astragulus dasyglottis	Purple milk vetch
Bromus inermis	Smooth brome
Carex	Carex
Carex atherodes	Awned sedge
Cirsium arvense	Canada Thistle
Dactylis glomerata	Orchard grass
Descurainia sophia	Flixweed
Eleocharis erythropoda	Rush
Elymus repens	Quack grass
Erigeron casepitosus	Tufted fleabane
Festuca campestris	Idaho fescue
Fragaria virginiana	Strawberry
Geum triflorum	Three flowered aven
Gutierrezia sarothrae	Broomweed
Juncus balticus	Baltic rush
Koeleria macrantha	June grass

Scientific name	Common name
Linaria vulgaris	Toad flax
Medicago sativa	Alfalfa
Melilotus officinalis	Sweet clover
Mentha arvensis	Wild mint
Monarda fistulosa	Horse mint
Muhlenbergia cuspidata	Plains muhly
Oxytropis sericea	Early loco-weed
Penstomen procerus	Beard tongue
Phlox hoodsii	Hooded phlox
Poa compressa	Canada bluegrass
Poa pratensis	Kentucky Blue
Potentilla concinna	Early cinquefoil
Potentilla hippiana	Woolly cinquefoil
Potentilla pensylvanica	Prairie cinquefoil
Puccinellia nuttalliana	Alkali grass
Rosa acicularis	Prairie rose
Salix exigua	Sandbar willow
Scirpus microcapus	Bulrush
Shepherdia canadensis	Silver berry
Solidago canadensis	Graceful goldenrod
Sphaeralcea coccinea	Mallow
Stellaria longipes	Chickweed
Stipa comata	Needle and thread
Stipa viridula	Green needle
Symphoricarpos occidentalis	Snowberry
Tragopogon dubius	Goats beard
Urtica dioica	Stinging nettle

Appendix 4. Example of a Nutrient Management Plan

Nutrient management plans (NMPs) were developed for several of the beneficial management practices (BMPs) sites in the Indianfarm Creek Watershed and the Whelp Creek Sub-watershed, as well as for the Battersea Drain Field and the Lower Little Bow River Field sites. The NMPs were developed either for the application of inorganic fertilizer or livestock manure. General agronomic principles were used to develop the NMPs. Soil-test samples were collected from the 0- to 60-cm layer to determine nitrogen (N) phosphorus (P) status of soils. The Alberta Farm Fertilizer Information and Recommendation Manager (AAFIRM) program (AAFRD 2005b) was used to developed nutrient recommendations. Soil-test results, as well as other soil information, previous crop type, crop type to be grown, fertilizer price, and expected crop sale price were entered into AFFIRM to generate nutrient recommendations. Manure application rates were calculated based on the AFFIRM output results when appropriate. However, at many of the BMP sites, little or no N was required, and generally P was adequate for optimum crop growth. Under these conditions, manure was applied based on the one or more years of total P removal by the crop. Laboratory results of manure sample analysis and assumptions on the availability of N and P in manure to crops were used to determine the final application rates for manure.

The following is an example of the NMP developed for the West Field site in the Whelp Creek Sub-watershed for the 2010 crop year. The crop in 2010 was wheat and chicken manure was the nutrient source. Manure was applied in spring 2010.

1. AAFIRM Results

<u>INPUT</u>

Legal land location: NW7-40-27-W4 **Soil Group:** Black Northwest

Fertilizer cost[z] **($ kg^{-1}):** **N** 1.06 **P** 0.73 **K** 0.99 **S** 0.44

Crop: CWRS wheat (2010) **Sale price**[y] **($ Mg^{-1}):** 131.89
Previous crop: Canola (2009) **Yield ($Mg\ ha^{-1}$):** 3.08 **Tillage:** conventional
Residue management: baled **Manure applied:** yes **Irrigation:** no

Soil test values[x]**:**

Depth (cm)	**NO_3-N**	**P**	K	**S**	**pH**	**EC ($dS\ m^{-1}$)**	**Texture**
	---------- (mg kg^{-1})	----------					
0-15	6.56	36.7	n/a	n/a	6.5	1	medium
15-30	2.99	21.2	n/a	n/a	6.5	1	medium
30-60	1.06	10.1	n/a	n/a	6.5	1	medium

Soil test organic matter (%): 6.5 **Spring soil moisture:** medium

Investment ratio: 1 to 1

OUTPUT

Nutrient recommendations:

Crop	Moisture level	N	P_2O_5	K_2O	S	Predicted yield
		----------	---------- (kg ha^{-1})	----------	----------	(Mg ha^{-1})
wheat	wet	168	0	n/a	n/a	3.2
	medium	134	0	n/a	n/a	4.0
	dry	101	0	n/a	n/a	4.9

[z] Source: unknown
[y] Source: unknown
[x] Results from soil samples collected on October 7, 2009.

An investment ratio of 2-to-1 is often used for fertilizer recommendation. This means that for the last dollar spent on fertilizer, a return of $2 is released. The 2:1 ratio allows for some risk if full yield potential is not obtained. For manure owned by the producer, we do not have to worry about the economic risk factor and can go for maximum yield. Therefore, an investment ratio of 1-to-1 was used.

2. Manure Nutrient Content

Average (n = 6) nutrient content of chicken manure samples collected on February 18, 2010. Values are expressed on a weight-wet basis.

Moisture	NH_4-N	Total N	Total P
(%)	----------	(kg Mg^{-1})	----------
48.3	6.5	41.7	9.6

3. Assumptions

- Manure moisture and nutrient content did not change since February
- 55% of the organic N was mineralized (becomes available for crop use)
- 50% of the NH_4-N was lost after application (or 50% is retained) for cool, dry conditions.

4. Calculations

Based on text book numbers from the Canadian Fertilizer Institute (2001), spring wheat (harvested portion) will remove an average of 11.5 kg ha^{-1} P based on a yield of 2.7 Mg ha^{-1}. A target yield of 4.0 Mg ha^{-1} (based on the N recommendation above for medium spring moisture) would remove about 17.0 kg ha^{-1} P.

Nitrogen is recommended; whereas, P is not recommended. The application of manure will result in an over application of P for at least the first crop year after manure application. Soil-text P is not excessive at this site. The frequency of manure application for this site will be 3 to 4 yr. In order to prevent STP from accumulating in the soil, application was based on 4 yr of P removal.

Total P application: $17.0\ kg\ ha^{-1}\ yr^{-1}\ \ 4\ yr = 68\ kg\ ha^{-1}$

Manure rate: $68\ kg\ ha^{-1}\ \ 9.6\ kg\ Mg^{-1} = 7.1\ Mg\ ha^{-1}$

5. Post-application Results

Details: 12 loads applied
8074 kg per load (8.1 Mg per load)
13.7 ha of land
7.1 Mg ha^{-1} application rate
Applied April 15 and 16, 2010 and incorporation was delayed 1 wk.

The actual application rate was the same as the recommended application rate for a 4-yr application of P removal. However, the manure was applied 2 mo after the manure was sampled in February. The manure was sampled a second time on April 14, 2010 prior to application and the results were:

Moisture	NH_4-N	Total N	Total P
(%)	----------	(kg Mg^{-1})	----------
27.8	9.1	37.1	12.8

The amount of total P applied in the 2010 crop year, based on the April analysis:

Total P: 12.8 kg Mg^{-1} 7.1 Mg ha^{-1} = 91 kg ha^{-1}

The amount of crop N available in the 2010 crop year, based on the April analysis:

Organic N mineralized: (37.1 kg Mg^{-1} – 9.1 kg Mg^{-1}) 0.55 = 15.4 kg Mg^{-1}
NH_4-N retained: 9.1 kg Mg^{-1} 0.5 = 4.6 kg Mg^{-1}
Crop N: 15.4 kg Mg^{-1} + 4.6 kg Mg^{-1} = 20 kg Mg^{-1}
Total Crop N applied: 20 kg Mg^{-1} 7.1 Mg ha^{-1} = 142 kg ha^{-1}

Instead of a 4-yr application of crop P removal, about 5 yr of crop P removal was applied. The higher amount was caused by the drier condition of the manure at the time of application (27.8%) compared to when manure was sampled in February (48.3%). Based on medium moisture conditions during the crop year, the fertilizer N recommendation was 134 kg ha^{-1}. Therefore, the amount of crop N expected to become available during the 2010 crop year was slightly higher at 142 kg ha^{-1} from an application rate of 7.1 Mg ha^{-1}.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