was calculated individually for each PFRA watershed assuming that all units of land in a watershed were allowed to export the same amount of phosphorus per unit area.

Concentration of TP in runoff from a specific soil polygon (TP_i) within a watershed is a function of polygon TP total load (l_i) and polygon runoff volume (q_i), and is defined as,

$$TP_i = (l_i / q_i) \times 1000 \quad (6)$$

Where:
TP_i = concentration of TP in runoff from a soil polygon (mg L^{-1})
l_i = TP load from a soil polygon (kg). The subscript (i) is the soil-polygon number
q_i = soil-polygon annual average runoff volume (m^3)

Also, l_i can be expressed as,

$$l_i = L_{ex} \times a_i \quad (7)$$

Where
a_i = polygon drainage area (m^2)

When Equation 4 was entered into Equation 7, the total load of TP for a soil polygon (l_i) was calculated as

$$l_i = ((Q \times TP/1000) / A) \times a_i \quad (8)$$

A runoff factor (RF_i) was calculated for each soil polygon (i) using Equation 9. The RF_i value was calculated using the output from WEPP hydrologic modelling.

$$RF_i = D_{WEPP} / d_{WEPPi} \quad (9)$$

Where:
D_{WEPP} = watershed WEPP predicted average annual runoff depth (mm)
d_{WEPPi} = soil-polygon WEPP predicted average annual runoff depth (mm)

The D_{WEPP} value was calculated as follows.

$$D_{WEPP} = (\sum q_{WEPPi} / A) \times 1000 \quad (10)$$

The q_{WEPPi} value was calculated as follows.

$$q_{WEPPi} = (d_{WEPPi} \times a_i) / 1000 \quad (11)$$

The RF_i term represents the relative difference in runoff potential among soil polygons within a specific watershed. An RF_i value greater than one indicates that a specific soil polygon has a runoff potential lower than the average mean of the entire watershed, and the reverse is true when the RF_i value is less than one.

Soil-polygon q_i was computed as

$$q_i = (a_i \times d_i)/1000 \quad (12)$$

Where:
d_i = soil-polygon annual unit runoff depth (mm)

A specific soil-polygon adjusted annual unit runoff (d_i) can be estimated as

$$d_i = D / RF_i \quad (13)$$

Where:
D = watershed annual unit runoff depth (mm) = (Q/A) x 1000

When Equations 8 and 12 were entered into Equation 6 and the equation simplified, the a_i variable was cancelled out, Q and A converted to D, and D and d_i converted to RF_i. The resulting weighted concentration limit (TP_i) in runoff from a polygon was a function of the TPRWQL (TP) and the associated soil-polygon runoff factor (RF_i).

$$TP_i = TP \times RF_i \quad (14)$$

In the final calculation of TP_i, the equation does not rely on the predicted accuracy of runoff; rather, it relies on the relative accuracy used to allocate measured runoff volumes among the soil polygons. The calculated TP_i in Equation 14 was then substituted into the measured field-scale relationship between STP and runoff TP FWMC shown in Equations 1 and 3.

The application of the STP limit method at the microwatershed scale was similar to the application at the watershed scale. Analogous calculations were repeated using the microwatershed annual unit runoff and water quality limit data. At this scale, the microwatershed runoff volume (q_i) was estimated by multiplying the calculated annual unit runoff of the corresponding soil-polygon and microwatershed drainage area. The microwatershed TP was based on allowed runoff TP concentration calculated for the soil polygon where the microwatershed was located. Next, the hillslope polygon TP values within microwatersheds were adjusted according to runoff potential.

In addition to the STP calculations, the method outlined in Equation 8 allows computation of the maximum load of TP (l_i) for each soil polygon. Current l_i calculations were based on the total discharge flow (Q) observed at the watershed outlet, and were further modified for each soil polygon within the watershed according to the calculated runoff factor (RF_i). These calculations most likely overestimated the l_i values since the TP term in the annual TP export coefficient (L_{ex}) calculation (Equation 4) corresponds to the total flow (assumed $Q_s = Q$), as it was assumed there was no base flow contributions. Forrest et al. (2004) found that TP $FWMC_{Qb}$ in shallow groundwater (< 30 m) in Alberta ranged from 0.001 to 2.346 mg L^{-1}, and its median value was 0.043 mg L^{-1}. These values were much lower than the TP $FWMC_{Qs}$ reported by Little et al.

(2006) and Depoe (2004). These observations suggest that l_i and STP limits should be based on TP FWMC$_{Qs}$, which can be calculated as TP FWMC$_{Qs}$ = ((TP FWMC x Q) - (TP FWMC$_{Qb}$ x Q_b)) / Qs. This approach would account for dilution effects due to lower TP FWMC$_{Qb}$ and would result in lower l_i and higher STP for the same water quality limit. However, additional research is required to collect field TP FWMC$_{Qb}$ data, which are required to separate Q into Q_s and Q_b components.

APPLICATION OF CALCULATION PROCEDURE

Approach

Seven watersheds were chosen to illustrate the proposed method of calculating STP limits at the PFRA watershed scale: Colquhoun Creek (*CC*), Wabash Creek (*WC*), Buffalo Creek (*BC*), Threehills Creek (*TC*), Mosquito Creek (*MC*), and Kennedy Coulee (*KC*). These watersheds represent areas of runoff depth ranging from 1 to 100 mm throughout Alberta (Fig. 6).

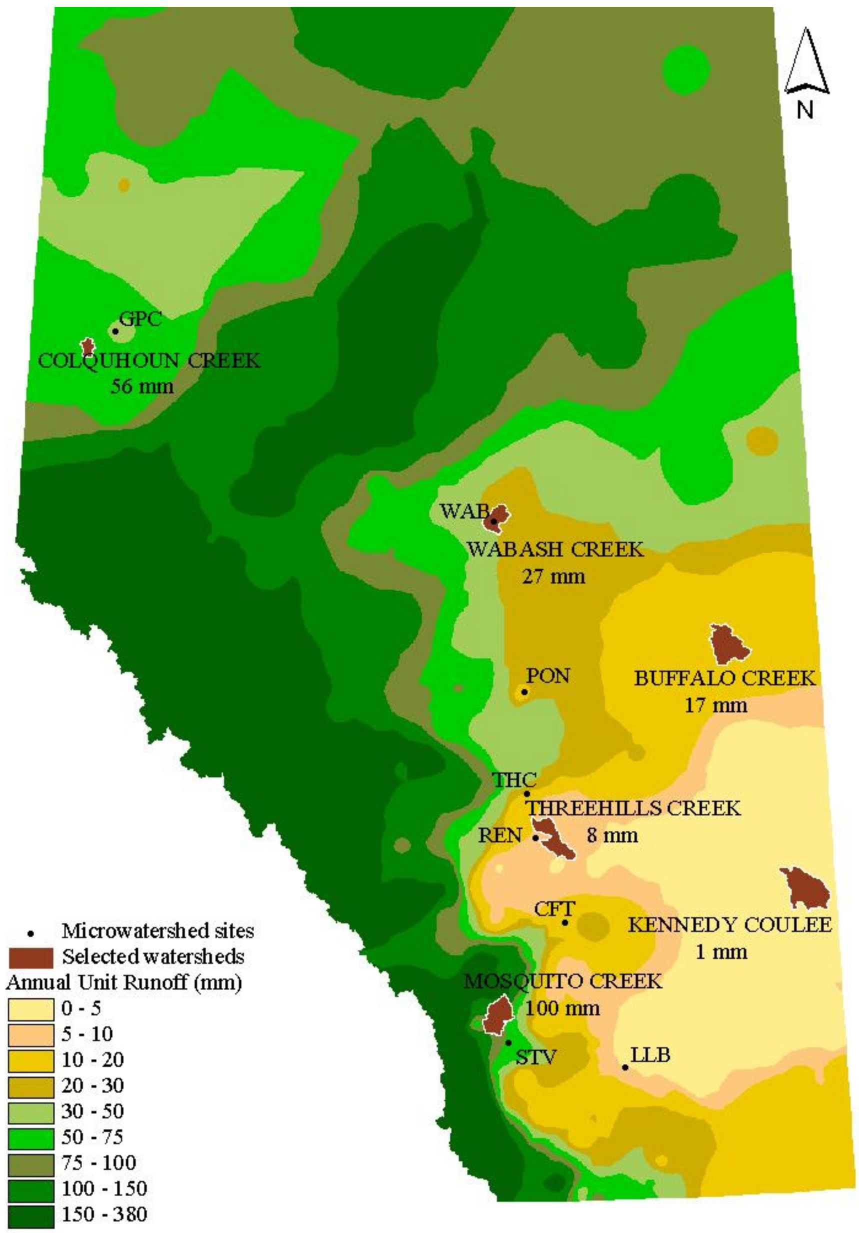


Fig. 6. Location of selected microwatersheds and watersheds used to demonstrate the calculation of soil phosphorus limits.

The TP load and STP limit calculations are shown in Appendices 1 and 2. Calculations were conducted separately for the 0.5 mg L^{-1} (Appendix 1) and 1.0 mg L^{-1} (Appendix 2) watershed-scale TPRWQLs. Initially, the annual runoff volume (Q) was calculated using Equation 5, and the TP export coefficient (L_{ex}) was calculated using Equation 4 for each watershed. Then the WEPP-predicted runoff depths (d_{WEPPi}) were entered for all watershed soil polygons to calculate WEPP-predicted average runoff volume for the polygons (q_{WEPPi}) using Equation 11 and the WEPP-predicted runoff depth for the watershed (D_{WEPP}) using Equation 10. Next, a runoff factor (RF_i) was computed for each soil polygon using Equation 9. Finally, the soil-polygon-adjusted runoff depths (d_i), using Equation 13, allowable TP concentrations (TP_i), using Equation 14, and STP limits (STP_i), using Equations 1 and 3, were calculated. The allowed TP load (l_i) assigned to each soil polygon was estimated by multiplying soil-polygon area (a_i) and the TP export coefficient (L_{ex}) using Equation 7. Since the L_{ex} is uniform for the entire watershed, the l_i limits were directly proportional to a_i.

In addition to the calculation of STP limits at the watershed scale, similar calculations were conducted for the seven microwatersheds (Fig. 6). Within each microwatershed, a number of hillslope polygons were identified using the Geo-spatial interface for WEPP model called GeoWEPP (Renschler et al. 2002). Each polygon was represented by hillslope steepness and its length, based on the terrain analysis of the site-specific 5-m grid resolution of the DEM data. For the calculation of microwatershed STP limits, the soil-polygon scale water quality limits (TP_iWQL) and annual unit runoff (d_i) were derived directly from the corresponding AGRASID soil polygon TP_i for the specific microwatersheds. The soil-polygon TP_i and d_i values became the water quality limit and runoff depth for the microwatersheds. The calculated L_{ex}, RF_{ii}, d_{ii}, TP_{ii}, STP_{ii}, and l_{ii} values are listed in Appendices 3 and 4. The (ii) index indicates microwatershed resolution of the hillslope polygons.

The STP limit calculations were also conducted for all soil polygons in the agricultural zone of Alberta. The TPRWQLs of 0.5 and 1.0 mg L^{-1} were also selected as the target concentrations for the total surface runoff volume in each watershed, as discussed previously.

Results and Discussion

Results of the STP method application shown in Appendices 1, 2, 3, and 4 indicate that the selection of TPRWQL had a major impact on calculated STP limits. The range of L_{ex}, TP_i, STP_i, and l_i values more than doubled when the TPRWQL was increased from 0.5 to 1.0 mg L^{-1}. However, there was very little difference between the calculated results from the $STP_{0\text{-}2.5}$ and $STP_{0\text{-}15}$ equations. The $STP_{0\text{-}2.5}$ equation generally predicted higher STP values than the $STP_{0\text{-}15}$ equation. This was not surprising since STP concentration in soil often decreases with depth (Sharpley 1985; Guertal et al. 1991; Crozier et al. 1999). Little et al. (2006) found no significant differences among the slopes of the relationships between STP at the different depths and TP FWMC in runoff at the Microwatershed Study sites.

Table 1 shows the summary of the calculated TP_i and STP_i values for the selected watersheds. Within the table, the L_{ex} values relate directly to the selected TPRWQL and watershed runoff depth. The increment of the L_{ex} value in a specific watershed is proportional to the increase of

TPRWQL. For the 0.5 mg L^{-1} TPRWQL, the *TP allow* mean concentration in runoff ranged from 0.50 to 0.75 mg L^{-1}. For the 1.0 mg L^{-1} TPRWQL, the *TP allow* mean concentration in runoff ranged from 1.01 to 1.50 mg L^{-1}.

Table 1. Summary of calculated TP_i and STP_i limits at the selected PFRA watersheds.

PFRA watersheds[z]		*BC*	*CC*	*KC*	*MC*	*TC*	*WC*
Number of soil polygons		80	24	148	91	125	35
D_i (mm)		17	56	1	100	8	27
TP runoff water quality limit = 0.5 mg L^{-1}							
L_{ex} (kg m^{-2})		8.50E-06	2.80E-05	5.00E-07	5.00E-05	4.00E-06	1.35E-05
TP_i *allow* (mg L^{-1})	Min.	0.27	0.26	0.19	0.20	0.20	0.19
	Max.	4.47	1.53	3.17	4.23	2.21	0.79
	Mean	0.70	0.62	0.67	0.68	0.75	0.50
$STP_{i\ 0\text{-}2.5}$ (mg kg^{-1})	Min.	18	17	12	13	13	11
	Max.	341	115	241	322	167	58
	Mean	51	45	48	49	55	36
$STP_{i\ 0\text{-}15}$ (mg kg^{-1})	Min.	8	7	2	3	3	2
	Max.	308	98	215	291	146	45
	Mean	39	33	36	37	42	25
TP runoff water quality limit = 1.0 mg L^{-1}							
L_{ex} (kg m^{-2})		1.70E-05	5.60E-05	1.00E-06	1.00E-04	8.00E-06	2.70E-05
TP_i *allow* (mg L^{-1})	Min.	0.54	0.53	0.38	0.41	0.41	0.37
	Max.	8.94	3.06	6.34	8.46	4.42	1.58
	Mean	1.40	1.24	1.34	1.36	1.50	1.01
$STP_{i\ 0\text{-}2.5}$ (mg kg^{-1})	Min.	39	38	26	28	28	26
	Max.	685	232	485	648	337	119
	Mean	105	92	100	102	112	74
$STP_{i\ 0\text{-}15}$ (mg kg^{-1})	Min.	27	26	16	18	18	15
	Max.	627	207	441	593	304	102
	Mean	89	77	84	86	96	60

[z] *CC* = Colquhoun Creek, *WC* = Wabash Creek, *BC* = Buffalo Creek, *TC* = Threehills Creek, *MC* = Mosquito Creek, and *KC* = Kennedy Coulee.

The associated $STP_{i\ 0\text{-}2.5}$ mean and $STP_{i\ 0\text{-}15}$ mean values for the 0.5 mg L^{-1} TPRWQL ranged from 25 to 55 mg kg^{-1} (Table 1). These STP values are below 60 mg kg^{-1}, which is generally considered the agronomic threshold in the 0- to 15-cm soil layer (Howard 2006). As a result, the calculated STP limits indicate potential challenges for soil-phosphorus management in these watersheds when 0.5 mg L^{-1} TPRWQL was used. However, when the TPRWQL was increased to 1.0 mg L^{-1}, the calculated $STP_{i\ 0\text{-}2.5}$ mean and $STP_{i\ 0\text{-}15}$ mean values ranged from 60 to 112 mg kg^{-1}.

There was a wide range between the calculated minimum and maximum STP limits within each watershed. For example, in the *BC* watershed, the $STP_{i\ 0\text{-}2.5}$ ranged from 18 to 341 mg kg^{-1} and $STP_{i\ 0\text{-}15}$ ranged from 8 to 308 mg kg^{-1}. The range of STP limits was even larger when the TPRWQL increased from 0.5 to 1.0 mg L^{-1}. The magnitude of the STP variance was also directly related to runoff potential within each watershed. Watersheds that had more uniform soil and landscape conditions had a smaller variance of runoff and STP values among soil polygons.

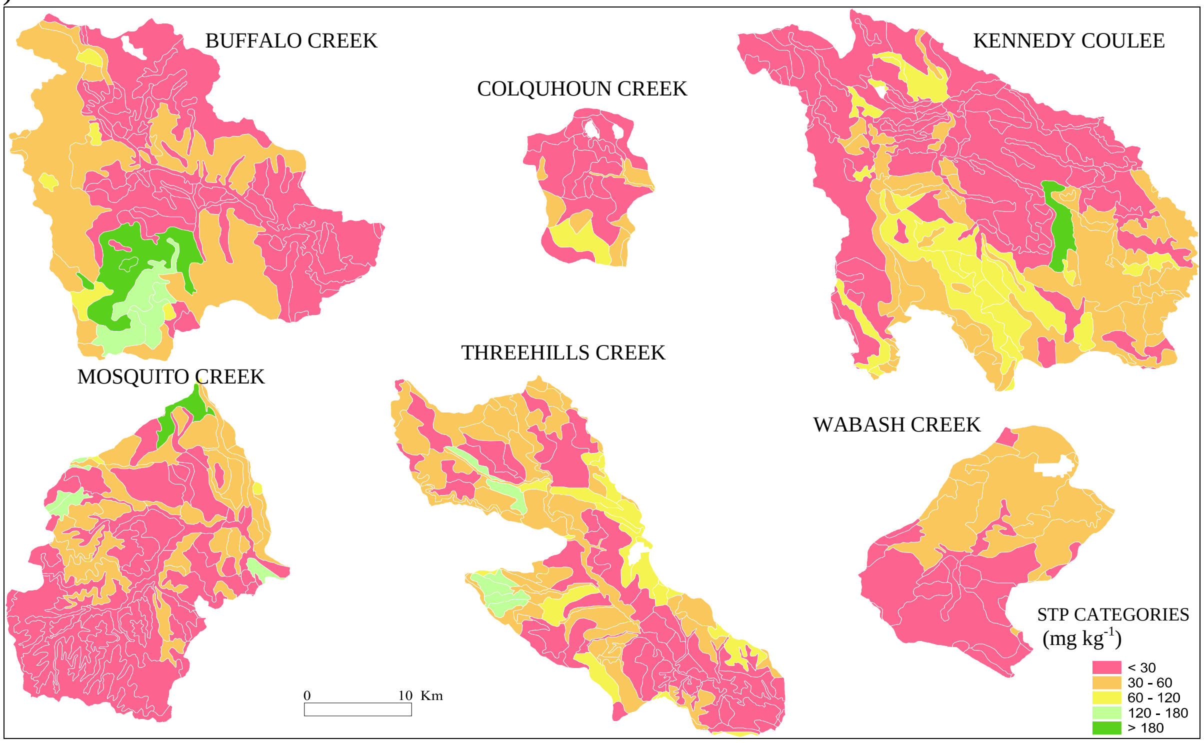
The distribution of STP values within a watershed was also related to runoff potential among soil polygons. Based on the principles of the proposed STP limit calculation method, the minimum STP values relate to polygons with high runoff potential and the computed STP limits in these areas were below the agronomic crop requirements. The opposite was true for polygons with low runoff potential where calculated STP limits were greater than agronomic crop requirements (Fig. 7).

The calculated mean STP limits among selected watersheds do not relate to the differences in runoff depth among watersheds. For example, Kennedy Coulee (*KC*) and Mosquito Creek (*MC*) watersheds have similar STP ranges despite having different runoff potentials (Table 1). This phenomenon is related to the condition of the STP method, which assumes that all fields within a watershed export the same TP amount per watershed unit area (L_{ex}). The L_{ex} coefficient is calculated for each watershed separately by multiplying the TPRWQL with the watershed runoff volume per its drainage area (runoff potential). Since the TPRWQL has the same value among watersheds, the L_{ex} coefficient is directly proportional to the runoff potential of each watershed. For example, the L_{ex} at the *KC* watershed is 100 times smaller than at the *MC* watershed because it also has a runoff depth 100 times lower than the *MC* watershed. Ultimately, the *MC* watershed will be allowed to export 100 times more phosphorus than the *KC* watershed, despite the fact that both watersheds use the same TPRWQL and have similar estimated STP limits (Fig. 7).

The TP_iWQLs for the selected microwatersheds ranged from 0.36 mg L^{-1} to 0.83 mg L^{-1} for the TPRWQL of 0.5 mg L^{-1} and from 0.72 mg L^{-1} to 1.67 mg L^{-1} for the TPRWQL of 1.0 mg L^{-1} (Table 2). When a TPRWQL of 0.5 mg L^{-1} was used, all microwatersheds had the calculated $STP_{ii\ 0\text{-}15}$ mean limits lower than 60 mg kg^{-1}, which was similar to the results from the watershed-scale STP calculations (Table 1). When a TPRWQL of 1.0 mg L^{-1} was used, only two out of seven microwatersheds had $STP_{ii\ 0\text{-}15}$ mean limits above 60 mg kg^{-1}. Figure 8 shows the distribution of estimated STP limits within the microwatersheds when Equation 3 (0- to 15-cm soil layer) was used.

The results of STP limit calculations for all soil polygons in the agricultural zone of Alberta are shown in Fig. 9, using Equation 3 (0 to 15 cm) and TPRWQLs of 0.5 and 1.0 mg L^{-1} as the target concentrations in the total runoff volume from each watershed. A summary of the calculated TP_i and STP_i at the soil-polygon scale is shown in Table 3. These results were categorized in five groups: STP < 30 mg kg^{-1}, STP >= 30 and < 60 mg kg^{-1}, STP >= 60 and < 120 mg kg^{-1}, STP >= 120 and < 180 mg kg^{-1}, and STP >= 180 mg kg^{-1}. This grouping illustrates the sensitivity of the STP equations and the selected TPRWQL values on the calculated TP and STP limits. At the TPRWQL of 0.5 mg L^{-1}, the majority of agricultural soils in the province were grouped into two STP categories < 60 mg kg^{-1}, which was lower than the agronomic threshold. However, with the TPRWQL of 1.0 mg L^{-1}, most of agricultural soils were grouped into STP categories >= 60 mg kg^{-1}. In the >= 180 mg kg^{-1} STP category, the mean TP_i values were greater than 8.0 mg L^{-1}, which was the maximum value used to developed the STP runoff TP equations (Little et al. 2006), and thus, TP_i values greater than 8 mg L^{-1} should not be used for the STP limit calculations.

(a)



(b)

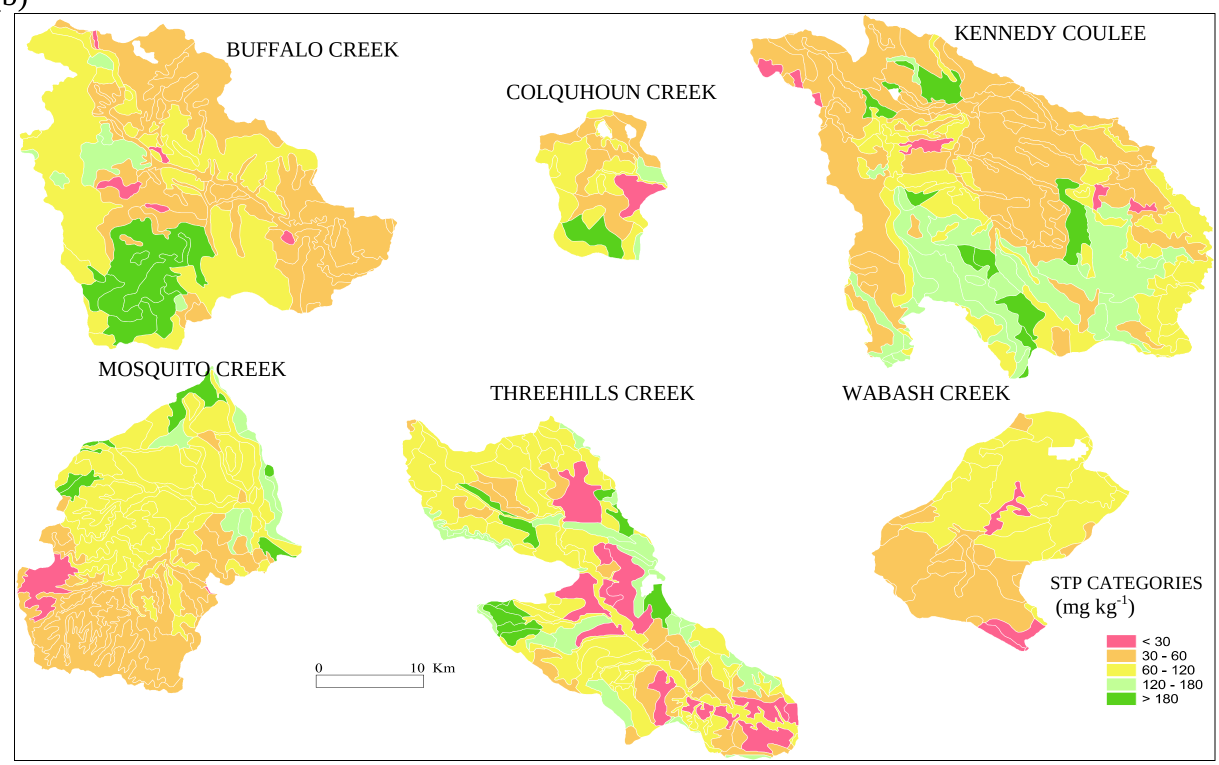


Fig. 7. Distribution of calculated soil-test phosphorus (STP) limits at the watershed level using Equation 3 (0- to 15-cm soil layer) and total phosphorus runoff water quality limits (TPRWQLs) of (a) 0.5 and (b) 1.0 mg L^{-1}.

Table 2. Summary of calculated TP_{ii} and STP_{ii} limits at the selected microwatersheds.

Selected microwatersheds		PON	REN	CFT	THC	GPC	LLB	WAB
d_i (mm)		19	13	18	25	50	*7*	27
				Watershed TPRWQL = 0.5 mg L⁻¹				
TP_i *WQL* (mg L^{-1})		0.36	0.52	0.83	0.74	0.50	0.51	0.46
TP_{ii} (mg L^{-1})	Mean	0.31	0.44	0.91	0.73	0.48	0.48	0.46
$STP_{ii\ 0\text{-}2.5}$ (mg kg^{-1})	Mean	21	31	67	53	34	34	33
$STP_{ii\ 0\text{-}15}$ (mg kg^{-1})	Mean	10	20	53	40	23	23	22
				Watershed TPRWQL = 1.0 mg L⁻¹				
TP_i *WQL* (mg L^{-1})		0.72	1.05	1.67	1.48	1.00	1.02	0.92
TP_{ii} (mg L^{-1})	Mean	0.47	0.70	1.83	1.35	0.90	0.96	0.72
$STP_{ii\ 0\text{-}2.5}$ (mg kg^{-1})	Mean	33	51	137	101	66	71	52
$STP_{ii\ 0\text{-}15}$ (mg kg^{-1})	Mean	22	39	119	85	53	57	40

Results of this initial approximation of STP limits calculated for the six selected watersheds (Appendices 1 and 2, Table 1, and Fig. 7) and for the microwatershed within each watershed (Appendices 3 and 4, Tables 2 and 4, Fig. 8) may cause challenges for soil-phosphorus management for agricultural production. A major challenge will be managing soils that have STP limits lower than the agronomic threshold of 60 mg kg^{-1} shown in Figs. 7, 8, and 9. The dilemma is that soil testing and fertilizer recommendations may indicate that some phosphorus application is required to achieve optimum crop yield; whereas, low phosphorus limits would require that little to no phosphorus be applied. The challenge is how can the addition of fertilizer phosphorus be managed for soils with low STP limits? Another major challenge is to compare STP limits to actual STP concentrations in the soil. For example, the calculated STP limits shown in Table 4 represent the soil polygon STP levels needed to meet the water quality limit for total runoff volume in each watershed based on the assumptions and methods used. If this is an area of intensive livestock production with a history of manure application, similar to the PON and LLB microwatersheds (Table 4), the actual STP values may be much greater than any of the calculated STP limits. The obvious course of action is to stop applying phosphorus; however, this leads to the challenge of what to do with manure if a land base for application is no longer available or is greatly reduced.

(a)

(b)

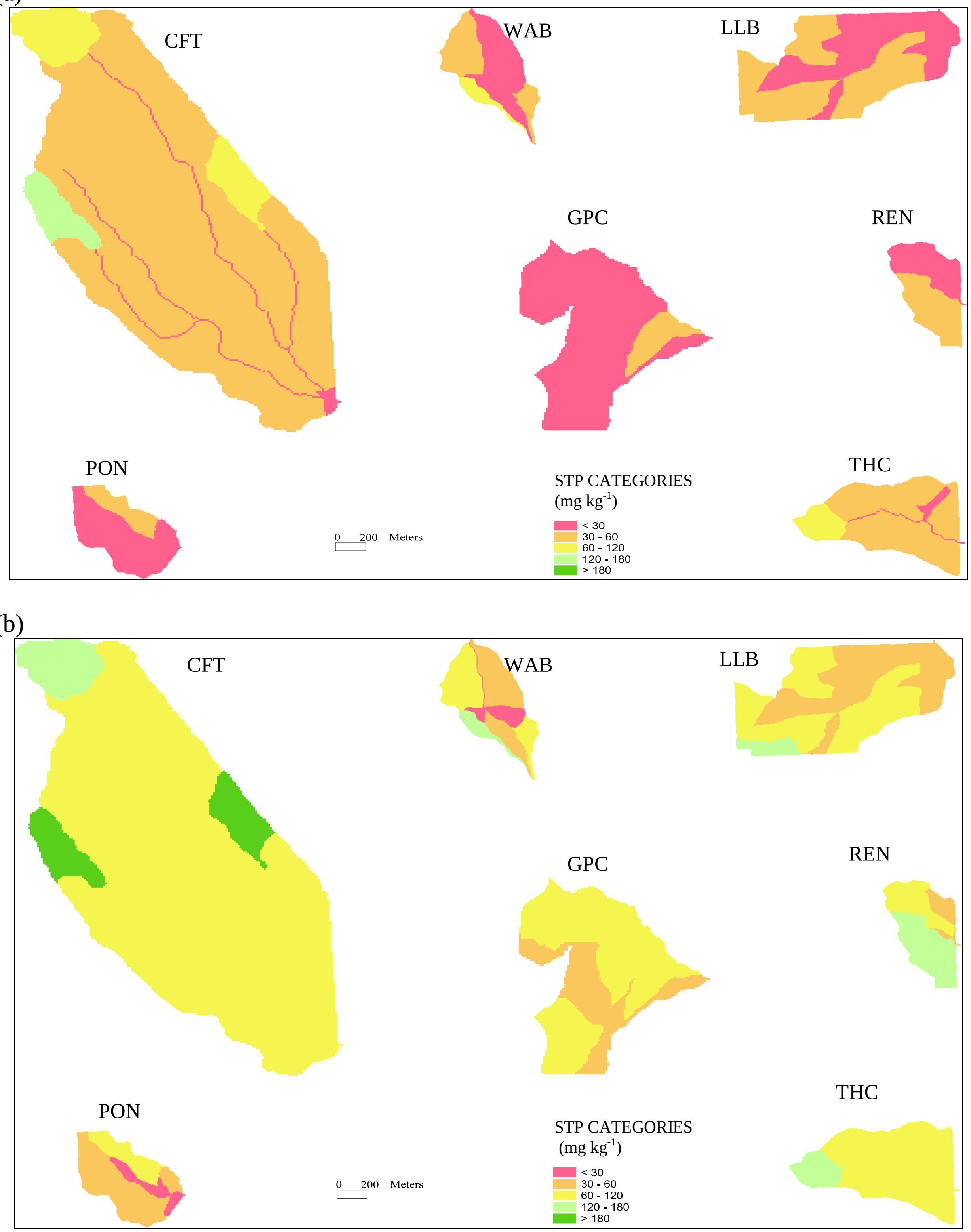


Fig. 8. Distribution of calculated soil-test phosphorus (STP) limits at the microwatershed level using Equation 3 (0- to 15-cm soil layer) and total phosphorus runoff water quality limits (TPRWQLs) of (a) 0.5 and (b) 1.0 mg L^{-1}.

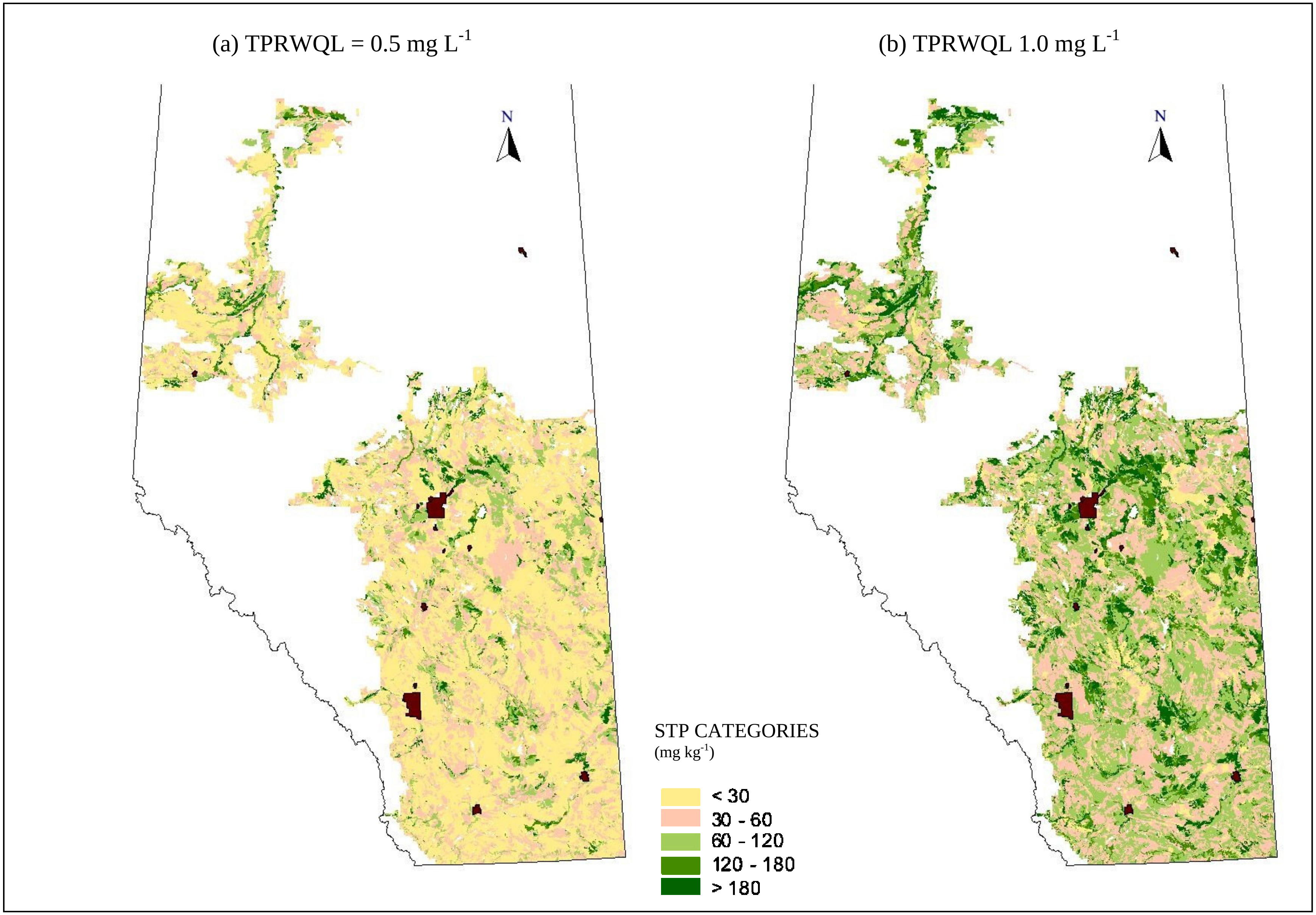


Fig. 9. Distribution of calculated soil-test phosphorus (STP) limits for agricultural soils in Alberta using Equation 3 (0- to 15-cm soil layer) and total phosphorus runoff water quality limits (TPRWQLs) of (a) 0.5 and (b) 1.0 mg L^{-1}.

Table 3. Distribution of calculated soil-test phosphorus (STP) limits for all AGRASID soil polygons in the agricultural zone of Alberta using different total phosphorus runoff water quality limits (TPRWQLs) and STP models.

Water quality limit	TPRWQL = 0.5 mg L^{-1}		TPRWQL = 1.0 mg L^{-1}	
STP equations	$STP_{0-2.5}$	STP_{0-15}	$STP_{0-2.5}$	STP_{0-15}
		STP < 30 mg kg^{-1}		
AGRASID area [z] (%)	29.4	55.7	2.4	7.7
Mean TP (mg L^{-1})	0.32	0.41	0.34	0.45
Mean STP (mg kg^{-1})	22	18	23	21
		STP >= 30 and < 60 mg kg^{-1}		
AGRASID area [z] (%)	47.2	27.9	24.0	35.6
Mean TP (mg L^{-1})	0.58	0.73	0.66	0.8
Mean STP (mg kg^{-1})	41	41	48	46
		STP >= 60 and < 120 mg kg^{-1}		
AGRASID area [z] (%)	16.9	11.3	49.3	37.8
Mean TP (mg L^{-1})	1.08	1.29	1.13	1.31
Mean STP (mg kg^{-1})	80	81	84	82
		STP >= 120 and < 180 mg kg^{-1}		
AGRASID area [z] (%)	3.5	2.7	12.6	9.9
Mean TP (mg L^{-1})	1.9	2.17	1.91	2.18
Mean STP (mg kg^{-1})	143	143	144	145
		STP >= 180 mg kg^{-1}		
AGRASID area [z] (%)	3.0	2.4	11.6	9.0
Mean TP (mg L^{-1})	12.26	14.42	8.81	10.56
Mean STP (mg kg^{-1})	NA [x]	NA	NA	NA

[z] Total agricultural area of soil polygons in AGRASID database = 24,768,750 ha.
[x] NA = not available because "Mean TP" values were beyond the range of the STP-TP relationship.

Table 4. Comparison between microwatershed measured and soil polygon calculated soil-test phosphorus (STP) values.

PFRA watershed ID	Soil polygon #	Micro-watershed name	Runoff depth (mm)		Allow TP (mg L^{-1})	STP in 0 to 15 cm (mg kg^{-1})	
			PFRA watershed	Soil polygon		Measured fall 2004	Calculated limit
07GE003	22260	GPC	50	50	1.00	27	60
07BC003	19653	WAB	27	29	0.92	25	54
05FA015	13124	PON	19	27	0.72	366	40
05CE018	13984	THC	25	17	1.48	23	94
05CE016	13938	REN	13	12	1.05	21	63
05BM008	6657	CFT	18	11	1.67	35	108
05AB041	10618	STV	69	75	0.92	4	54
05AC023	5931	LLB	7	7	1.02	242	61

SUMMARY AND CONCLUSIONS

A method was developed to calculate site-specific STP limits at watershed and microwatershed scales in Alberta. The method used STP and TP FWMC relationships, which were developed from Alberta-based field data, the WEPP hydrological model, and hypothetical runoff water quality limits of 0.5 and 1.0 mg L^{-1} TP. Two major assumptions were applied in the development of the method: (1) there is no base flow and surface flow volume is equal to the total flow volume from a watershed, and (2) each unit area within a watershed contributes equally to the TP load. The water quality limits were applied to the total runoff volume in the watershed prior to runoff entering the stream. The method uses a WEPP-calculated runoff factor instead of actual runoff depth to allocate the measured runoff volumes within each watershed. The proposed method can use either TP or DRP concentrations in runoff water to calculate STP limits.

In the proposed method, TPRWQLs for agricultural land were assigned at a watershed scale and WEPP model simulations were used to calculate runoff factors (RF_i) for all AGRASID soil polygons defined in each watershed. The soil-polygon scale represents the most detailed level of soil information that is available in Alberta. However, the soil-polygon boundaries do not follow landscape topography, which is associated with watershed or sub-watershed boundaries. To estimate the RF_i values at the sub-watershed scale, DEM data would be required as input in WEPP model simulations.

The proposed method most likely overestimated TP loads (l_i) because the ***TP*** term in the annual TP export coefficient (L_{ex}) calculation (Equation 4) corresponds to the total flow (Q), and it was assumed that TP concentrations in surface flow (TP $FWMC_{Qs}$) and in base flow (TP $FWMC_{Qb}$) were the same. In reality, the TP concentration in surface flow is higher than in base flow. As well, Q_s is often a larger portion of Q than Q_b. This suggests that TP loads and STP limits should be based on TP concentrations in surface flow. This approach would account for dilution by base flow and would result in lower TP loads and higher STP limits for the same water quality limit. However, additional research is required to collect field data on base flow volumes and phosphorus concentrations so that total flow from a watershed can be separated into surface- and base-flow components.

The calculated STP limits at the watershed and microwatershed scales were variable among soil and hillslope polygons. In each watershed and microwatershed, the variability was directly related to the runoff potential (RF_i) among polygons, the TPRWQL selected, and the STP equation. The RF_i was related to soil type, landform model, and climate condition. Generally, the WEPP model predicted RF_i values less than 1 for polygons with runoff potentials higher than the entire watershed. Consequently, these types of polygons were allowed the lowest STP limits.

Calculated STP values were highly sensitive to the TPRWQL chosen. The STP limits more than doubled when the TPRWQL was increased from 0.5 to 1.0 mg L^{-1}. However, there was very little difference between the results calculated using the $STP_{0\text{-}2.5}$ and $STP_{0\text{-}15}$ equations.

The Microwatershed Study measurements of STP used to develop the linear regression models relating measured concentrations of TP of 0.1 to 8.0 mg L^{-1} in natural runoff had a very good fit with the observed data (r^2 = 0.86 and 0.87). However, the application of these equations beyond the range of measured TP concentrations is not recommended. The STP-TP relationship developed at the microwatershed scale was also extrapolated to the soil-polygon scale, with the assumption that a similar relationship exists at both scales, although this hypothesis was not validated with field data.

The method used to calculate phosphorus limits showed that a TPRWQL value of 0.5 mg L^{-1} resulted in STP limits of 60 mg kg^{-1} or less in the top 15 cm of soil in most of the land base within the selected watersheds and microwatersheds. When a TPRWQL value of 1.0 mg L^{-1} was used, STP limits for most of the land base ranged from 30 to 120 mg kg^{-1}.

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APPENDICES

Appendix 1. Estimated allowed total phosphorus (TP) concentrations, soil-test phosphorus (STP 0-2.5 cm and STP 0-15 cm) limits, and TP loads within selected watersheds using a TP runoff water quality limit (TPRWQL) of 0.5 mg L^{-1}.

Table A1.1. Wabash Creek watershed.

Stn. PFRA name	Soil poly #	Stn. PFRA RD mm	Soil poly area m^2	Stn. PFRA RV m^3	TP export coeffcient kg m^{-2}	WEPP RD^z mm	WEPP RV^y m^3	Avg. WEPP RD mm	Runoff factor	Adjusted RD mm	Estimated RV m^3	Allow TP mg L^{-1}	STP 0-2.5 cm mg kg^{-1}	STP 0-15 cm mg kg^{-1}	TP load kg
ID	*i*	*D*	a_i	*Q*	L_{ex}	$dwepp_i$	$qwepp_i$	*Dwepp*	RF_i	d_i	q_i	TP_i	$STP_{0\text{-}2.5}$	$STP_{0\text{-}15}$	l_i
07BC003	19597	27	2.58E+06	8.57E+06	1.35E-05	5.85	15076	3.4	0.6	46	119472	0.29	19	9	34.8
07BC003	19658	27	3.59E+06	8.57E+06	1.35E-05	2.75	9861	3.4	1.2	22	78146	0.62	45	33	48.4
07BC003	19617	27	1.55E+07	8.57E+06	1.35E-05	2.15	33302	3.4	1.6	17	263906	0.79	58	45	209.1
07BC003	19640	27	7.16E+06	8.57E+06	1.35E-05	2.39	17101	3.4	1.4	19	135523	0.71	52	39	96.6
07BC003	19649	27	1.88E+06	8.57E+06	1.35E-05	2.52	4743	3.4	1.4	20	37585	0.68	49	37	25.4
07BC003	19663	27	4.31E+07	8.57E+06	1.35E-05	2.37	102162	3.4	1.4	19	809603	0.72	52	40	581.9
07BC003	19660	27	4.30E+06	8.57E+06	1.35E-05	2.75	11827	3.4	1.2	22	93725	0.62	45	33	58.1
07BC003	19654	27	1.89E+07	8.57E+06	1.35E-05	2.60	49067	3.4	1.3	21	388845	0.66	47	35	254.8
07BC003	28206	27	3.39E+07	8.57E+06	1.35E-05	2.49	84377	3.4	1.4	20	668668	0.68	50	37	457.5
07BC003	19648	27	1.38E+06	8.57E+06	1.35E-05	2.88	3978	3.4	1.2	23	31527	0.59	43	31	18.6
07BC003	19659	27	6.07E+06	8.57E+06	1.35E-05	9.14	55477	3.4	0.4	72	439637	0.19	11	2	81.9
07BC003	19661	27	4.70E+06	8.57E+06	1.35E-05	3.49	16414	3.4	1.0	28	130075	0.49	35	23	63.5
07BC003	19641	27	2.12E+07	8.57E+06	1.35E-05	2.92	61911	3.4	1.2	23	490627	0.58	42	30	286.2
07BC003	19636	27	1.56E+06	8.57E+06	1.35E-05	4.08	6358	3.4	0.8	32	50383	0.42	29	18	21.0
07BC003	19645	27	8.00E+06	8.57E+06	1.35E-05	2.35	18804	3.4	1.4	19	149015	0.72	53	40	108.0
07BC003	19643	27	2.85E+06	8.57E+06	1.35E-05	3.58	10211	3.4	1.0	28	80917	0.48	34	23	38.5
07BC003	14050	27	2.63E+06	8.57E+06	1.35E-05	3.69	9704	3.4	0.9	29	76903	0.46	33	22	35.5
07BC003	19642	27	1.82E+07	8.57E+06	1.35E-05	3.04	55245	3.4	1.1	24	437804	0.56	40	29	245.3
07BC003	19667	27	4.07E+06	8.57E+06	1.35E-05	4.10	16701	3.4	0.8	32	132351	0.42	29	18	55.0
07BC003	19652	27	4.94E+06	8.57E+06	1.35E-05	3.69	18212	3.4	0.9	29	144328	0.46	33	22	66.6
07BC003	19633	27	2.87E+07	8.57E+06	1.35E-05	3.76	108077	3.4	0.9	30	856482	0.45	32	21	388.0
07BC003	19639	27	3.60E+06	8.57E+06	1.35E-05	3.81	13735	3.4	0.9	30	108842	0.45	31	21	48.7

Table A1.1. Wabash Creek watershed.

Stn. PFRA name	Soil poly #	Stn. PFRA RD	Soil poly area	Stn. PFRA RV	TP export coeffcient	WEPP RD[z]	WEPP RV[y]	Avg. WEPP RD	Runoff factor	Adjusted RD	Estimated RV	Allow TP	STP 0-2.5 cm	STP 0-15 cm	TP load
		mm	m^2	m^3	kg m^{-2}	mm	m^3	mm		mm	m^3	mg L^{-1}	mg kg^{-1}	mg kg^{-1}	kg
ID	*i*	*D*	a_i	*Q*	L_{ex}	$dwepp_i$	$qwepp_i$	*Dwepp*	RF_i	d_i	q_i	TP_i	$STP_{0\text{-}2.5}$	$STP_{0\text{-}15}$	l_i
07BC003	19653	27	3.78E+06	8.57E+06	1.35E-05	3.72	14078	3.4	0.9	29	111561	0.46	32	21	51.1
07BC003	14080	27	8.53E+05	8.57E+06	1.35E-05	2.94	2507	3.4	1.2	23	19865	0.58	42	30	11.5
07BC003	19634	27	1.03E+07	8.57E+06	1.35E-05	4.63	47768	3.4	0.7	37	378552	0.37	25	15	139.3
07BC003	19638	27	4.48E+06	8.57E+06	1.35E-05	4.32	19358	3.4	0.8	34	153408	0.39	27	17	60.5
07BC003	19635	27	4.63E+07	8.57E+06	1.35E-05	4.25	196607	3.4	0.8	34	1558051	0.40	28	17	624.5
07BC003	19632	27	4.24E+05	8.57E+06	1.35E-05	4.15	1761	3.4	0.8	33	13956	0.41	29	18	5.7
07BC003	14065	27	4.64E+05	8.57E+06	1.35E-05	2.48	1151	3.4	1.4	20	9122	0.69	50	38	6.3
07BC003	14064	27	1.03E+06	8.57E+06	1.35E-05	3.13	3209	3.4	1.1	25	25434	0.54	39	27	13.8
07BC003	18748	27	1.14E+06	8.57E+06	1.35E-05	3.69	4195	3.4	0.9	29	33241	0.46	33	22	15.3
07BC003	14077	27	6.28E+06	8.57E+06	1.35E-05	7.19	45158	3.4	0.5	57	357862	0.24	15	5	84.8
07BC003	18738	27	3.30E+06	8.57E+06	1.35E-05	6.64	21909	3.4	0.5	53	173626	0.26	17	7	44.5
07BC003	14071	27	1.24E+05	8.57E+06	1.35E-05	6.40	793	3.4	0.5	51	6282	0.27	17	8	1.7
Total			3.17E+08				1080836								4282.7

[z] RD = runoff depth
[y] RV = runoff volume

Table A1.2. Colquihoun Creek watershed.

Stn. PFRA name	Soil poly #	Stn. PFRA RD mm	Soil poly area m^2	Stn. PFRA RV m^3	TP export coeffcient kg m^{-2}	WEPP RD[z] mm	WEPP RV[y] m^3	Avg. WEPP RD mm	Runoff factor	Adjusted RD mm	Estimated RV m^3	Allow TP mg L^{-1}	STP 0-2.5 cm mg kg^{-1}	STP 0-15 cm mg kg^{-1}	TP load kg
ID	*i*	*D*	a_i	*Q*	L_{ex}	$dwepp_i$	$qwepp_i$	*Dwepp*	RF_i	d_i	q_i	TP_i	$STP_{0\text{-}2.5}$	$STP_{0\text{-}15}$	l_i
07GE006	23621	56	7.40E+06	7.22E+06	2.80E-05	9.47	70034	8.3	0.88	64	473223	0.44	31	20	207.1
07GE006	23477	56	4.77E+06	7.22E+06	2.80E-05	10.26	48934	8.3	0.81	69	330650	0.40	28	17	133.5
07GE006	23629	56	4.15E+06	7.22E+06	2.80E-05	4.49	18636	8.3	1.85	30	125927	0.92	68	54	116.2
07GE006	23511	56	1.96E+06	7.22E+06	2.80E-05	7.49	14650	8.3	1.11	51	98989	0.55	40	28	54.8
07GE006	23492	56	7.60E+06	7.22E+06	2.80E-05	9.92	75409	8.3	0.84	67	509541	0.42	29	18	212.8
07GE006	23455	56	2.66E+06	7.22E+06	2.80E-05	7.38	19617	8.3	1.12	50	132553	0.56	40	29	74.4
07GE006	23491	56	5.14E+06	7.22E+06	2.80E-05	11.95	61441	8.3	0.69	81	415156	0.35	24	13	144.0
07GE006	23525	56	1.60E+07	7.22E+06	2.80E-05	7.44	118711	8.3	1.11	50	802129	0.56	40	28	446.8
07GE006	23449	56	7.18E+06	7.22E+06	2.80E-05	10.69	76734	8.3	0.78	72	518492	0.39	27	16	201.0
07GE006	23506	56	1.37E+06	7.22E+06	2.80E-05	7.12	9741	8.3	1.16	48	65820	0.58	42	30	38.3
07GE006	23524	56	8.83E+06	7.22E+06	2.80E-05	7.49	66129	8.3	1.11	51	446834	0.55	40	28	247.2
07GE006	23642	56	1.81E+06	7.22E+06	2.80E-05	4.73	8573	8.3	1.75	32	57926	0.88	64	51	50.7
07GE006	23622	56	9.93E+06	7.22E+06	2.80E-05	15.69	155832	8.3	0.53	106	1052961	0.26	17	7	278.1
07GE006	23515	56	1.33E+06	7.22E+06	2.80E-05	7.79	10360	8.3	1.06	53	70006	0.53	38	27	37.2
07GE006	23559	56	4.76E+06	7.22E+06	2.80E-05	5.39	25683	8.3	1.54	36	173541	0.77	56	43	133.4
07GE006	23571	56	1.36E+07	7.22E+06	2.80E-05	9.88	134260	8.3	0.84	67	907198	0.42	29	19	380.5
07GE006	23560	56	7.16E+06	7.22E+06	2.80E-05	7.78	55671	8.3	1.07	53	376168	0.53	38	27	200.4
07GE006	23563	56	3.26E+06	7.22E+06	2.80E-05	7.21	23508	8.3	1.15	49	158845	0.57	41	30	91.3
07GE006	23554	56	2.12E+06	7.22E+06	2.80E-05	7.09	15052	8.3	1.17	48	101706	0.58	42	30	59.4
07GE006	23572	56	1.27E+07	7.22E+06	2.80E-05	2.71	34431	8.3	3.06	18	232653	1.53	115	98	355.7
07GE006	23575	56	3.88E+06	7.22E+06	2.80E-05	5.06	19651	8.3	1.64	34	132784	0.82	60	47	108.7
07GE006	23573	56	1.45E+06	7.22E+06	2.80E-05	4.24	6159	8.3	1.95	29	41620	0.98	72	58	40.7
Total			1.29E+08				1069219								3612.4

[z] RD = runoff depth
[y] RV = runoff volume

Table A1.3. Mosquito Creek watershed.

Stn. PFRA name	Soil poly #	Stn. PFRA RD mm	Soil poly area m^2	Stn. PFRA RV m^3	TP export coeffcient kg m^{-2}	WEPP RD^z mm	WEPP RV^y m^3	Avg. WEPP RD mm	Runoff factor	Adjusted RD mm	Estimated RV m^3	Allow TP mg L^{-1}	STP 0-2.5 cm mg kg^{-1}	STP 0-15 cm mg kg^{-1}	TP load kg
ID	*i*	*D*	a_i	*Q*	L_{ex}	$dwepp_i$	$qwepp_i$	*Dwepp*	RF_i	d_i	q_i	TP_i	$STP_{0-2.5}$	STP_{0-15}	l_i
05AC001	10912	100	2.45E+05	5.23E+07	5.00E-05	3.05	749	6.2	2.02	49	12122	1.01	75	61	12.3
05AC001	10806	100	3.54E+06	5.23E+07	5.00E-05	3.26	11554	6.2	1.89	53	187082	0.95	70	56	177.2
05AC001	10914	100	6.23E+05	5.23E+07	5.00E-05	2.28	1421	6.2	2.71	37	23009	1.35	101	85	31.2
05AC001	10827	100	1.06E+07	5.23E+07	5.00E-05	3.74	39507	6.2	1.65	61	639685	0.83	61	48	528.2
05AC001	10805	100	1.02E+07	5.23E+07	5.00E-05	0.73	7449	6.2	8.46	12	120617	4.23	322	291	510.2
05AC001	10816	100	2.28E+06	5.23E+07	5.00E-05	3.74	8542	6.2	1.65	61	138312	0.83	61	48	114.2
05AC001	10829	100	3.39E+06	5.23E+07	5.00E-05	5.94	20138	6.2	1.04	96	326065	0.52	37	26	169.5
05AC001	10888	100	7.09E+06	5.23E+07	5.00E-05	5.78	40978	6.2	1.07	94	663500	0.53	38	27	354.5
05AC001	10821	100	9.07E+06	5.23E+07	5.00E-05	3.88	35197	6.2	1.59	63	569901	0.80	58	45	453.6
05AC001	10915	100	7.04E+06	5.23E+07	5.00E-05	3.43	24144	6.2	1.80	56	390936	0.90	66	53	352.0
05AC001	10819	100	9.69E+05	5.23E+07	5.00E-05	1.95	1890	6.2	3.17	32	30597	1.58	119	102	48.5
05AC001	10818	100	1.91E+06	5.23E+07	5.00E-05	3.32	6327	6.2	1.86	54	102450	0.93	69	55	95.3
05AC001	10825	100	5.40E+06	5.23E+07	5.00E-05	3.36	18127	6.2	1.84	54	293512	0.92	68	54	269.8
05AC001	10823	100	8.73E+06	5.23E+07	5.00E-05	3.32	28988	6.2	1.86	54	469363	0.93	69	55	436.6
05AC001	10808	100	2.35E+06	5.23E+07	5.00E-05	6.47	15181	6.2	0.95	105	245804	0.48	34	23	117.3
05AC001	10824	100	5.30E+06	5.23E+07	5.00E-05	4.85	25700	6.2	1.27	79	416133	0.64	46	34	265.0
05AC001	11812	100	3.00E+06	5.23E+07	5.00E-05	1.41	4224	6.2	4.38	23	68394	2.19	165	145	149.8
05AC001	10810	100	1.25E+07	5.23E+07	5.00E-05	5.78	72052	6.2	1.07	94	1166647	0.53	38	27	623.3
05AC001	10809	100	6.06E+06	5.23E+07	5.00E-05	3.77	22860	6.2	1.64	61	370138	0.82	60	47	303.2
05AC001	11831	100	1.28E+06	5.23E+07	5.00E-05	4.93	6286	6.2	1.25	80	101786	0.63	45	33	63.8
05AC001	10811	100	1.90E+07	5.23E+07	5.00E-05	5.78	109908	6.2	1.07	94	1779596	0.53	38	27	950.8
05AC001	10828	100	4.26E+06	5.23E+07	5.00E-05	6.11	26025	6.2	1.01	99	421397	0.51	36	25	213.0
05AC001	29149	100	1.44E+06	5.23E+07	5.00E-05	4.76	6860	6.2	1.30	77	111078	0.65	47	35	72.1
05AC001	10814	100	1.70E+06	5.23E+07	5.00E-05	5.78	9830	6.2	1.07	94	159165	0.53	38	27	85.0
05AC001	10843	100	6.68E+06	5.23E+07	5.00E-05	4.76	31790	6.2	1.30	77	514734	0.65	47	35	333.9
05AC001	10812	100	1.78E+06	5.23E+07	5.00E-05	5.78	10268	6.2	1.07	94	166254	0.53	38	27	88.8
05AC001	10838	100	6.89E+06	5.23E+07	5.00E-05	5.81	40028	6.2	1.06	94	648116	0.53	38	27	344.5

Table A1.3. Mosquito Creek watershed.

Stn. PFRA name	Soil poly #	Stn. PFRA RD mm	Soil poly area m^2	Stn. PFRA RV m^3	TP export coeffcient kg m^{-2}	WEPP RD^z mm	WEPP RV^y m^3	Avg. WEPP RD mm	Runoff factor	Adjusted RD mm	Estimated RV m^3	Allow TP mg L^{-1}	STP 0-2.5 cm mg kg^{-1}	STP 0-15 cm mg kg^{-1}	TP load kg
ID	*i*	*D*	a_i	*Q*	L_{ex}	$dwepp_i$	$qwepp_i$	*Dwepp*	RF_i	d_i	q_i	TP_i	$STP_{0-2.5}$	STP_{0-15}	l_i
05AC001	11818	100	4.80E+06	5.23E+07	5.00E-05	5.64	27093	6.2	1.10	91	438686	0.55	39	28	240.2
05AC001	10840	100	4.08E+06	5.23E+07	5.00E-05	1.41	5754	6.2	4.38	23	93166	2.19	165	145	204.0
05AC001	29065	100	6.78E+06	5.23E+07	5.00E-05	5.94	40274	6.2	1.04	96	652110	0.52	37	26	339.0
05AC001	10837	100	4.29E+06	5.23E+07	5.00E-05	4.34	18601	6.2	1.42	70	301190	0.71	52	39	214.3
05AC001	29064	100	1.91E+06	5.23E+07	5.00E-05	4.76	9088	6.2	1.30	77	147143	0.65	47	35	95.5
05AC001	10845	100	4.58E+06	5.23E+07	5.00E-05	5.13	23505	6.2	1.20	83	380592	0.60	43	32	229.1
05AC001	12165	100	6.00E+06	5.23E+07	5.00E-05	5.15	30920	6.2	1.20	83	500649	0.60	43	31	300.2
05AC001	29066	100	6.96E+06	5.23E+07	5.00E-05	5.94	41315	6.2	1.04	96	668966	0.52	37	26	347.8
05AC001	10813	100	8.12E+05	5.23E+07	5.00E-05	5.78	4691	6.2	1.07	94	75963	0.53	38	27	40.6
05AC001	10807	100	8.91E+05	5.23E+07	5.00E-05	6.47	5767	6.2	0.95	105	93373	0.48	34	23	44.6
05AC001	28169	100	1.51E+07	5.23E+07	5.00E-05	5.74	86869	6.2	1.08	93	1406568	0.54	38	27	756.7
05AC001	12136	100	8.08E+06	5.23E+07	5.00E-05	5.33	43047	6.2	1.16	86	697004	0.58	42	30	403.8
05AC001	10846	100	2.21E+06	5.23E+07	5.00E-05	3.49	7710	6.2	1.77	57	124832	0.88	65	52	110.5
05AC001	12158	100	4.30E+06	5.23E+07	5.00E-05	5.49	23630	6.2	1.12	89	382607	0.56	40	29	215.2
05AC001	12168	100	8.13E+06	5.23E+07	5.00E-05	5.66	46033	6.2	1.09	92	745355	0.55	39	28	406.7
05AC001	10848	100	4.06E+06	5.23E+07	5.00E-05	3.28	13321	6.2	1.88	53	215684	0.94	69	56	203.1
05AC001	10852	100	4.78E+06	5.23E+07	5.00E-05	3.36	16051	6.2	1.84	54	259891	0.92	68	54	238.9
05AC001	12162	100	6.66E+06	5.23E+07	5.00E-05	6.09	40530	6.2	1.01	99	656252	0.51	36	25	332.8
05AC001	10869	100	4.46E+06	5.23E+07	5.00E-05	6.88	30683	6.2	0.90	111	496806	0.45	32	21	223.0
05AC001	10847	100	1.28E+06	5.23E+07	5.00E-05	3.49	4484	6.2	1.77	57	72601	0.88	65	52	64.2
05AC001	10857	100	8.59E+06	5.23E+07	5.00E-05	5.94	51037	6.2	1.04	96	826377	0.52	37	26	429.6
05AC001	10861	100	1.12E+07	5.23E+07	5.00E-05	6.47	72568	6.2	0.95	105	1175008	0.48	34	23	560.8
05AC001	12178	100	5.35E+06	5.23E+07	5.00E-05	5.13	27426	6.2	1.20	83	444082	0.60	43	32	267.3
05AC001	12179	100	1.11E+07	5.23E+07	5.00E-05	6.36	70859	6.2	0.97	103	1147329	0.49	34	23	557.1
05AC001	12138	100	9.10E+06	5.23E+07	5.00E-05	5.18	47157	6.2	1.19	84	763561	0.60	43	31	455.2
05AC001	12140	100	3.83E+06	5.23E+07	5.00E-05	3.80	14565	6.2	1.63	62	235838	0.81	60	47	191.6
05AC001	12157	100	2.65E+06	5.23E+07	5.00E-05	8.02	21216	6.2	0.77	130	343528	0.39	27	16	132.3
05AC001	10872	100	2.15E+06	5.23E+07	5.00E-05	7.24	15586	6.2	0.85	117	252368	0.43	30	19	107.6

Table A1.3. Mosquito Creek watershed.

Stn. PFRA name	Soil poly #	Stn. PFRA RD	Soil poly area	Stn. PFRA RV	TP export coeffcient	WEPP RD[z]	WEPP RV[y]	Avg. WEPP RD	Runoff factor	Adjusted RD	Estimated RV	Allow TP	STP 0-2.5 cm	STP 0-15 cm	TP load
		mm	m^2	m^3	kg m^{-2}	mm	m^3	mm		mm	m^3	mg L^{-1}	mg kg^{-1}	mg kg^{-1}	kg
ID	*i*	*D*	a_i	*Q*	L_{ex}	$dwepp_i$	$qwepp_i$	*Dwepp*	RF_i	d_i	q_i	TP_i	$STP_{0-2.5}$	STP_{0-15}	l_i
05AC001	12163	100	1.17E+07	5.23E+07	5.00E-05	5.15	60271	6.2	1.20	83	975897	0.60	43	31	585.2
05AC001	10841	100	3.41E+06	5.23E+07	5.00E-05	1.37	4669	6.2	4.51	22	75600	2.25	170	150	170.4
05AC001	10656	100	3.22E+06	5.23E+07	5.00E-05	3.73	11996	6.2	1.66	60	194233	0.83	61	48	160.8
05AC001	10615	100	9.79E+06	5.23E+07	5.00E-05	8.12	79502	6.2	0.76	131	1287268	0.38	26	16	489.5
05AC001	10871	100	1.46E+06	5.23E+07	5.00E-05	7.24	10600	6.2	0.85	117	171629	0.43	30	19	73.2
05AC001	12143	100	3.94E+06	5.23E+07	5.00E-05	6.04	23784	6.2	1.02	98	385108	0.51	36	25	196.9
05AC001	12150	100	1.71E+06	5.23E+07	5.00E-05	8.67	14806	6.2	0.71	140	239729	0.36	24	14	85.4
05AC001	10860	100	4.82E+05	5.23E+07	5.00E-05	10.36	4990	6.2	0.60	168	80790	0.30	20	10	24.1
05AC001	12146	100	1.81E+07	5.23E+07	5.00E-05	11.14	201124	6.2	0.55	180	3256554	0.28	18	8	902.7
05AC001	12176	100	3.97E+06	5.23E+07	5.00E-05	5.82	23097	6.2	1.06	94	373989	0.53	38	26	198.4
05AC001	10741	100	2.09E+06	5.23E+07	5.00E-05	3.65	7629	6.2	1.69	59	123531	0.85	62	49	104.5
05AC001	10835	100	1.08E+06	5.23E+07	5.00E-05	5.78	6259	6.2	1.07	94	101347	0.53	38	27	54.1
05AC001	12177	100	1.39E+06	5.23E+07	5.00E-05	5.39	7476	6.2	1.15	87	121052	0.57	41	29	69.4
05AC001	12152	100	1.46E+07	5.23E+07	5.00E-05	7.05	102803	6.2	0.88	114	1664556	0.44	31	20	729.1
05AC001	10753	100	4.91E+06	5.23E+07	5.00E-05	5.02	24665	6.2	1.23	81	399369	0.62	44	33	245.7
05AC001	10648	100	5.62E+06	5.23E+07	5.00E-05	7.02	39466	6.2	0.88	114	639018	0.44	31	20	281.1
05AC001	10875	100	5.05E+04	5.23E+07	5.00E-05	7.24	366	6.2	0.85	117	5921	0.43	30	19	2.5
05AC001	12141	100	2.98E+06	5.23E+07	5.00E-05	7.49	22342	6.2	0.82	121	361755	0.41	29	18	149.1
05AC001	12142	100	1.23E+06	5.23E+07	5.00E-05	8.65	10667	6.2	0.71	140	172724	0.36	24	14	61.7
05AC001	12137	100	2.59E+06	5.23E+07	5.00E-05	7.11	18448	6.2	0.87	115	298704	0.43	30	20	129.7
05AC001	10770	100	2.29E+05	5.23E+07	5.00E-05	15.15	3468	6.2	0.41	245	56146	0.20	13	3	11.4
05AC001	12164	100	1.59E+06	5.23E+07	5.00E-05	7.49	11932	6.2	0.82	121	193195	0.41	29	18	79.7
05AC001	12148	100	1.46E+06	5.23E+07	5.00E-05	5.47	7970	6.2	1.13	89	129054	0.56	40	29	72.9
05AC001	12147	100	5.12E+06	5.23E+07	5.00E-05	6.64	33965	6.2	0.93	108	549960	0.47	33	22	255.8
05AC001	10617	100	2.64E+06	5.23E+07	5.00E-05	8.12	21418	6.2	0.76	131	346794	0.38	26	16	131.9
05AC001	10620	100	2.19E+06	5.23E+07	5.00E-05	8.12	17783	6.2	0.76	131	287940	0.38	26	16	109.5
05AC001	12145	100	2.14E+06	5.23E+07	5.00E-05	8.65	18486	6.2	0.71	140	299315	0.36	24	14	106.9
05AC001	12144	100	1.87E+06	5.23E+07	5.00E-05	6.10	11432	6.2	1.01	99	185103	0.51	36	25	93.7

Table A1.3. Mosquito Creek watershed.

Stn. PFRA name	Soil poly #	Stn. PFRA RD mm	Soil poly area m^2	Stn. PFRA RV m^3	TP export coeffcient kg m^{-2}	WEPP RD[z] mm	WEPP RV[y] m^3	Avg. WEPP RD mm	Runoff factor	Adjusted RD mm	Estimated RV m^3	Allow TP mg L^{-1}	STP 0-2.5 cm mg kg^{-1}	STP 0-15 cm mg kg^{-1}	TP load kg
ID	*i*	*D*	a_i	*Q*	L_{ex}	$dwepp_i$	$qwepp_i$	*Dwepp*	RF_i	d_i	q_i	TP_i	$STP_{0-2.5}$	STP_{0-15}	l_i
05AC001	12156	100	2.46E+07	5.23E+07	5.00E-05	8.23	202594	6.2	0.75	133	3280347	0.38	26	15	1230.8
05AC001	12171	100	3.37E+06	5.23E+07	5.00E-05	5.19	17509	6.2	1.19	84	283502	0.59	43	31	168.7
05AC001	12159	100	2.84E+06	5.23E+07	5.00E-05	7.99	22724	6.2	0.77	129	367943	0.39	27	16	142.2
05AC001	12153	100	1.26E+07	5.23E+07	5.00E-05	8.67	109109	6.2	0.71	140	1766659	0.36	24	14	629.2
05AC001	12167	100	8.29E+06	5.23E+07	5.00E-05	7.49	62104	6.2	0.82	121	1005569	0.41	29	18	414.6
05AC001	12139	100	1.05E+07	5.23E+07	5.00E-05	10.45	110115	6.2	0.59	169	1782961	0.30	20	10	526.9
05AC001	12151	100	8.71E+06	5.23E+07	5.00E-05	8.67	75474	6.2	0.71	140	1222057	0.36	24	14	435.3
05AC001	12161	100	4.26E+07	5.23E+07	5.00E-05	8.46	360449	6.2	0.73	137	5836291	0.37	25	15	2130.3
Total			5.23E+08				3227296								26127.8

[z] RD = runoff depth
[y] RV = runoff volume

Table A1.4. Three Hills Creek watershed.

Stn. PFRA name	Soil poly #	Stn. PFRA RD mm	Soil poly area m^2	Stn. PFRA RV m^3	TP export coeffcient kg m^{-2}	WEPP RD[z] mm	WEPP RV[y] m^3	Avg. WEPP RD mm	Runoff factor	Adjusted RD mm	Estimated RV m^3	Allow TP mg L^{-1}	STP 0-2.5 cm mg kg^{-1}	STP 0-15 cm mg kg^{-1}	TP load kg
ID		*D*	a_i	*Q*	L_{ex}	$dwepp_i$	$qwepp_i$	*Dwepp*	RF_i	d_i	q_i	TP_i	$STP_{0-2.5}$	STP_{0-15}	l_i
05CE007	13900	8	5.04E+05	4.44E+06	4.00E-06	3.86	1945	7.3	1.90	4	2121	1.0	70	56	2.0
05CE007	13924	8	1.32E+07	4.44E+06	4.00E-06	5.76	75995	7.3	1.27	6	82869	0.6	46	34	52.8
05CE007	7675	8	7.65E+06	4.44E+06	4.00E-06	5.11	39105	7.3	1.44	6	42643	0.7	52	40	30.6
05CE007	13911	8	1.87E+06	4.44E+06	4.00E-06	4.60	8603	7.3	1.59	5	9381	0.8	58	46	7.5
05CE007	13914	8	7.63E+05	4.44E+06	4.00E-06	8.46	6455	7.3	0.87	9	7038	0.4	30	20	3.1
05CE007	7660	8	3.65E+06	4.44E+06	4.00E-06	6.54	23898	7.3	1.12	7	26060	0.6	40	29	14.6
05CE007	13921	8	4.78E+06	4.44E+06	4.00E-06	5.35	25556	7.3	1.37	6	27868	0.7	50	38	19.1
05CE007	14004	8	1.67E+06	4.44E+06	4.00E-06	3.94	6561	7.3	1.86	4	7155	0.9	69	55	6.7
05CE007	14003	8	4.18E+06	4.44E+06	4.00E-06	4.60	19217	7.3	1.59	5	20956	0.8	58	46	16.7
05CE007	13928	8	9.66E+06	4.44E+06	4.00E-06	6.47	62513	7.3	1.13	7	68169	0.6	41	29	38.6
05CE007	7654	8	2.23E+06	4.44E+06	4.00E-06	5.00	11134	7.3	1.47	5	12142	0.7	53	41	8.9
05CE007	14002	8	8.12E+05	4.44E+06	4.00E-06	4.60	3737	7.3	1.59	5	4075	0.8	58	46	3.2
05CE007	7652	8	7.05E+06	4.44E+06	4.00E-06	5.47	38576	7.3	1.34	6	42065	0.7	49	36	28.2
05CE007	13996	8	4.44E+06	4.44E+06	4.00E-06	4.17	18517	7.3	1.76	5	20192	0.9	65	51	17.8
05CE007	14006	8	6.19E+06	4.44E+06	4.00E-06	7.00	43330	7.3	1.05	8	47249	0.5	37	26	24.8
05CE007	7667	8	2.53E+06	4.44E+06	4.00E-06	6.19	15631	7.3	1.19	7	17045	0.6	43	31	10.1
05CE007	13925	8	9.39E+06	4.44E+06	4.00E-06	5.76	54060	7.3	1.27	6	58950	0.6	46	34	37.5
05CE007	13922	8	4.96E+06	4.44E+06	4.00E-06	5.35	26518	7.3	1.37	6	28917	0.7	50	38	19.8
05CE007	7665	8	1.80E+07	4.44E+06	4.00E-06	15.30	275078	7.3	0.48	17	299962	0.2	15	6	71.9
05CE007	7668	8	4.81E+06	4.44E+06	4.00E-06	9.39	45185	7.3	0.78	10	49273	0.4	27	16	19.2
05CE007	7351	8	1.78E+07	4.44E+06	4.00E-06	6.72	119848	7.3	1.09	7	130689	0.5	39	28	71.3
05CE007	7672	8	7.39E+06	4.44E+06	4.00E-06	5.69	42054	7.3	1.29	6	45858	0.6	47	35	29.6
05CE007	13915	8	7.03E+06	4.44E+06	4.00E-06	8.20	57654	7.3	0.89	9	62870	0.4	31	21	28.1
05CE007	13917	8	2.30E+06	4.44E+06	4.00E-06	6.90	15870	7.3	1.06	8	17306	0.5	38	27	9.2
05CE007	13926	8	5.81E+06	4.44E+06	4.00E-06	9.16	53235	7.3	0.80	10	58051	0.4	28	17	23.2
05CE007	7657	8	3.50E+06	4.44E+06	4.00E-06	6.63	23194	7.3	1.11	7	25293	0.6	40	28	14.0
05CE007	13956	8	3.15E+06	4.44E+06	4.00E-06	1.87	5888	7.3	3.92	2	6420	2.0	148	129	12.6