

impacts reported in this study are conservative. Had the post-BMP treatment period been conducted during the winter months, greater BMP impacts (more reductions in water quality concentrations and loadings) would have been resulted. In spite of these limitations, this study has clearly shown that off-stream water sources for grazing cattle are quite effective in reducing the amount of sediment bound and fecal bacteria contributed to streams without resorting to stream bank fencing.

Future studies should compare the economic costs and environmental benefits of off-stream water sources, as a stream bank erosion and water quality BMP, to those of stream bank fencing. Water quality and stream bank erosion results of this study should be compared to those which fenced cattle from streams. Also, the scale of BMP implementation, either farm, watershed or regional, should be a major component of such an analysis. Such an analysis should address the economic feasibility of providing off-stream water sources compared with mandatory stream bank fencing in order to protect water resources.

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**Table 1. Comparison of length of time spent by each cow drinking from the stream and being in the stream area.**

Date	Farm	Cumulative time per cow drinking from the stream	Cumulative time per cow being in the stream area
<b>Pre-BMP<sup>†</sup></b>			
11-22-94	South Bender	6.20	13.33
12-03-94	River Ridge	6.62	12.71
1-10-95	North Bender	7.35	12.02
Mean		6.72	12.69
<b>Post-BMP<sup>‡</sup></b>			
6-29-95	River Ridge	0.62	3.55
8-22-95	South Bender	1.31	12.33
9-26-95	River Ridge	0.24	2.80
Mean		0.72	6.19
% Reduction in Mean		89.4	51.2

All values expressed in minutes. †: without water trough. ‡: with water trough.

**Table 2. Off-stream water source preference during the post-BMP treatment period.**

Date	Farm	Reduction in % of time spent drinking in stream due to trough installation
6-29-95	River Ridge	92
8-22-95	South Bender	90
9-26-95	North Bender	93
Average		91.7

**Table 3. Results of stream cross-sectional surveys on the River Ridge Farm**

	Pre-BMP	Post-BMP	D <sup>1</sup>
P -value			0.747
Mean	1.84	1.81	0.03
st. dev.	0.51	0.80	0.87
% Reduction		1.6	

Means and standard deviations area expressed in terms of feet of stream bank erosion. (\*) significant at 0.05 level. D<sup>1</sup> = Difference between pre- and post BMP values.

**Table 4. Flow-weighted concentrations and loadings of water quality nutrients for the outlet of the River Ridge stream.**

Parameter	Flow-Weighted Concentration (mg/L)			Loading (kg/cm rain)		
	Pre-BMP	Post-BMP	% Change	Pre-BMP	Post-BMP	% Change
Total Suspended Solids (TSS)	132.35	14.28	-89.21	292.84	11.06	-96.22*‡
Total Nitrogen (TN)	1.340	1.237	-7.72	3.02	1.34	-55.63‡
Ammonium (NH <sub>4</sub> )	0.321	0.090	-72.06	0.52	0.12	-76.92‡
Nitrate (NO <sub>3</sub> )	0.167	0.229	37.05	0.31	0.35	12.90
Sediment Bound Nitrogen (SBN)	0.472	0.468	-0.66	1.05	0.55	-47.62
Total Phosphorus (TP)	0.203	0.072	-64.56	3.25	0.08	-97.54‡
Orthophosphates (PO <sub>4</sub> )	0.004	0.007	98.47	0.04	0.01	-75.00
Sediment Bound Phosphorus (SBP)	0.120	0.068	-42.87	0.93	0.07	-92.47‡

‡ = Significant difference between means at  $\alpha = 0.05$  level. \* = A negative value (-) indicates a reduction due to the installation of the BMP.

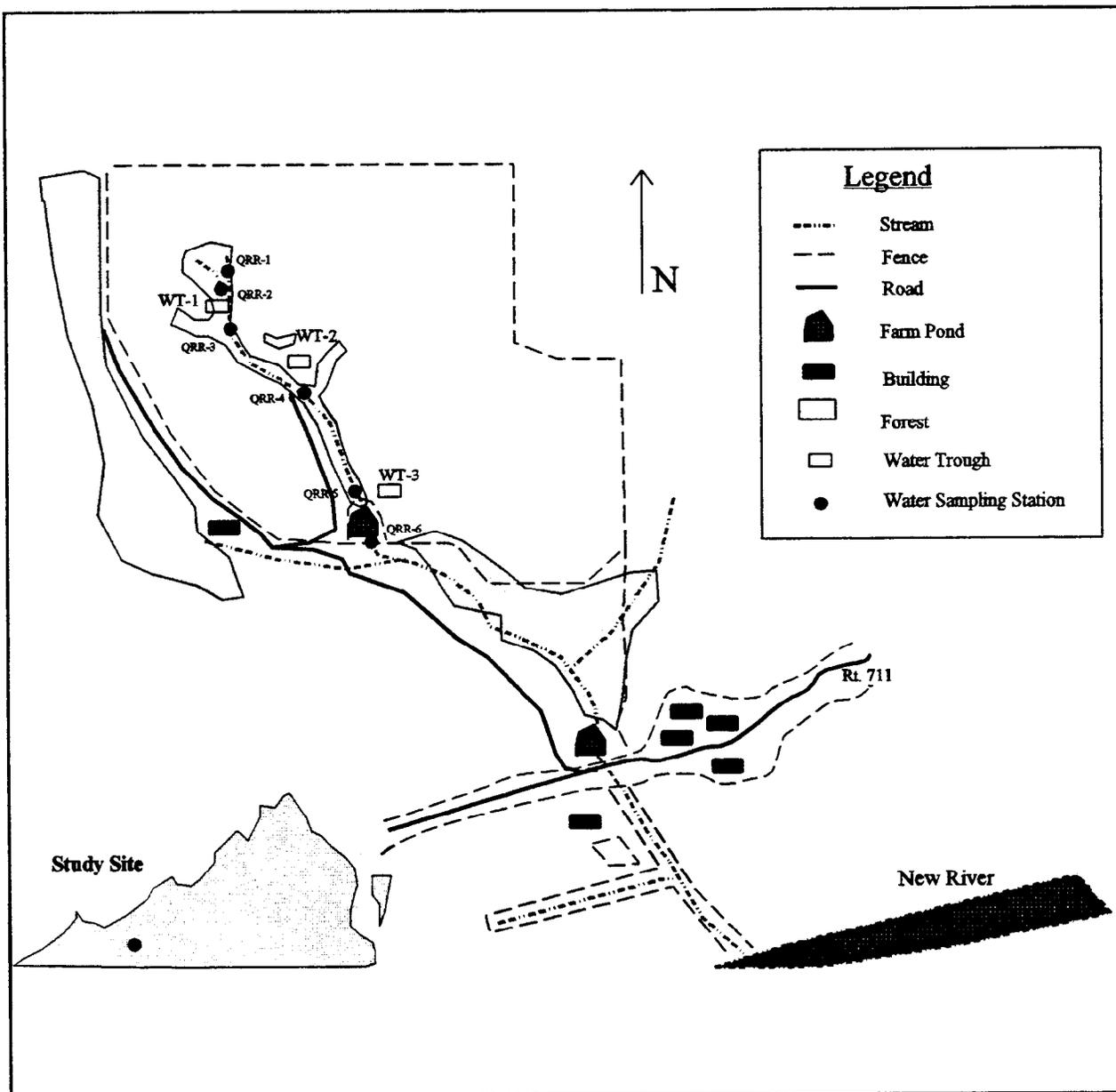
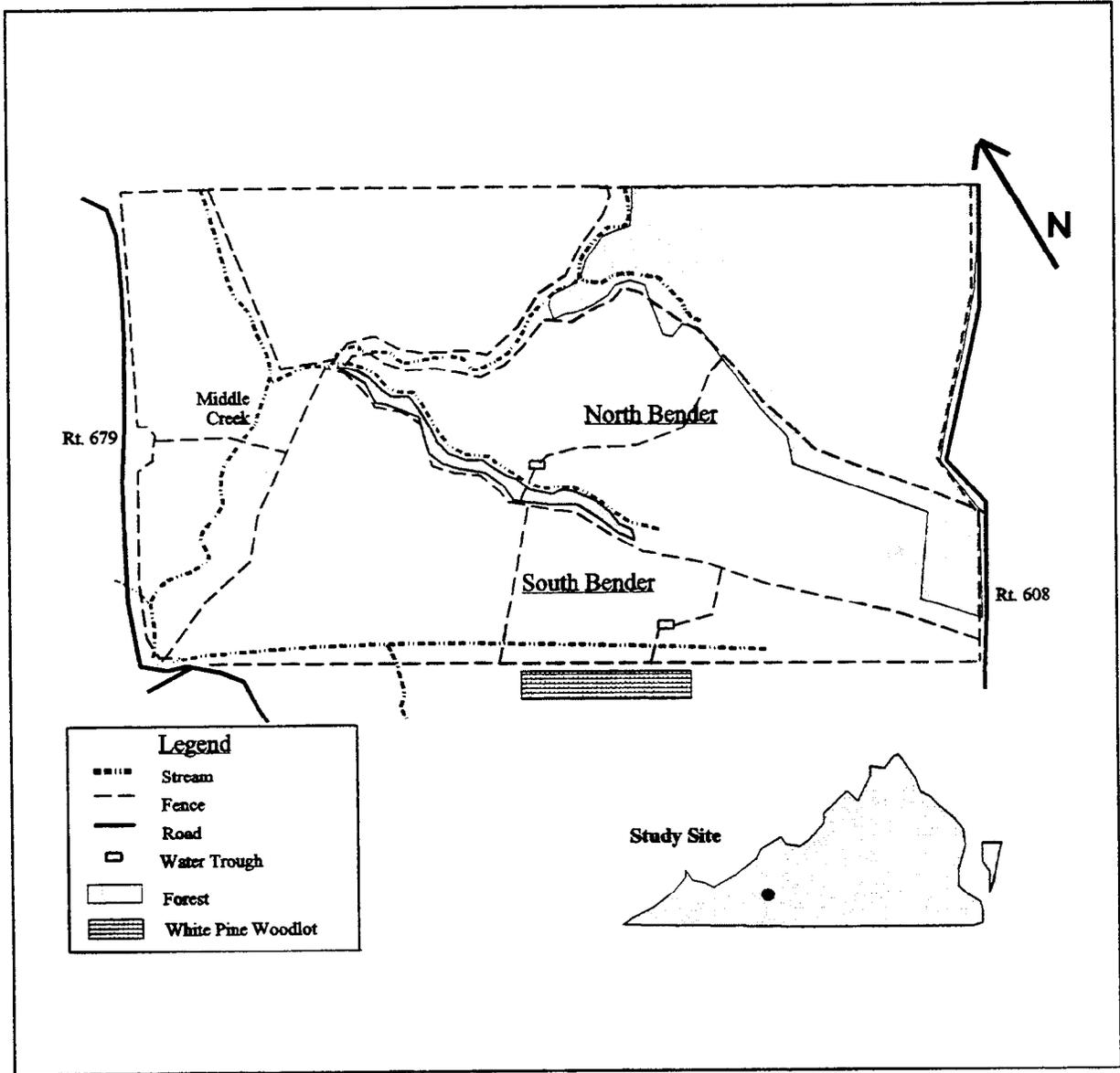
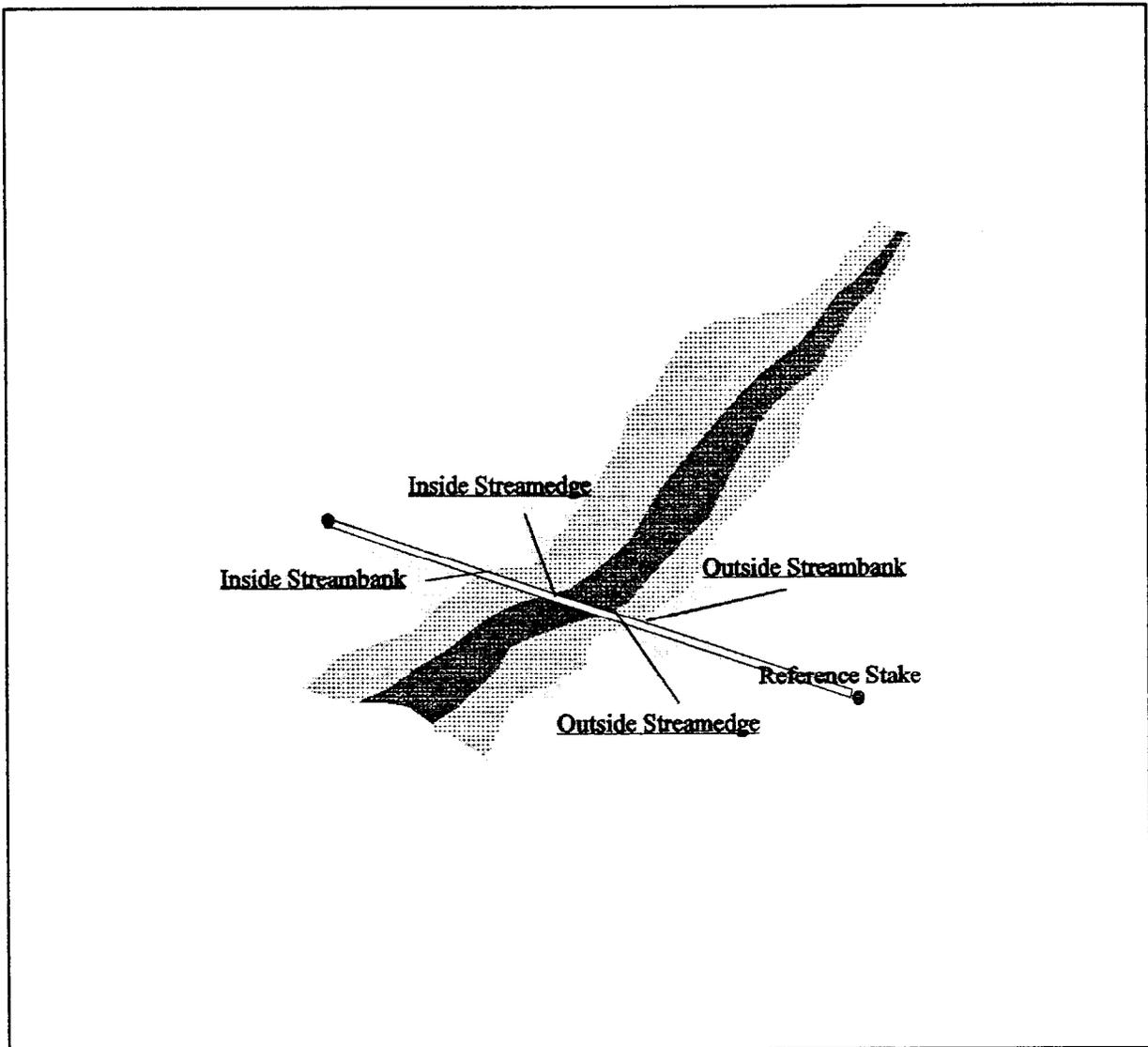


Figure 1. Location of study site at the River Ridge Farm in Independence, Virginia.



**Figure 2. Location of study site at the Bender Farm in Floyd, Virginia.**



**Figure 3. Schematic the methodology used for measuring a stream cross section to estimate stream bank erosion.**

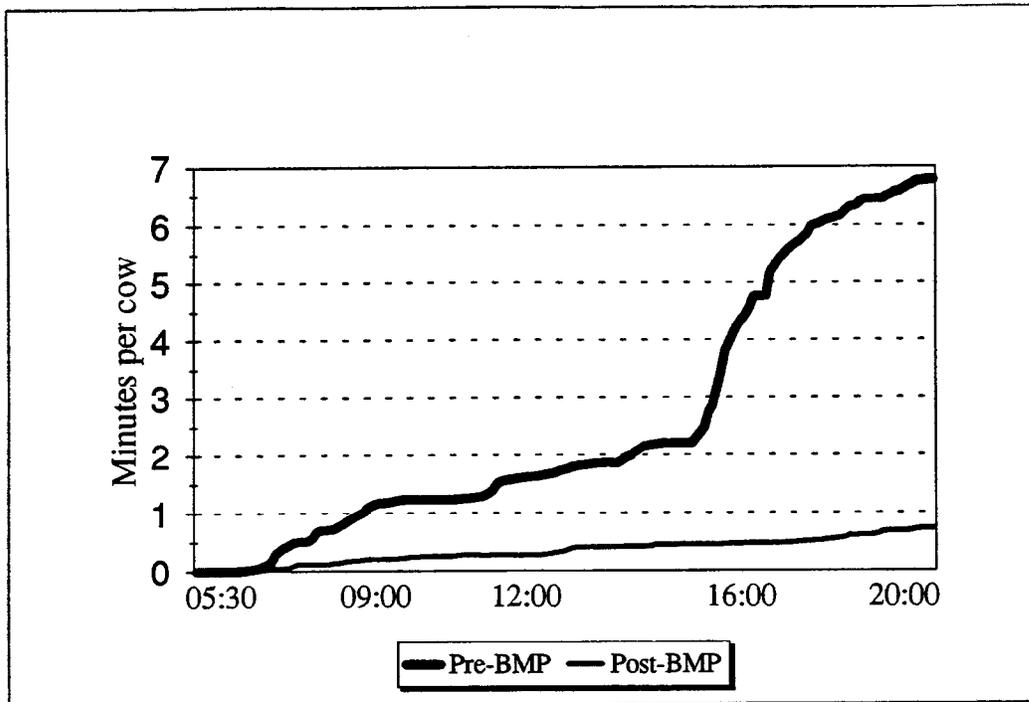


Figure 4. Cumulative time per cow spent in the stream drinking for an average cow-day.

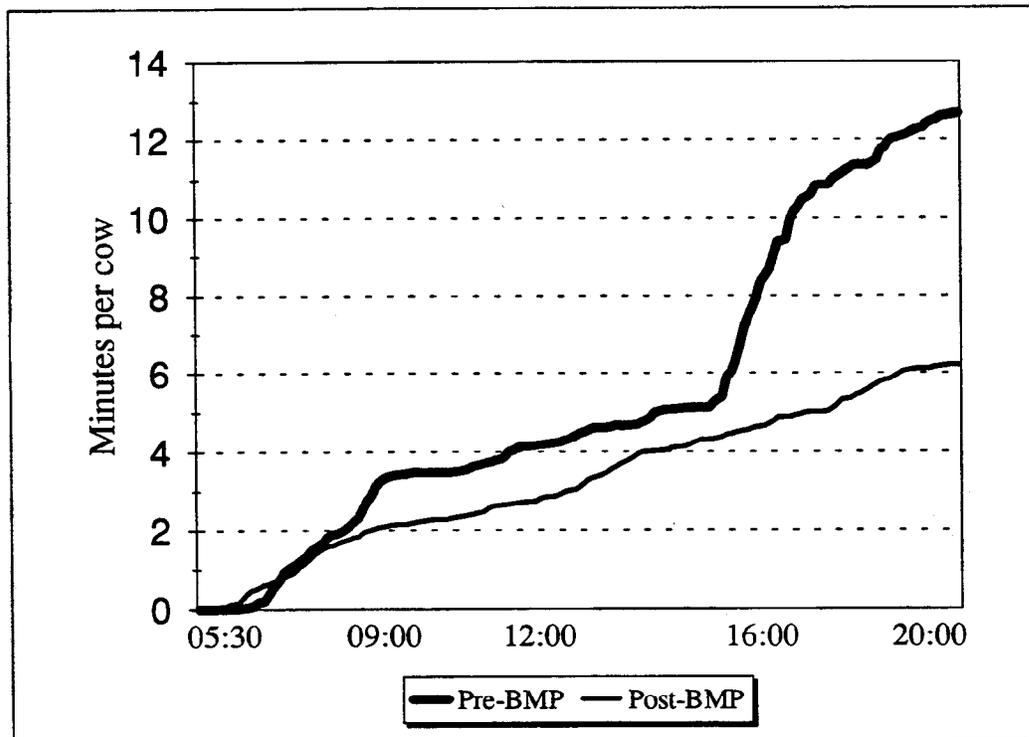


Figure 5. Cumulative time per cow spent in the stream area for an average cow-day.

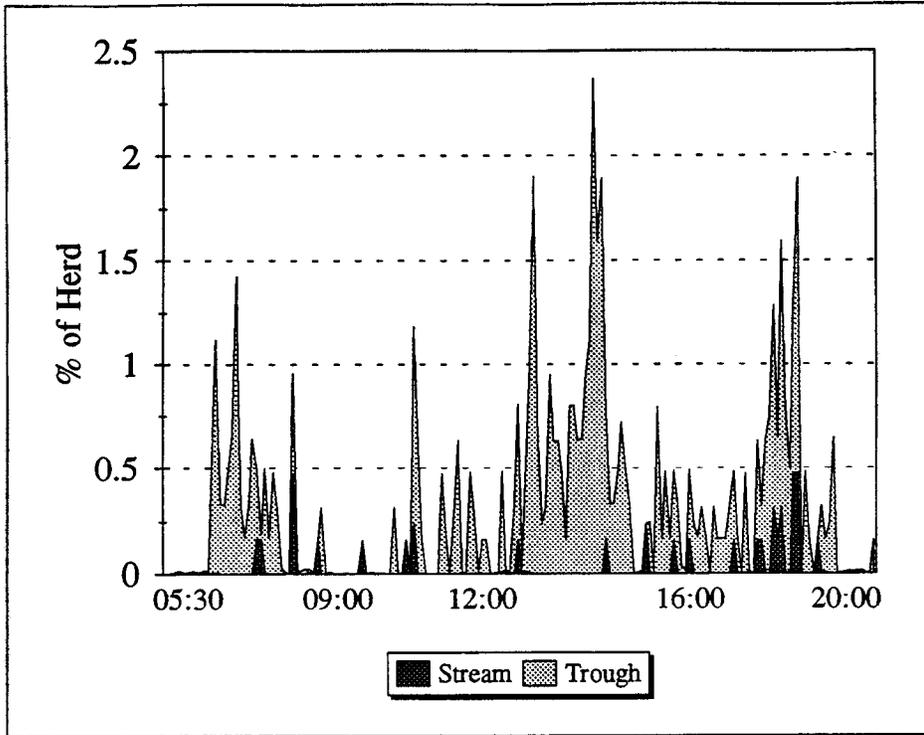


Figure 6. Cattle water source preference during the post-BMP treatment period.

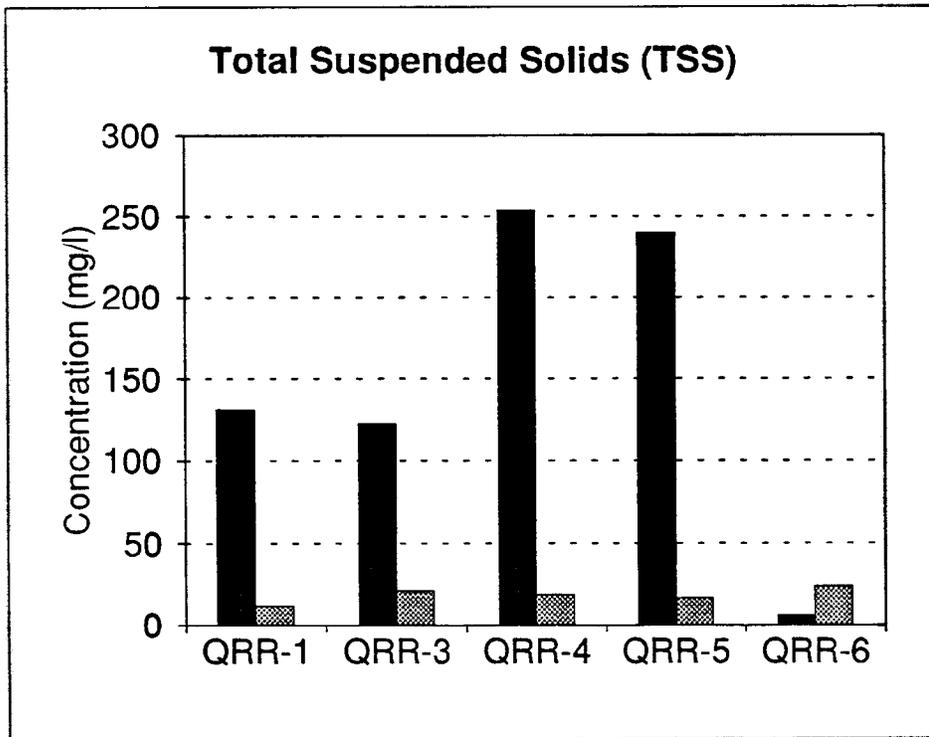


Figure 7. Average concentration of total suspended solids for all stations on the River Ridge Farm.

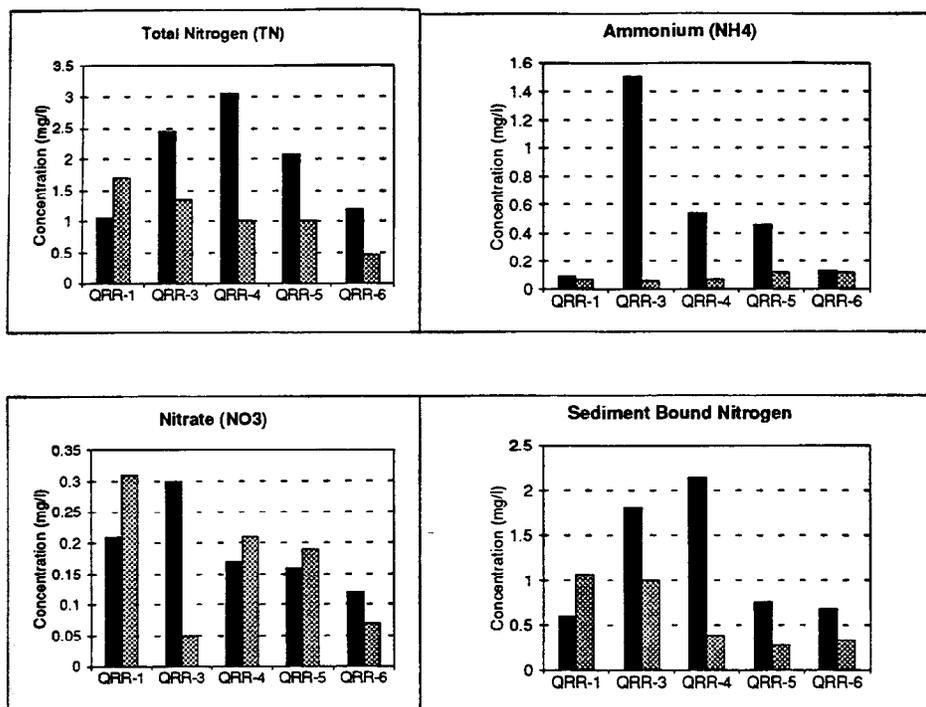


Figure 8. Average concentration of total nitrogen, ammonium, nitrate and sediment-bound nitrogen for all stations on the River Ridge Farm.

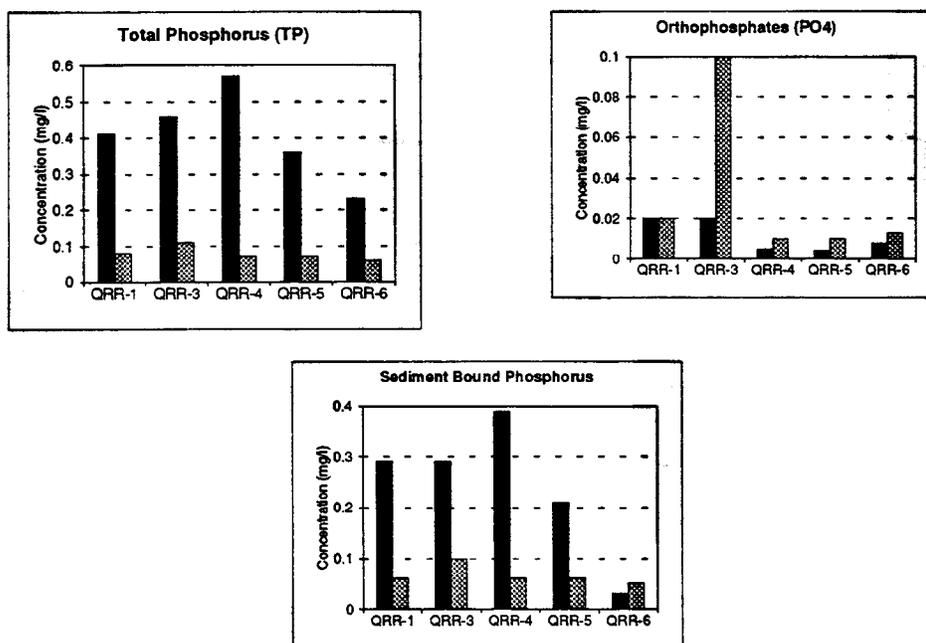


Figure 9. Average concentration of total phosphorus, orthophosphates and sediment-bound phosphorus for all stations on the River Ridge Farm.

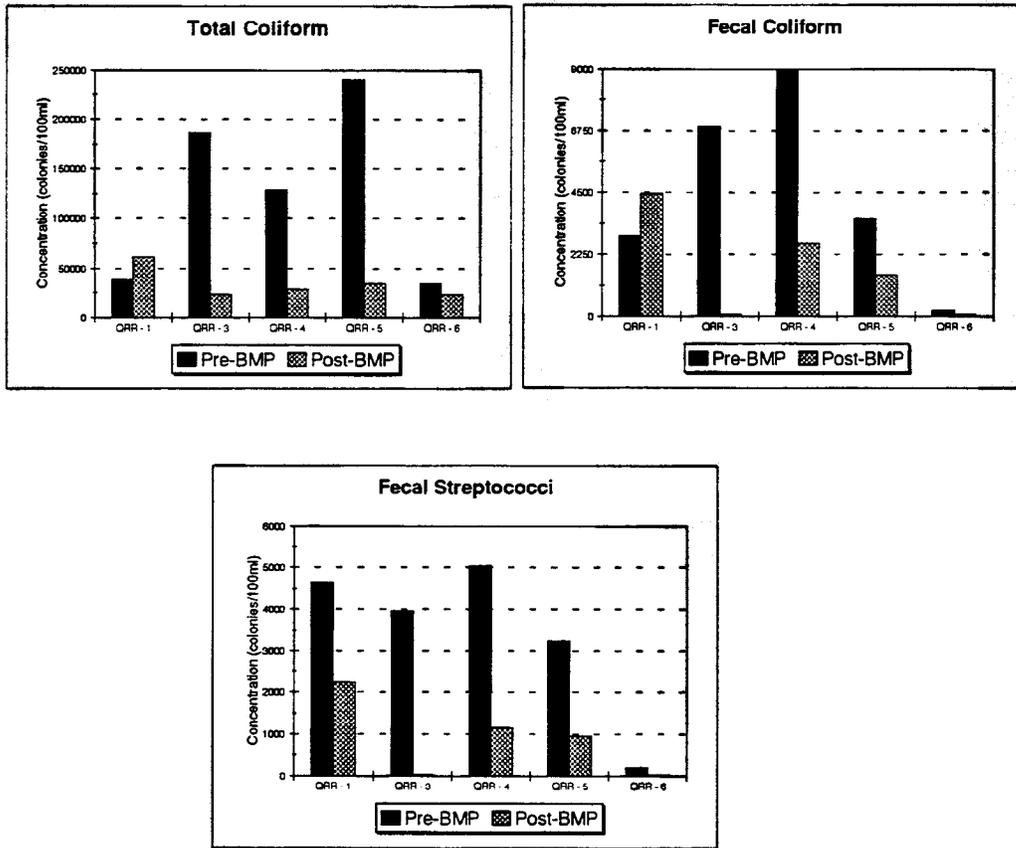


Figure 10. Average concentration for total coliform, fecal coliform and fecal streptococci for all stations on the River Ridge Farm.