CHAPTER 5
CALIBRATION AND VALIDATION

Once SWAT was calibrated and validated for the pilot areas, a similar process was employed to model the remainder of the basin. The basin was divided into seven models that were joined together as needed. The model areas were selected based on confluence with major waterways, number of reservoirs, location of gaging stations, and to accommodate SWAT limitations. The seven areas are shown on Figure 4.1 and consist of the Afton model, Bark River model, Crawfish River model, Middle Rock River model, Turtle Creek model, Upper Rock River model, and Yahara River model. The calibration and validation of these models will be discussed individually after a discussion on the general calibration and validation procedure.

General Calibration and Validation Procedure

All results reported were simulated with a modified version of SWAT 98.1. The model was first calibrated to flows, then sediment, and finally phosphorus. Once calibration was complete it was not adjusted to make another component fit. For example, once hydrology was calibrated, the hydrologic component of the model was not adjusted to make the sediment component fit. When calibrating for sediment, only the model components affecting erosion were adjusted. Once all three components were calibrated, the hydrology was rechecked to ensure that modifications to the other components had not affected the hydrology calibration.

The two pilot areas were used as the primary calibration sites. Because the remaining gaging stations (the seven sites listed above) had primarily flow data, alternative methods had to be developed for calibrating sediment and phosphorus. The monitoring conducted by the Rock River Partnership provided one year of data and was used more as validation data then calibration. No attempt was made to try to match model output to this data.

The first calibration step was to match the hydrology. This was accomplished by balancing surface water, groundwater, and ET. Adjustment of surface water and groundwater was made by adjustment of the groundwater parameters, the NRCS curve numbers, soil hydraulic conductivity and bulk density, and the crop growth routine. Adjustment of ET was made based on adjusting the ET parameters and the crop growth routine. The portioning between groundwater and surface flow was estimated using the base-flow separation model. ET rates were verified by data collected from the UW-Extension Agricultural Research Station at Arlington.

Hydrology was balanced first on a yearly basis looking at average annual totals, then monthly (to verify snowfall and snowmelt routines), and then daily. The goal of the modeling from the start was to calibrate the hydrology to the annual totals. Daily calibration was conducted only to check the daily routines such as crop growth, and ET. The crop growth routine was calibrated because of its effects on ET and biomass production. Excess biomass can cause an overestimate of the amount of residue that is available to reduce soil erosion. Nutrient uptake would also be affected. To adjust crop yields, the crop's biomass energy factor (BE) located in the SWAT crop database was reduced from default values of 40, 20, and 35 to 24, 14, and 25 for corn, alfalfa, and oats respectively. These values were provided by Paul Baumgart and based on calibration of the Fox-Wolf SWAT model. The crop yields predicted by SWAT were then compared with those published in the USDA Agricultural Statistics.

In addition, potential heat units (PHU) of the crops were adjusted from default values. PHUs determine how fast a crop will mature based on energy units. Values were obtained from Paul Baumgart and adjusted to reflect the earlier maturity date for the southern portion of Wisconsin.

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The nutrient stress component of the model was deactivated. The nutrient stress component affects the plant growth routine based on the availability of nutrients. Given the excess amount of nutrients already in the soil, no stress should occur. To avoid potential problems, the nutrient component was deactivated and plant growth was controlled by adjustment of the BE factor.

Calibration and validation was performed against data obtained from the USGS gaging stations. Several discrepancies in data obtained from USGS gaging stations were noticed. Particular periods of concern are during the spring when ice jams may cause gauges to record artificially high flow measurements. The USGS does attempt to flag these data however there were several occurrences where this discrepancy may have been missed. If early spring high flows could not be correlated with a recorded precipitation event, it was assumed that an ice jam condition existed, and the reported flows were adjusted based on flows before and after the ice jam.

The spatial and temporal variations in rainfall were addressed during calibration and validation. Often a precipitation event occurred at one station but changes in monitored flow were not observed in an adjacent watershed. Due to the lack of stations, climate data had to be assigned to adjacent watersheds. This is important to remember when viewing output hydrographs. At times, the monitoring data would show a large runoff event while the model had not predicted one or vice versa. When precipitation was added to the graph, it was clear that in some cases the climate data did not record a precipitation event thus a runoff event was not simulated, however, the monitoring data showed a large runoff event. This indicated either an error in the gaging records or a spatial or temporal variation in rainfall. This can greatly affect the calibration results, however it does not have an impact on the model's ability to compare loadings form different management scenarios. Predictions of management scenarios are valid because climate factors remain constant under all management scenarios.

To measure the accuracy of the SWAT runs to measured values, the Nash Sutcliffe coefficient of efficiency and R-squared were utilized. The tests will compare simulated and monitored annual, monthly and daily values for flows. It was agreed, based on other modeling exercises, that values greater than 0.6 from either test applied to the annual flow values will be considered a good fit. R-squared values will tend to be higher than Nash Sutcliffe values. This is because an outlying value on a single event will significantly lower the Nash Sutcliffe coefficient while only slightly affecting the R-squared value.

During the calibration, it was found that 1993 was an extreme year in regards to rainfall. Given that many of the SWAT inputs are based on average values, it is not surprising that the model failed to make accurate predictions for such an extremely wet year. It was decided that 1993 would be discarded and the calibration validation period would be between 1980-1992 and 1994-1998 as the record period for individual stations allows. Approximately four years of validation were used and the validation period was selected throughout the 1980-1998 period. To aid in the selection of the years it was proposed to examine the records for the USGS station on the Rock River at Afton for the long term average flow, and the standard deviation of the flows. The USGS conducted this evaluation.. Two calibration periods and validation periods was selected, one including extreme (precipitation) years and one without. Selected calibration and validation periods with a high flow year and a low flow year were 1989-1996 and 1970-1987. The best periods without extreme conditions were 1980-1984 and 1994-1998. Given the availability of data from gaging sites, these recommended periods would be adhered to in dividing data between calibration and validation.

Calibration and validation proceeded from upstream to downstream. Once calibration was completed at a station, alterations were not made to the input files associated with that station to obtain a better fit at a downstream station. In addition, model parameters were not adjusted for downstream watersheds to

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offset errors in flow predictions. For example, if upstream stations were under predicting flows by 80%, one would not expect the next downstream station to be within 5% of measured flows. If this occurred, runoff was likely being over estimated in the downstream area. Of course, reservoirs, confluence with other rivers, and changes in groundwater contributions could offset this. For the most part, because of the level of information, the management files and associated files were not adjusted during calibration because sufficient data was not generally available to support it.

Once the pilot areas were calibrated, little to no changes were made in the management routines. A final calibration and validation was performed on all the management files to assure that predicted values were in line with expected values from field scale studies and literature values. Table 5.1 provides a summary of the evaluation of management files for a type B soil. The management files were evaluated with a default groundwater file, average type B soil values including an average slope of 2% and a slope length of 300 feet.

Table 5-1
Evaluation of Management Files

Management File	Surface Q (mm)	Sediment (t/h)	Organic P (k/h)	Soluble P (k/h)	Total P (k/h)	% P Drop Relative to Conventional Tillage	% P Drop Relative to Conservation Tillage
cs_con.mgt	61.057	0.754	0.617	0.058	0.675		
cs_oth.mgt	55.858	0.381	0.372	0.073	0.445	34%	
cs_mul.mgt	55.721	0.339	0.342	0.072	0.414	39%	
cs_til.mgt	33.803	0.161	0.295	0.096	0.391	42%	6%
sc_con.mgt	59.975	0.792	0.589	0.051	0.64		
sc_oth.mgt	56.519	0.458	0.402	0.068	0.47	27%	
sc_mul.mgt	55.942	0.349	0.347	0.082	0.429	33%	
sc_til.mgt	33.319	0.181	0.317	0.09	0.407	36%	5%
scc_con.mgt	59.294	0.673	0.548	0.059	0.607		
scc_oth.mgt	54.083	0.352	0.338	0.073	0.411	32%	
scc_mul.mgt	53.82	0.285	0.305	0.086	0.391	36%	
scc_til.mgt	40.215	0.156	0.263	0.099	0.362	40%	7%
csc_con.mgt	60.072	0.888	0.664	0.047	0.711		
csc_oth.mgt	55.443	0.429	0.386	0.064	0.45	37%	
csc_mul.mgt	54.894	0.362	0.363	0.079	0.442	38%	
csc_til.mgt	33.107	0.158	0.29	0.092	0.382	46%	14%
ccs_con.mgt	61.27	0.711	0.603	0.063	0.666		
ccs_oth.mgt	56.043	0.353	0.357	0.079	0.436	35%	
ccs_mul.mgt	55.893	0.302	0.329	0.093	0.422	37%	
ccs_til.mgt	32.877	0.146	0.272	0.096	0.368	45%	13%
ch_con.mgt	37.694	0.327	0.368	0.065	0.433		
ch_oth.mgt	33.088	0.161	0.196	0.067	0.263	39%	
ch_mul.mgt	32.04	0.143	0.179	0.071	0.25	42%	
ch_til.mgt	24.094	0.109	0.154	0.067	0.221	49%	12%
hc_con.mgt	38.358	0.354	0.38	0.07	0.45		
hc_oth.mgt	38.28	0.279	0.337	0.085	0.422	6%	
hc_mul.mgt	33.855	0.266	0.325	0.08	0.405	10%	

Management File	Surface Q (mm)	Sediment (t/h)	Organic P (k/h)	Soluble P (k/h)	Total P (k/h)	% P Drop Relative to Conventional Tillage	% P Drop Relative to Conservation Tillage
hc_til.mgt	26.156	0.18	0.247	0.071	0.318	29%	21%
cc_con.mgt	58.146	0.653	0.621	0.079	0.7		
cc_oth.mgt	53.135	0.294	0.336	0.094	0.43	39%	
cc_mul.mgt	52.945	0.241	0.298	0.109	0.407	42%	
cc_til.mgt	31.232	0.136	0.281	0.105	0.386	45%	5%
hs_con.mgt	40.316	0.42	0.463	0.076	0.539		
hs_mul.mgt	39.19	0.272	0.337	0.101	0.438	19%	
sh_con.mgt	38.862	0.358	0.407	0.069	0.476		
sh_mul.mgt	35.193	0.161	0.214	0.087	0.301	37%	
veg.mgt	68.997	0.309	0.388	0.141	0.529		
veg_hay.mgt	43.469	0.157	0.155	0.067	0.222		
hay_veg.mgt	43.976	0.243	0.216	0.059	0.275		
sod.mgt	6.423	0.006	0.003	0.006	0.009		
pas_for.mgt	1.93	0.005	0.002	0.008	0.01		
urban.mgt	113.344	0.468	0.49	0.2	0.69		
barren_roads.mgt	54.776	0.007	0.029	0.6	0.629		

Calibration at gaging stations for flow was limited to adjustment of the reservoir files, the baseflow and groundwater files, and regional soil parameters. Suspended solid loads were adjusted primarily by modification of the channel characteristics including channel cover and channel erosion parameters. In addition, the version of SWAT used in this study had global adjustment of the MUSLE formula for routing of sediment. These variables in the MUSLE equation were adjusted based on the characteristics of the watershed. Phosphorus numbers were not adjusted at this scale because the phosphorus parameters had been calibrated during the pilot scale modeling and sufficient data did not exist to justify modification of the parameters.

Afton Station (on the Rock River) Model

The Afton model included the Lower Rock River and Lake Koshkonong. It was selected based on the WDNR's Upper and Lower Rock River Basin divide and the separation of the Bark River and Yahara River systems. Calibration and validation data was available for three gaging stations. Stations included one long term USGS station with flow only (Rock River at Afton, USGS #5430500), one existing USGS station also monitored by the Rock River Partnership for one year (Rock River at Indianford, USGS #5427570), and one station that was monitored by the Rock River Partnership (Rock River at Fort Atkinson, USGS # 5427080). The calibration and validation data is summarized below. Hydrographs comparing daily flow are included in Appendix G.

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Table 5.2
Calibration/Validation Results
Rock River at Afton (USGS # 5430500)

Year	Predicted Flow (in. of runoff)	Measured Flow (in. of runoff)	% Difference
1989	6.64	5.67	17%
1990	7.89	6.71	17%
1991	8.00	6.95	15%
1992	9.61	8.80	9%
1993	14.56	15.95	9%
1994	5.28	8.41	37%
1995	5.97	6.74	11%
1996	12.91	11.40	13%
Totals	70.85	70.63	0%

For flow: R SQ. of 0.78 and a COE of 0.76.

This gage (USGS # 5430500) was the last gage in the Rock River before entering Illinois and includes most of the Rock River Basin in Wisconsin. This station was used primarily as validation because by this point in the system, parameters could not be adjusted to make the model predictions match at this point without altering results at upstream gages.

Table 5.3
Calibration/Validation Data
Rock River at Indianford (USGS #5427570)

Year	Predicted Flow (in. of runoff)	Measured Flow (in. of runoff)	% Difference
1989	6.82	5.11	34%
1990	7.44	6.68	11%
1991	7.25	6.83	6%
1992	9.05	9.15	1%
1993	13.11	16.78	22%
1994	4.52	7.68	41%
1995	4.90	6.19	21%
1996	12.04	11.64	3%
Totals	65.13	70.06	7%

For flow: R SQ. of 0.75 and a COE of 0.58.

The Rock River at Indianford and Fort Atkinson were both monitored for water quality parameters by the Partnership. Because there was only one year of data, it best served as validation data.

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Table 5.4
Validation Results
Rock River at Indianford (USGS #5427570)
USGS Water Year 1999

Flow (cfs-day)			**Sediment (tons/yr)**			**Phosphorus (lbs/yr)**		
Predicted	Measured	% Diff.	Predicted	Measured	% Diff.	Predicted	Measured	% Diff.
750,401	713,102	5%	51,416	102,637	50%	1,413,944	955,915	48 %

Table 5.5
Validation Results
Rock River at Fort Atkinson (USGS #5427080)
USGS Water Year 1999

Flow (cfs-day)			**Sediment (tons/yr)**			**Phosphorus (lbs/yr)**		
Predicted	Measured	% Diff.	Predicted	Measured	% Diff.	Predicted	Measured	% Diff.
644,138	622,133	4 %	120,365	116,204	4 %	1,263,345	1,063,913	19 %

Substantial difference was observed between the two stations regarding the accuracy of the predictions of sediment and phosphorus. The drainage areas of the two stations do not differ significantly, however, Fort Atkinson is above Lake Koshkonong and Indianford is located below Lake Koskonong. Results clearly indicate that SWAT is predicting a higher sediment settlement rate in the lake than is actually occurring and is not allowing for enough biological uptake of phosphorus. These problems are associated with the routing routines and do not affect the loading predictions for each sub-watershed, which are summarized before routing.

The Bark River Model

The Bark River model simulates the Bark River watershed before its confluence with the Rock River. Data was collected from two gaging stations located in the Bark River watershed, however, after review of the data only one station had records adequate for calibration and validation. The Bark River near Rome (USGS # 5426250) has a drainage area of 122 square miles and had flow data available for 1983 to present. Calibration results are summarized in Table 5.6 and yearly hydrographs are included in Appendix H.

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Table 5.6
Calibration/Validation Results
Bark River near Rome (USGS # 5426250)

Year	Predicted Flow (in. of runoff)	Measured Flow (in. of runoff)	% Difference
1989	7.75	5.98	29%
1990	8.19	8.14	1%
1991	8.33	8.61	3%
1992	10.73	9.45	14%
1993	15.59	15.88	2%
1994	5.16	8.35	38%
1995	5.96	7.77	23%
1996	12.98	9.89	31%
Totals	74.69	74.07	1%

For flow: R SQ. of 0.68 and a COE of 0.68.

Water quality data was not available at any of the stations located within the Bark River watershed. Average annual water yields matched fairly well between measured and predicted values, however, flows depicted on the daily hydrographs were not as accurate because of the presence of several reservoirs with controlled outlets.

Crawfish River Model

The Crawfish River model simulates the Crawfish River to its confluence with the Rock River. Two USGS stations had long term flow records and the Rock River Partnership monitored both sites for water quality parameters. Calibration and validation results are summarized below and yearly hydrographs are included in Appendix I.

Station #5425912 is located at the outlet of Beaver Dam Lake. Station 5426000 is located on the Crawfish River near Milford and captures almost the entire Crawfish River watershed.

Table 5.7
Calibration/Validation Results
Beaver Dam River (USGS #5425912)

Year	Predicted Flow (in. of runoff)	Measured Flow (in. of runoff)	% Difference
1989	12.11	5.53	119%
1990	15.12	6.94	118%
1991	13.55	7.43	82%
1992	16.76	9.03	86%
1993	27.29	20.09	36%
1994	3.90	5.60	30%
1995	4.33	6.67	35%
1996	25.53	13.15	94%
Totals	118.58	74.43	59%

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For flow: R SQ. of 0.73 and a COE of 0.44.

Table 5.8
Validation Data
Beaver Dam River (USGS #5425912)
USGS Water Year 1999

Flow (cfs-day)			Sediment (tons/yr)			Phosphorus (lbs/yr)		
Predicted	Measured	% Diff.	Predicted	Measured	% Diff.	Predicted	Measured	% Diff.
41,420	42,312	2 %	780	3,030	74 %	76,522	59,483	29 %

As was observed at Lake Koshkonong, results clearly indicate that SWAT is predicting a higher sediment settlement rate in the lake than is actually occurring and is not allowing for enough biological uptake of phosphorus. These problems are associated with the routing routines and do not affect the loading predictions for each sub-watershed, which are summarized before routing.

Table 5.9
Calibration Results
Crawfish River at Milford (USGS #5426000)

Year	Predicted Flow (in. of runoff)	Measured Flow (in. of runoff)	% Difference
1989	7.40	4.27	73%
1990	8.61	6.09	41%
1991	8.12	6.61	23%
1992	10.65	9.33	14%
1993	14.89	19.90	25%
1994	4.81	8.47	43%
1995	4.71	6.48	27%
1996	13.78	12.77	8%
Totals	72.99	73.92	1%

For flow: R SQ. of 0.65 and a COE of 0.37.

Table 5.10
Validation Results
Crawfish River at Milford (USGS #5426000)

Year	Predicted Flow (in. of runoff)	Measured Flow (in. of runoff)	% Difference
1970	2.92	2.41	21%
1971	10.32	7.20	43%
1972	6.44	6.46	0%
1973	15.85	17.97	12%
1974	11.65	11.93	2%
1975	6.46	9.50	32%
1976	6.23	6.92	10%
1977	3.06	2.04	50%
1978	11.07	8.29	34%
1979	9.40	12.34	24%

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Year	Predicted Flow (in. of runoff)	Measured Flow (in. of runoff)	% Difference
1980	4.66	7.62	39%
1981	8.70	7.80	12%
1982	8.42	10.15	17%
1983	8.86	10.57	16%
1984	10.30	9.17	12%
1985	10.56	11.24	6%
1986	16.08	19.64	18%
1987	10.03	11.75	15%
Totals	161.00	172.99	7%

For flow: R SQ. of 0.81 and a COE of 0.68.

Table 5.11
Validation Results
Crawfish River at Milford (USGS #5426000)
USGS Water Year 1999

Flow (cfs-day)			Sediment (tons/yr)			Phosphorus (lbs/yr)		
Predicted	Measured	% Diff.	Predicted	Measured	% Diff.	Predicted	Measured	% Diff.
247,107	195,384	26%	43,273	33,629	29%	532,401	326,506	63%

Middle Rock River Model:

The Middle Rock River model was created to allow the joining of the Crawfish and Upper models and provided an ending point matching the WDNR delineation for the Upper Rock River Basin. The loads calculated exiting the Middle model best represents the loads generated by the entire Upper Rock River Basin.

The Middle Rock River Model had one USGS gaging station with long term flow records and did not have any stations with water quality data. The drainage area for the station at Fort Atkinson (included in the Afton Model) consists mostly of the Upper Rock River Basin so water quality parameters can be tied back to that station. Calibration and validation results are summarized below and yearly hydrographs are included in Appendix J.

Table 5.12
Calibration Results
Rock River at Jefferson (USGS #5426031)

Year	Predicted Flow (in. of runoff)	Measured Flow (in. of runoff)	% Difference
1989	7.59	4.92	54%
1990	7.79	6.29	24%
1991	8.01	7.16	12%
1992	9.82	9.52	3%
1993	13.46	14.77	9%

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Totals	46.66	42.66	9%

For flow: R SQ. of 0.98 and a COE of 0.57.

Turtle Creek Model:

The Turtle Creek model was the first model created after completion of the pilot scale modeling. Turtle Creek does not enter the Rock River until after it crosses the Wisconsin – Illinois border. The Turtle Creek model had several gaging stations however most were associated with studies of Lake Delavan. In addition to the pilot area, two additional gaging stations were selected. One was located near the outlet of Lake Delavan and the other was located at Carvers Rock and included water quality monitoring through the Partnership. Calibration and validation results are summarized below and yearly hydrographs are included in Appendix K.

Table 5.13
Calibration Results
Lake Delavan Outlet (USGS #5431022)

Year	Predicted Flow (in. of runoff)	Measured Flow (in. of runoff)	% Difference
1989	5.28	5.02	5%
1990	8.37	3.70	126%
1991	7.04	3.54	99%
1992	8.35	5.35	56%
1993	11.78	13.72	14%
1994	3.51	5.53	37%
1995	4.98	5.10	2%
1996	10.74	8.33	29%
Totals	60.05	50.31	19%

For flow: R SQ. of 0.46 and a COE of 0.18.

Results at the outlet for Lake Delavan are misleading. The lake was drained in 1990 and 1991 for restoration work and a dam controls the lake level. Even though the average annual value is fairly close, examination of daily flows reveals that the model was unable to accurately predict the flows, as is expected given the management of the lake. These fluctuations evened out as the simulation moved downstream and the influence of the lake was tapered.

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Table 5.14
Calibration Results
Turtle Creek at Carvers Rock Rd (USGS #5431486)

Year	Predicted Flow (in. of runoff)	Measured Flow (in. of runoff)	% Difference
1989	5.80	5.61	3%
1990	7.52	6.10	23%
1991	7.75	6.11	27%
1992	9.32	7.98	17%
1993	13.35	16.17	17%
1994	6.26	7.99	22%
1995	6.40	6.32	1%
1996	11.82	9.17	29%
Totals	68.21	65.44	4%

For flow: R SQ. of 0.72 and a COE of 0.55.

Table 5.15
Validation Results
Turtle Creek at Carvers Rock Rd (USGS #5431486)

Year	Predicted Flow (in. of runoff)	Measured Flow (in. of runoff)	% Difference
1970	6.25	6.86	9%
1971	9.15	9.31	2%
1972	9.98	11.80	15%
1973	15.59	19.74	21%
1974	14.24	19.71	28%
1975	7.07	11.33	38%
1976	7.88	8.12	3%
1977	3.36	4.71	29%
1978	9.58	9.40	2%
1979	11.49	11.43	1%
1980	7.82	9.07	14%
1981	8.56	7.91	8%
1982	8.93	11.97	25%
1983	11.14	13.44	17%
1984	10.76	10.13	6%
1985	11.32	10.96	3%
1986	12.84	14.78	13%
1987	10.02	9.74	3%
Totals	175.96	200.40	12%

For flow: R SQ. of 0.80 and a COE of 0.48.

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Table 5.16
Validation Results
Turtle Creek at Carvers Rock Rd (USGS #5431486)
USGS Water Year 1999

Flow (cfs-day)			**Sediment (tons/yr)**			**Phosphorus (lbs/yr)**		
Predicted	Measured	% Diff.	Predicted	Measured	% Diff.	Predicted	Measured	% Diff.
67,063	65,100	3%	11,712	10,715	9%	112,076	69,250	62%

Validation results for flow and sediment are excellent however the predicted phosphorus load is considerably higher than the monitored load. Several explanations for these results were evaluated however, a definite cause could not be determined. Possible explanations include the influence of Lake Delavan, a difference from the normal Rock River fate and transport phenomena occurs in Turtle Creek because of stream characteristics, or the generalization of fertilizer applications does not accurately mimic actual practices in Turtle Creek.

Upper Rock River Model:

The Upper Rock River model had two USGS stations with long-term flow records. In addition the Rock River Partnership monitored water quality parameters at two sites. Calibration and validation results are summarized below and yearly hydrographs are included in Appendix L.

Table 5.17
Calibration Results
South Branch of the Rock River at Waupun (USGS #5423500)

Year	**Predicted Flow (in. of runoff)**	**Measured Flow (in. of runoff)**	**% Difference**
1989	2.06	5.53	63%
1990	2.84	6.94	59%
1991	4.47	7.43	40%
1992	4.22	9.03	53%
1993	7.95	20.09	60%
1994	5.51	5.60	2%
1995	3.76	6.67	44%
1996	6.50	13.15	51%
Totals	35.25	68.90	49%

For flow: R SQ. of 0.702 and a COE of - 0.32.

The poor correlation of the predicted to monitored flows at this station were traced back to two causes: 1) poor climate and rainfall data, 2) soil associations in different locations in the basin may have different physical characteristics (i.e infiltration), and 3) the presence of large wetland complexes (Horicon Marsh) in the Upper Rock. This seemed to be a problem with the entire Upper Rock River Model and was not observed as profoundly in the Crawfish Model.

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Station 5424057 is located near the outlet of the Horicon Marsh. Consideration should be made when viewing results since all of the modified wetland routines did not make it into the version of SWAT used for this project. In addition, given the level of management and complexity of the Horicon Marsh, almost any model would be challenged to accurately simulate the processes occurring.

Table 5.18
Validation Results
Rock River at Horicon (USGS #5424057)
USGS Water Year 1999

Flow (cfs-day)			**Sediment (tons/yr)**			**Phosphorus (lbs/yr)**		
Predicted	Measured	% Diff.	Predicted	Measured	% Diff.	Predicted	Measured	% Diff.
68,956	118,096	42 %	33,766	28,055	20 %	181,968	317,329	43 %

Station 5424082 is located at the outlet of Lake Sinissippi on the Rock River at Hustisford. Given the influence of the Horicon Marsh and the influence of the dam on the gaging site, SWAT had a difficult time simulating the flows out of the lake. Even though the R SQ. value is 0.89, no correlation between simulated and monitored loads should be made.

Table 5.19
Calibration Results
Rock River at Hustisford (USGS #5424082)

Year	**Predicted Flow (in. of runoff)**	**Measured Flow (in. of runoff)**	**% Difference**
1980	1.24	6.84	82%
1981	2.20	7.74	72%
1982	2.46	9.42	74%
1983	3.46	9.99	65%
1984	3.60	11.15	68%
Totals	5.90	24.00	75%

For flow: R SQ. of 0.89 and a COE of - 6.46

Downstream of Lake Sinissippi, results at gaging station 542550 were not as influenced by Horicon Marsh, however, errors between predicted and measured values mirrored those from upstream, just slightly dampened.

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Table 5.20
Calibration Results
Rock River at Watertown (USGS #5425500)

Year	Predicted Flow (in. of runoff)	Measured Flow (in. of runoff)	% Difference
1989	7.45	5.60	33%
1990	6.92	6.54	6%
1991	7.70	7.92	3%
1992	8.81	9.89	11%
1993	11.89	16.62	28%
1994	4.39	6.99	37%
1995	4.19	5.08	18%
1996	11.00	12.12	9%
Totals	62.35	70.75	12%

For flow: R SQ. of 0.77 and a COE of 0.42.

Table 5.21
Validation Results
Rock River at Watertown (USGS #5425500)
USGS Water Year 1999

Flow (cfs-day)			Sediment (tons/yr)			Phosphorus (lbs/yr)		
Predicted	Measured	% Diff.	Predicted	Measured	% Diff.	Predicted	Measured	% Diff.
255,603	253,439	1 %	43,360	37,291	16 %	465,175	431,304	8 %

Yahara River Model:

The Yahara River model includes the Madison chain of Lakes and the Badfish Creek watersheds and extends to the Yahara River confluence with the Rock River. Several gaging stations with water quality and flow data were located in the model area in addition to the pilot area. Calibration and validation results are summarized below and yearly hydrographs are included in Appendix M.

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Table 5.22
Calibration Results
Pheasant Branch at Middleton (USGS # 5427948)

Year	Predicted Flow (in. of runoff)	Measured Flow (in. of runoff)	% Difference
1989	0.92	2.81	67%
1990	3.07	2.46	24%
1991	3.58	2.30	56%
1992	4.31	2.91	48%
1993	9.18	8.16	13%
1994	1.95	4.07	52%
1995	2.62	2.58	2%
1996	6.26	4.50	39%
Totals	31.89	29.79	7%

For flow: R SQ. of 0.69 and a COE of 0.67.

Table 5.23
Calibration Results
Badfish Creek near Cooksville (USGS # 5430150)

Year	Predicted Flow (in. of runoff)	Measured Flow (in. of runoff)	% Difference
1994	15.68	18.52	15%
1995	17.54	16.30	8%
1996	20.99	20.06	5%
1997	16.85	18.75	10%
Totals	71.05	73.64	4%

For flow: R SQ. of 0.24 and a COE of 0.94.

Table 5.24
Validation Results
Badfish Creek near Cooksville (USGS # 5430150)

Year	Predicted Flow (in. of runoff)	Measured Flow (in. of runoff)	% Difference
1980	16.56	16.53	0%
1981	18.91	15.34	23%
1982	19.08	17.45	9%
1983	17.96	17.20	4%
1984	19.43	17.53	11%
Totals	91.94	84.04	9%

For flow: R SQ. of 0.03 and a COE of 0.10.

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Even though the totals appear close, the RSQ. And COE values are low because of the significanct influence of MMSD on the stream dynamics of the Badfish and lower reaches of the Yahara.

Table 5.25
Calibration Results
Yahara River at STH 59 (USGS # 5430175)

Year	Predicted Flow (in. of runoff)	Measured Flow (in. of runoff)	% Difference
1994	8.50	11.18	24%
1995	10.00	9.21	9%
1996	14.51	12.08	20%
1997	8.47	10.52	20%
Totals	41.47	42.98	4%

For flow: R SQ. of 0.31 and a COE of 0.84.

Table 5.26
Validation Results
Yahara River at STH 59 (USGS # 5430175)

Year	Predicted Flow (in. of runoff)	Measured Flow (in. of runoff)	% Difference
1980	7.95	8.09	2%
1981	11.64	9.09	28%
1982	9.98	10.22	2%
1983	9.88	9.87	0%
1984	12.84	9.87	30%
Totals	52.30	47.15	11%

For flow: R SQ. of 0.28 and a COE of 0.20.

Table 5.27
Validation Results
Yahara River at STH 59 (USGS # 5430175)
USGS Water Year 1999

Flow (cfs-day)			**Sediment (tons/yr)**			**Phosphorus (lbs/yr)**		
Predicted	Measured	% Diff.	Predicted	Measured	% Diff.	Predicted	Measured	% Diff.
157,651	162,142	3 %	19,118	21,880	13 %	239,574	174,911	37 %

The water quality results simulated for the Yahara River are consistent with those of the rest of the Rock River Basin. Sediment loads are likely being under predicted and phosphorus loads over predicted because of the influence of the lakes. Again, these errors are associated with the routing routines and do not affect the loading predictions for each sub-watershed, which are summarized before routing.

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