



# **Des Moines Headwaters, Lower Des Moines, and East Fork Des Moines River Basins Watershed Model Development**

## **Appendices A, B, and C**

**Prepared for**  
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# Appendix A. Detailed Snow Calibration Results

## WEATHER REGION 1

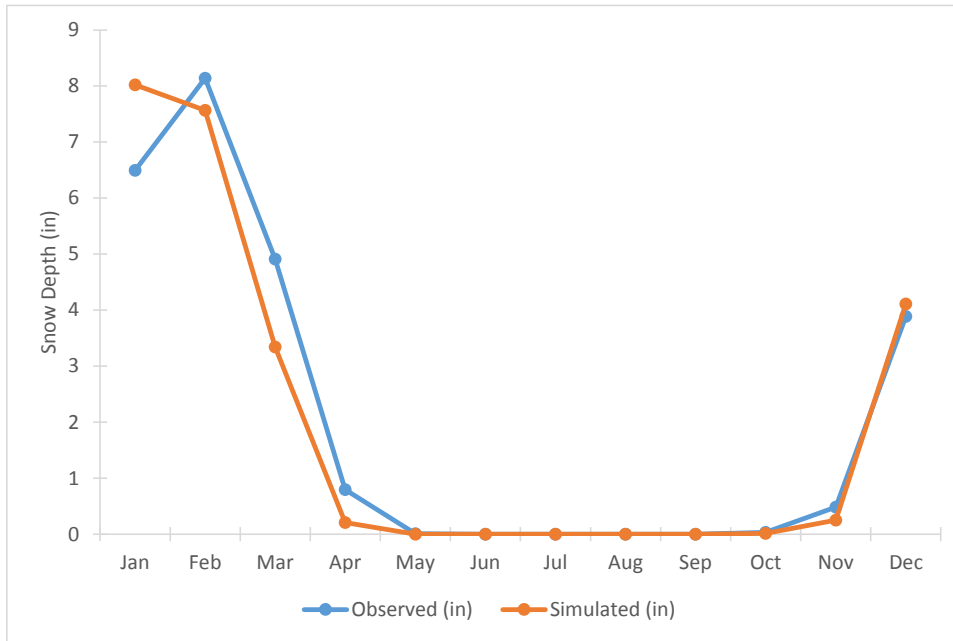


Figure 1. Mean monthly snow depth for weather region 1

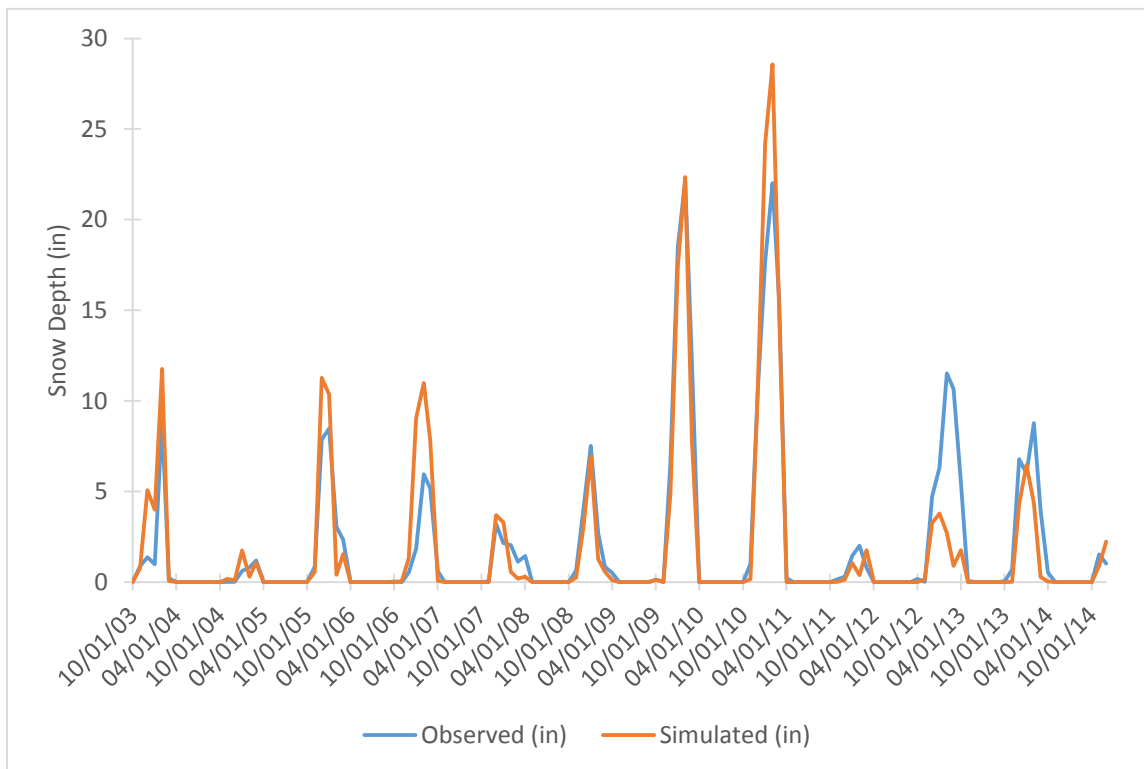
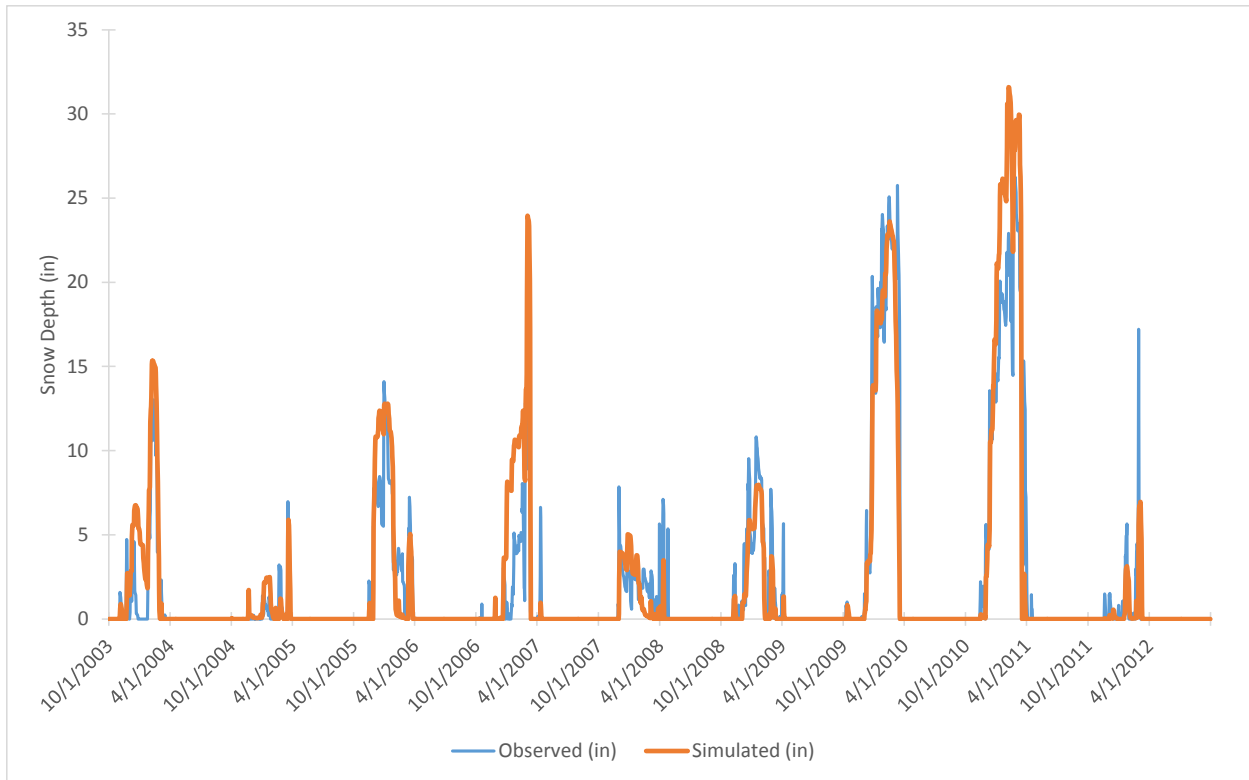
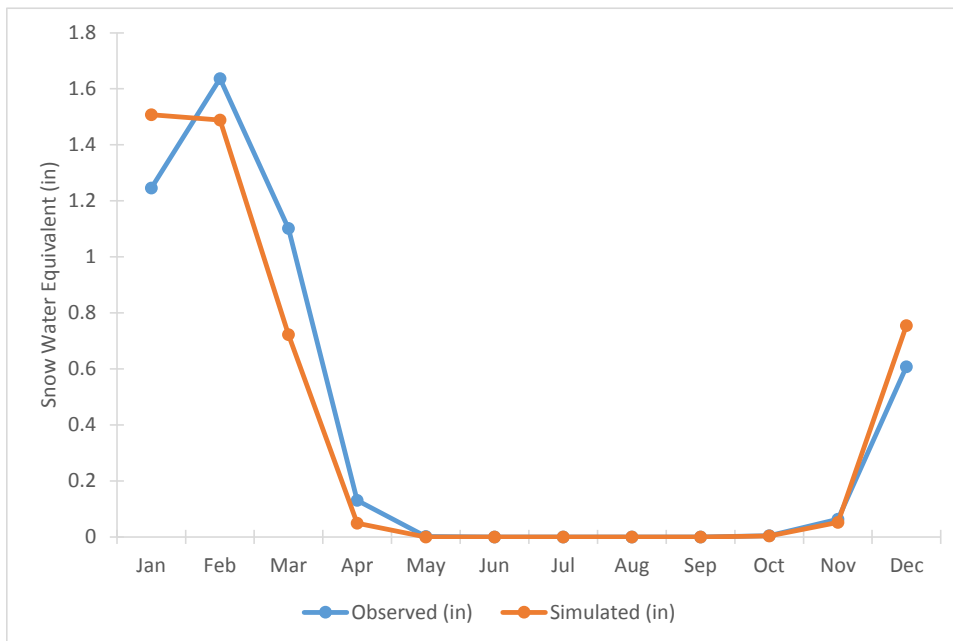


Figure 2. Mean monthly snow depth time-series for weather region 1



**Figure 3. Mean daily snow depth time-series for weather region 1**



**Figure 4. Mean monthly snow water equivalent for weather region 1**

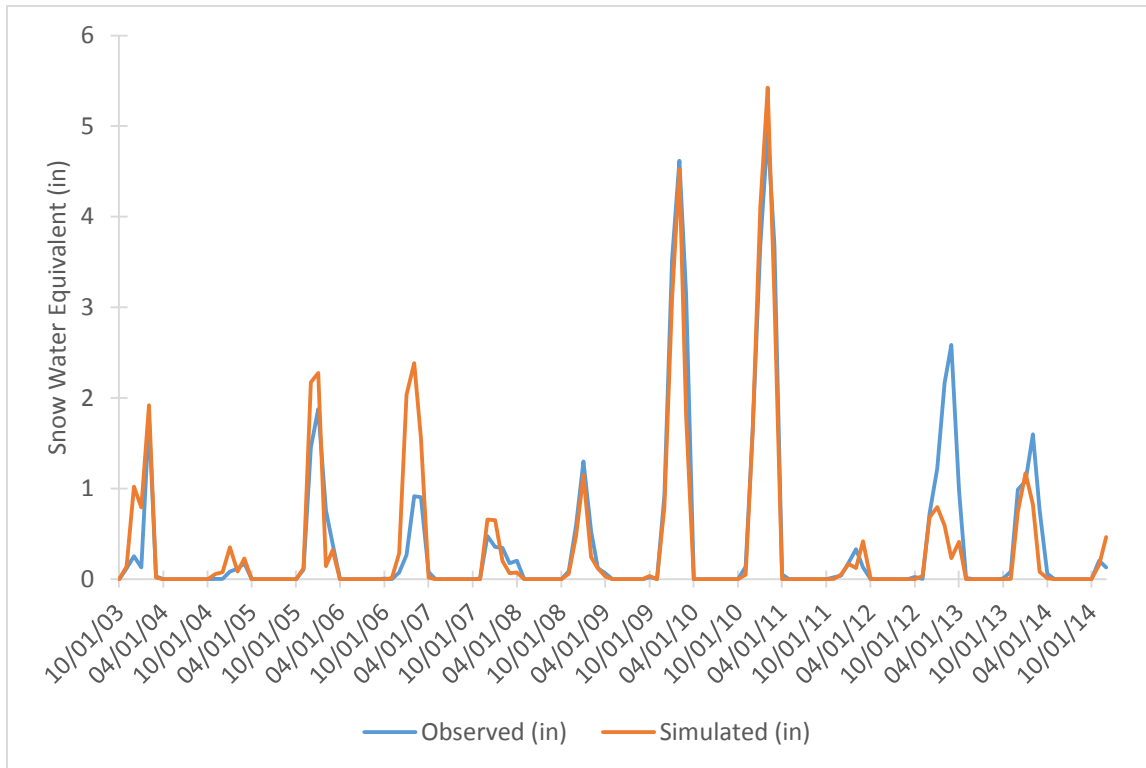


Figure 5. Mean monthly snow water equivalent time-series for weather region 1

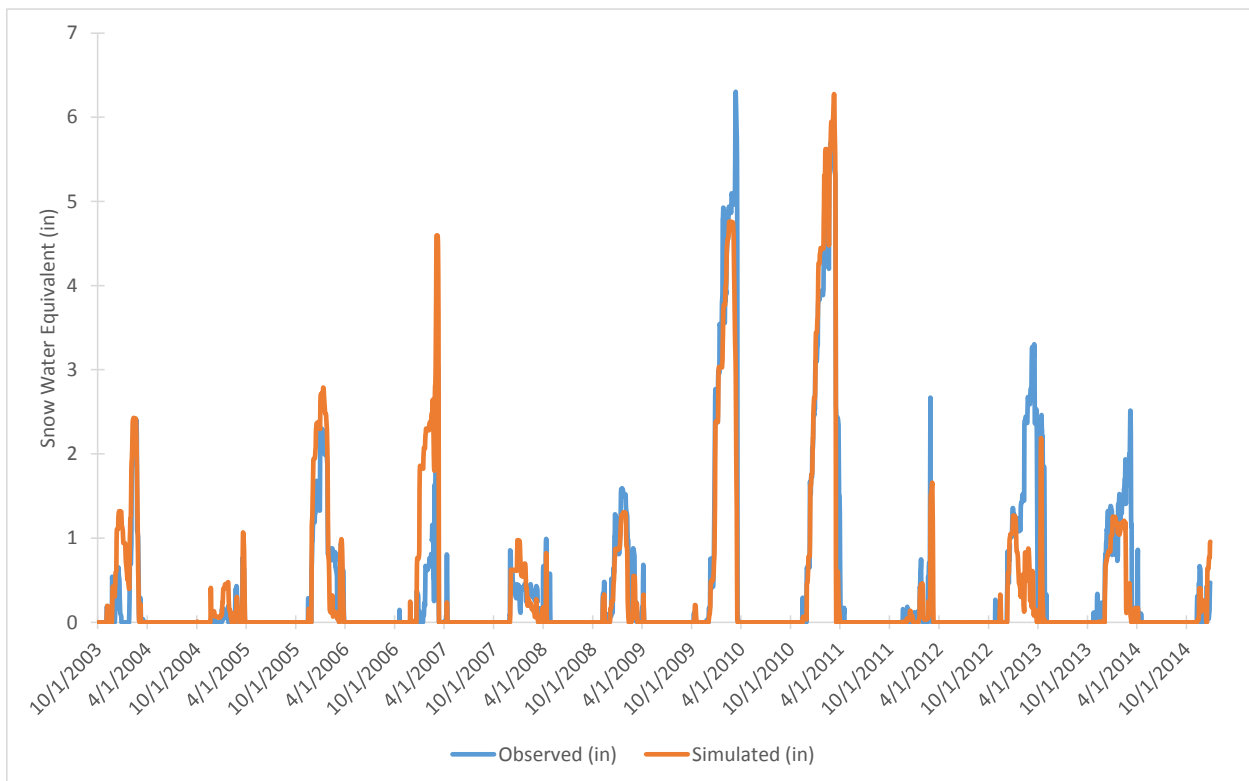


Figure 6. Mean daily snow water equivalent time-series for weather region 1

## WEATHER REGION 2

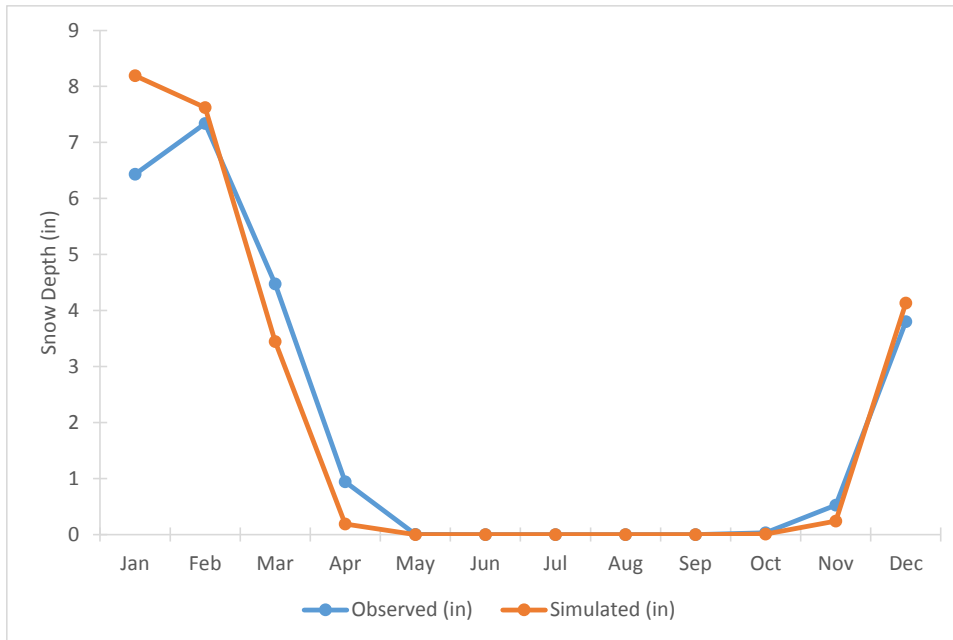


Figure 7. Mean monthly snow depth for weather region 2

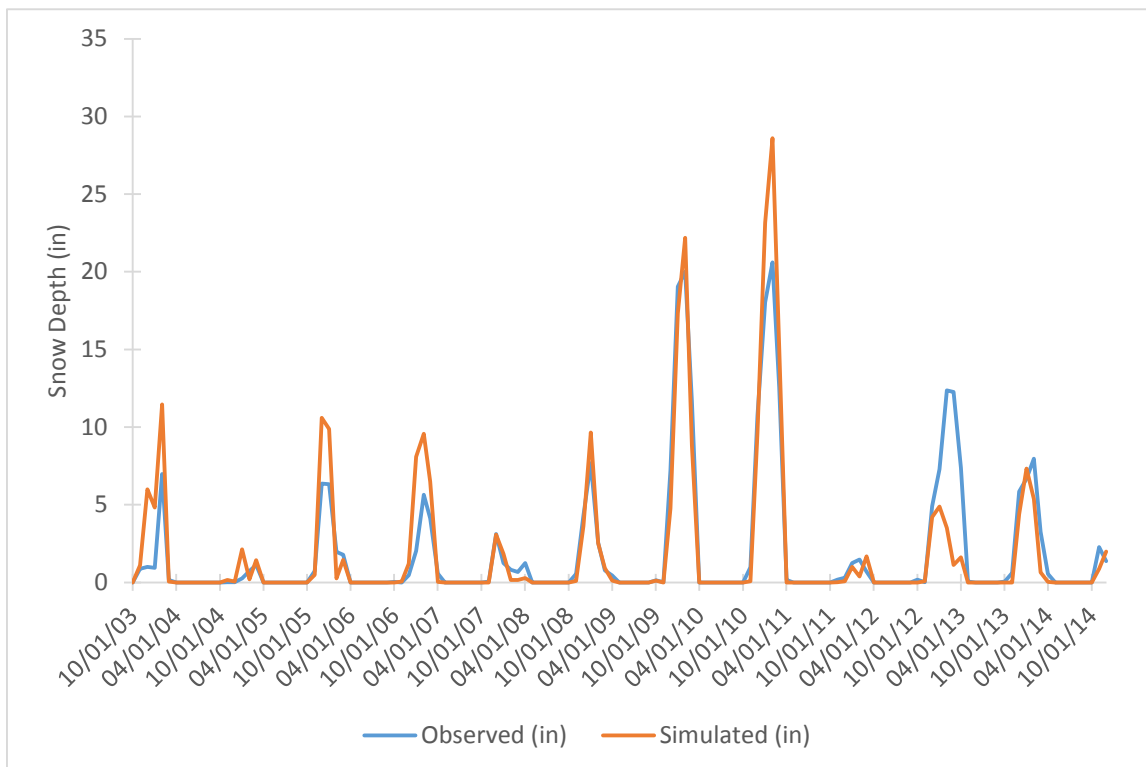


Figure 8. Mean monthly snow depth time-series for weather region 2

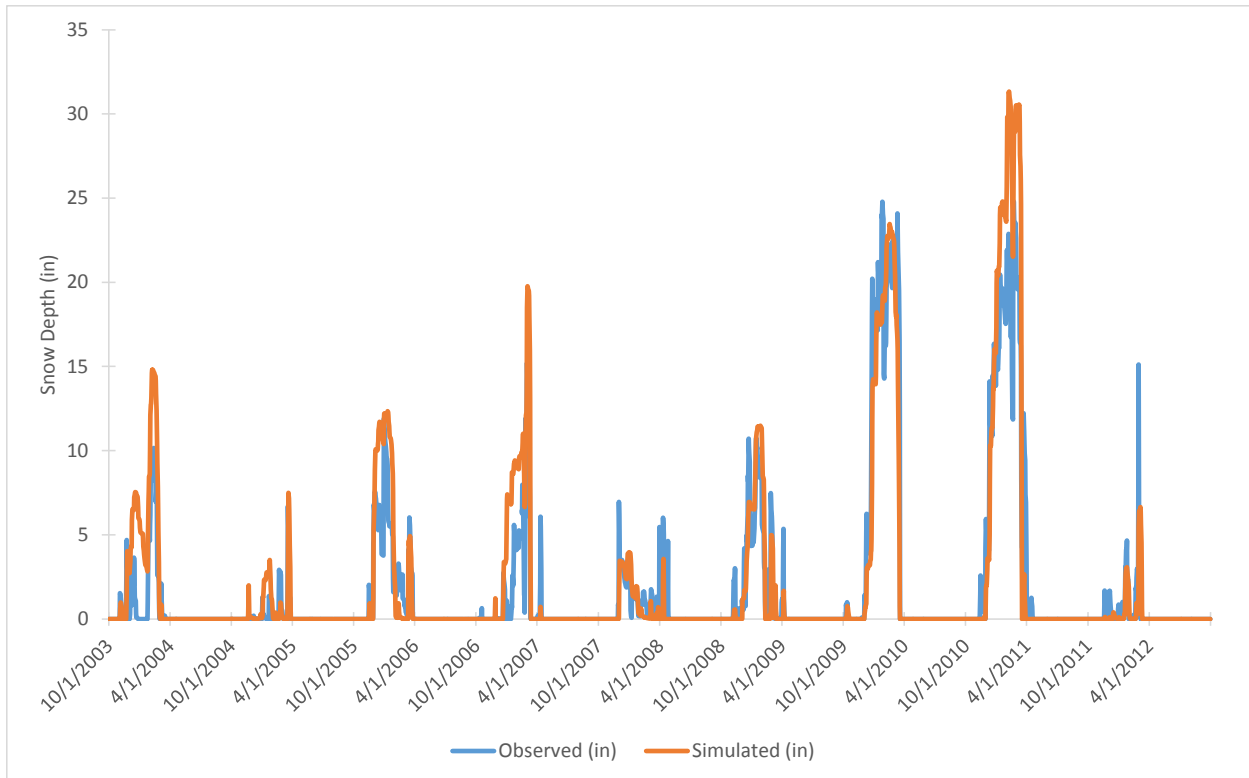


Figure 9. Mean daily snow depth time-series for weather region 2

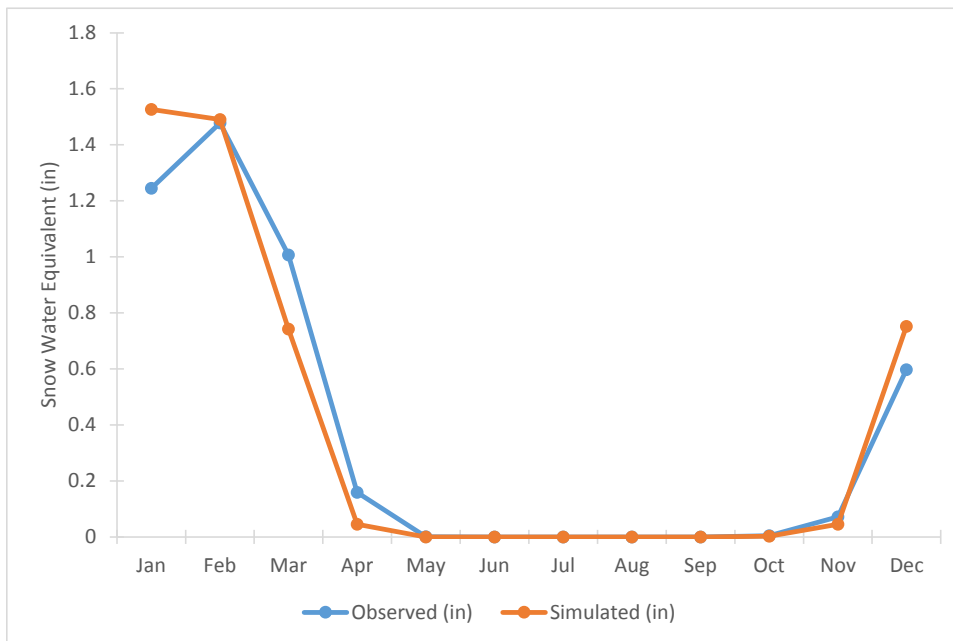


Figure 10. Mean monthly snow water equivalent for weather region 2

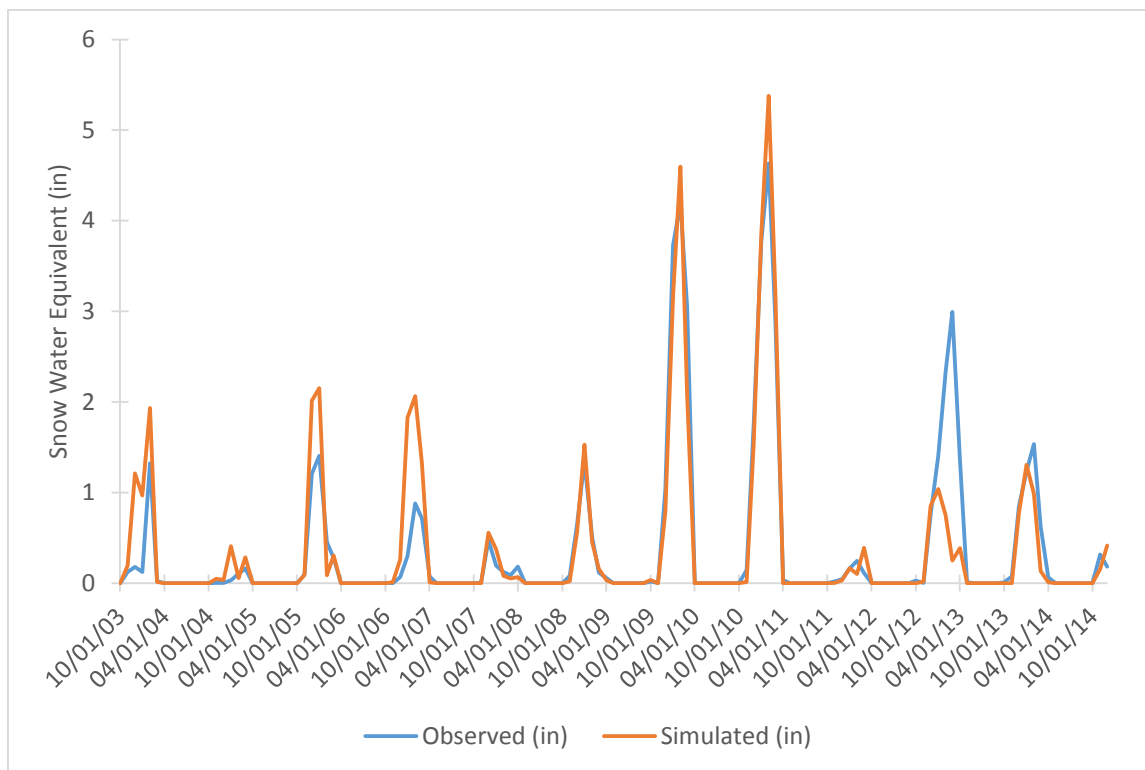


Figure 11. Mean monthly snow water equivalent time-series for weather region 2

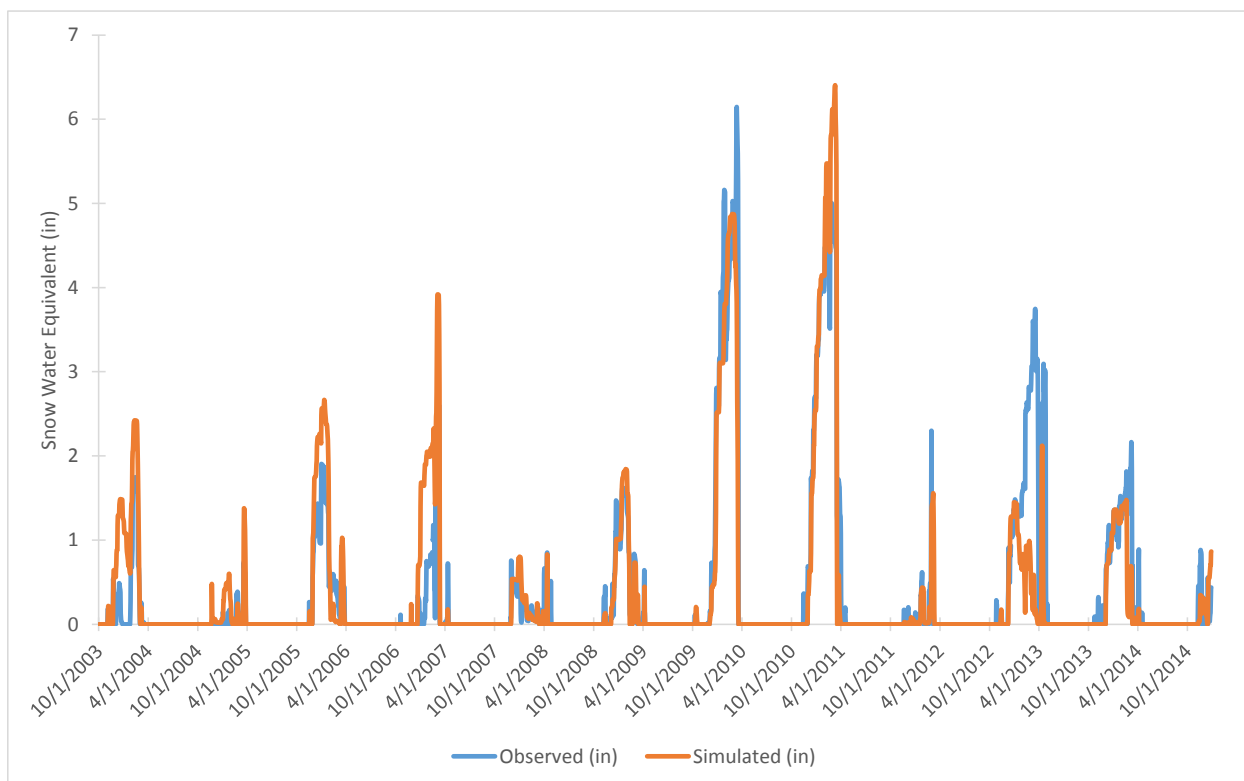


Figure 12. Mean daily snow water equivalent time-series for weather region 2



### WEATHER REGION 3

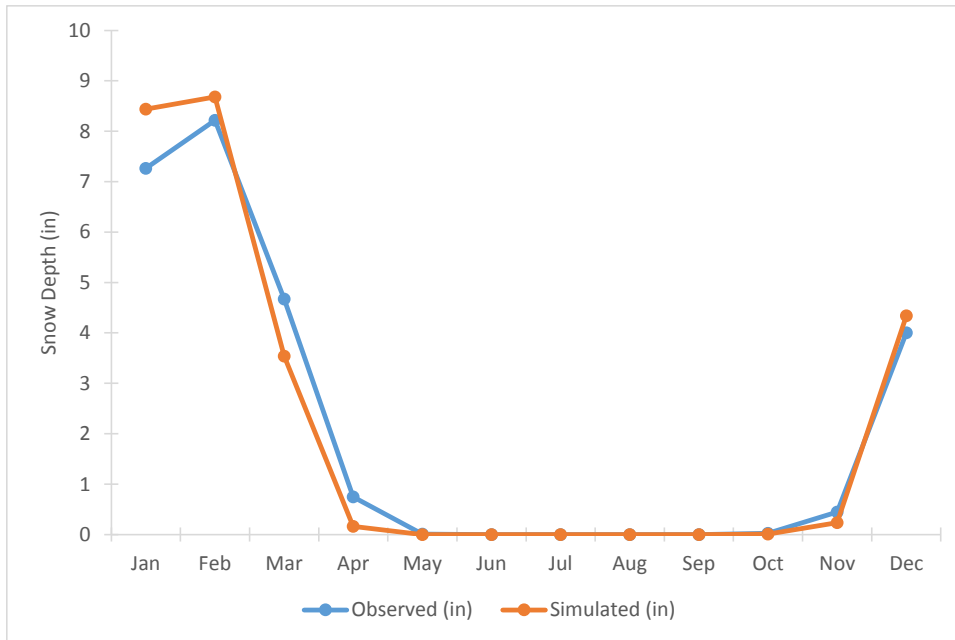


Figure 13. Mean monthly snow depth for weather region 3

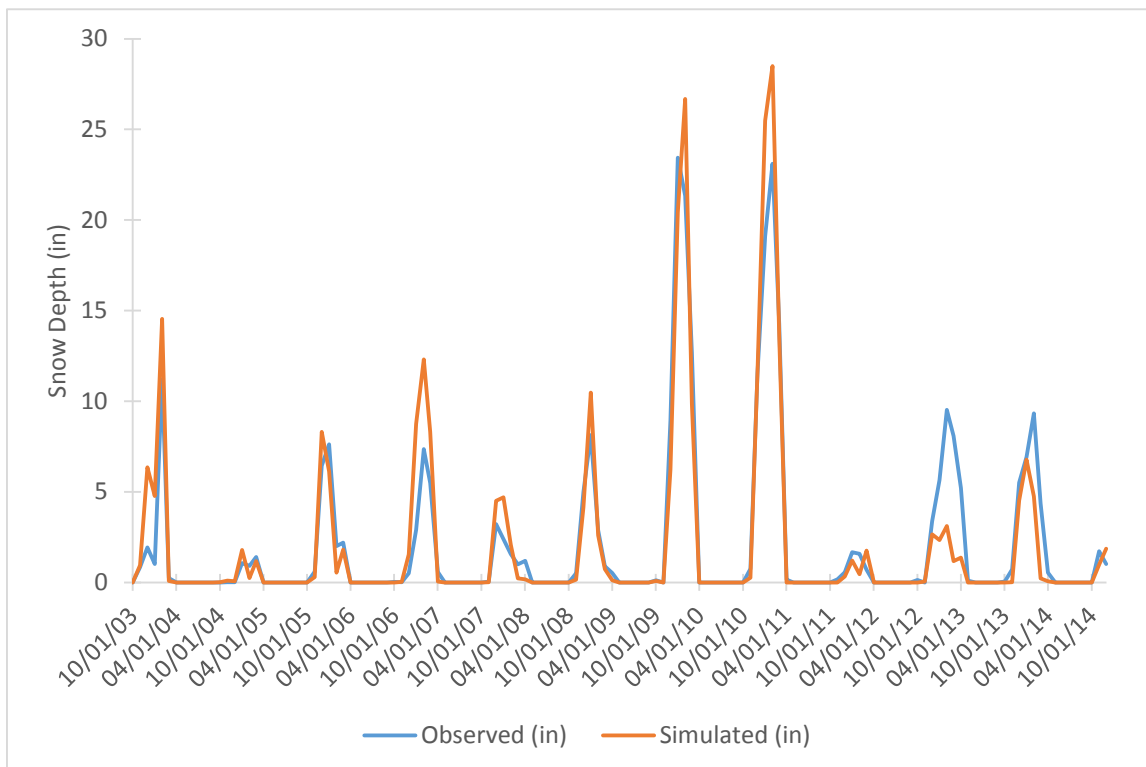
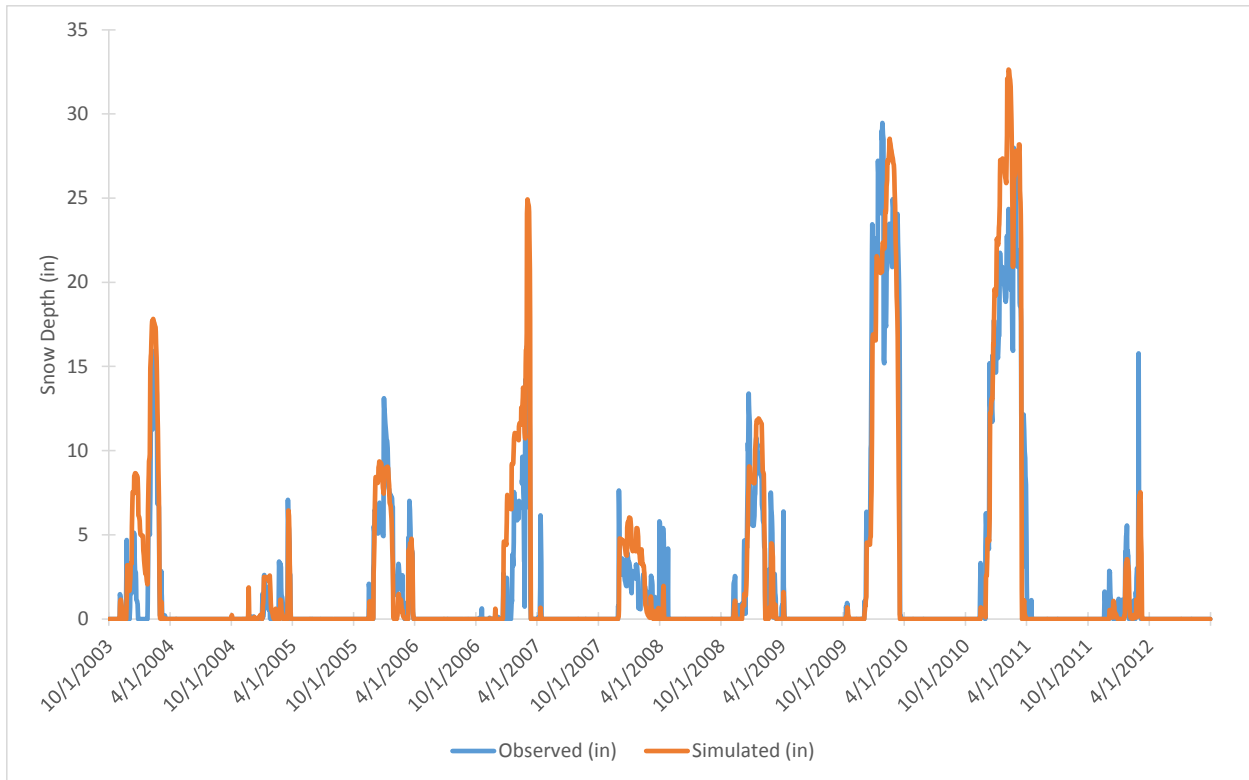
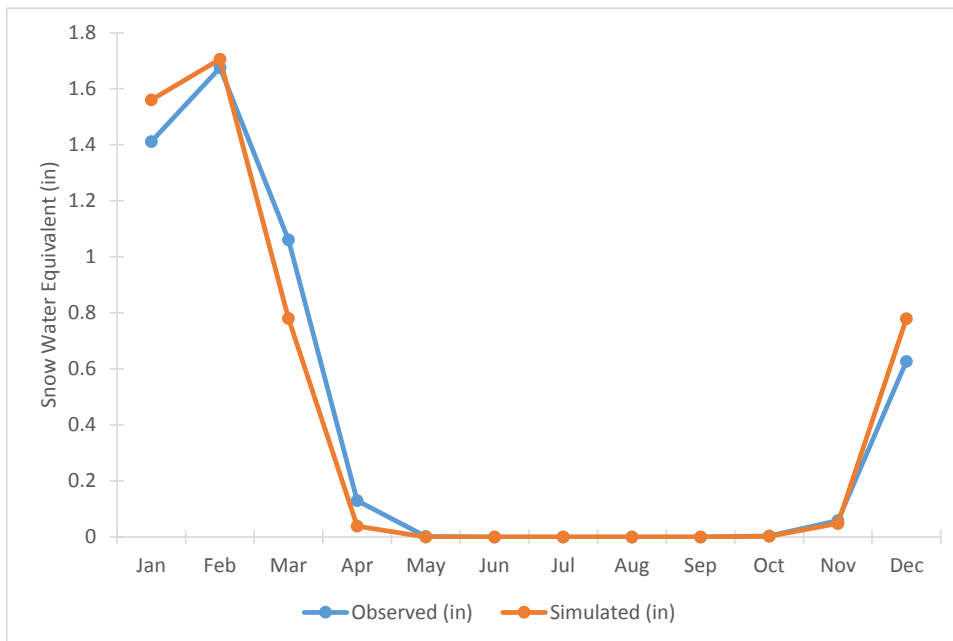


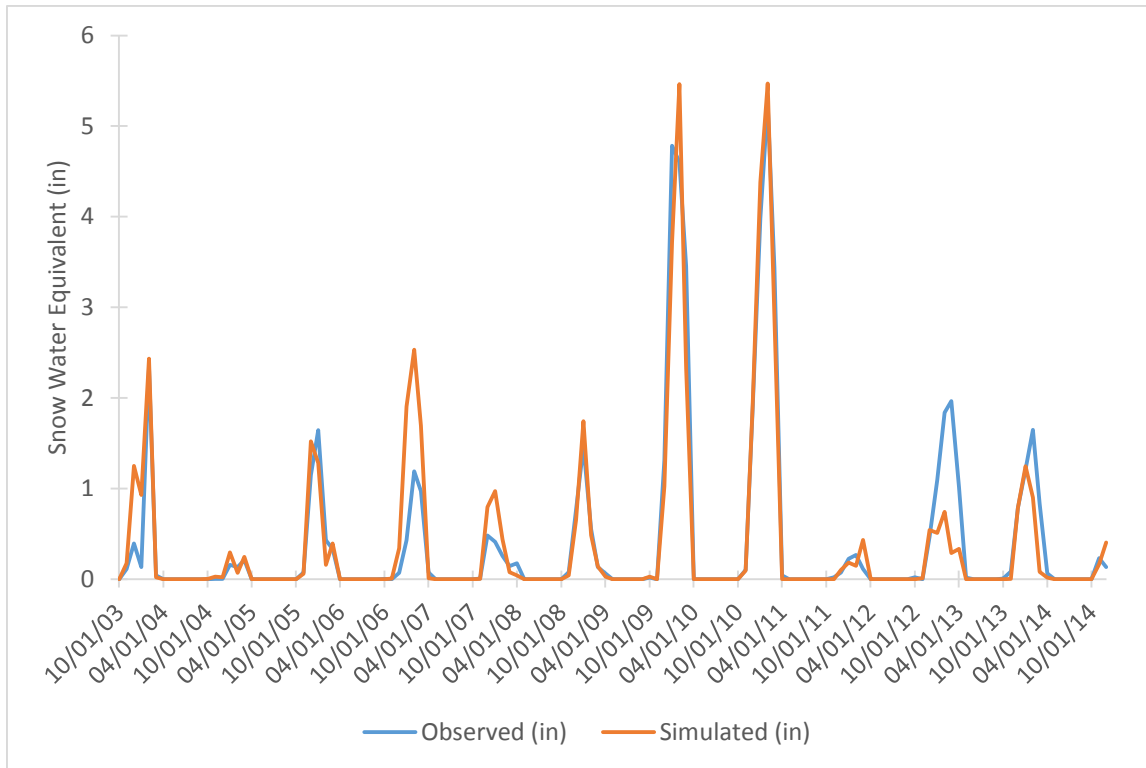
Figure 14. Mean monthly snow depth time-series for weather region 3



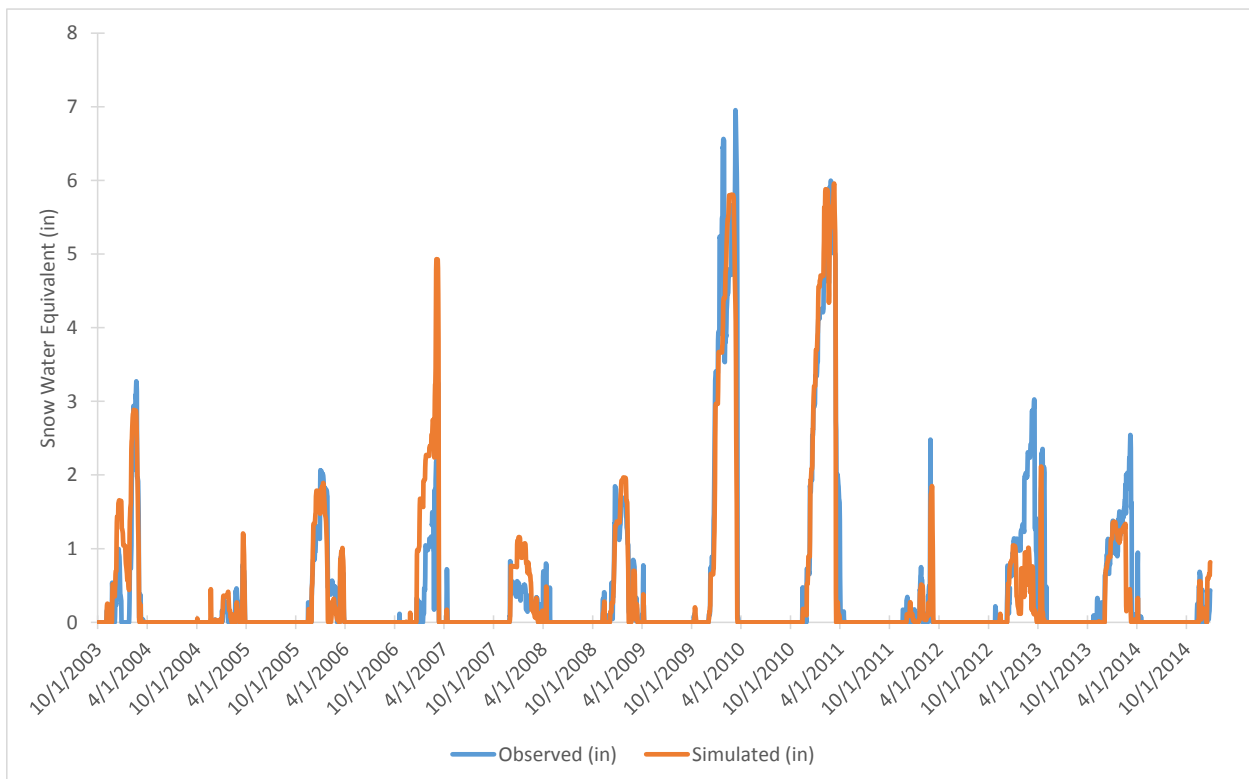
**Figure 15. Mean daily snow depth time-series for weather region 3**



**Figure 16. Mean monthly snow water equivalent for weather region 3**



**Figure 17. Mean monthly snow water equivalent time-series for weather region 3**



**Figure 18. Mean daily snow water equivalent time-series for weather region 3**

## WEATHER REGION 4

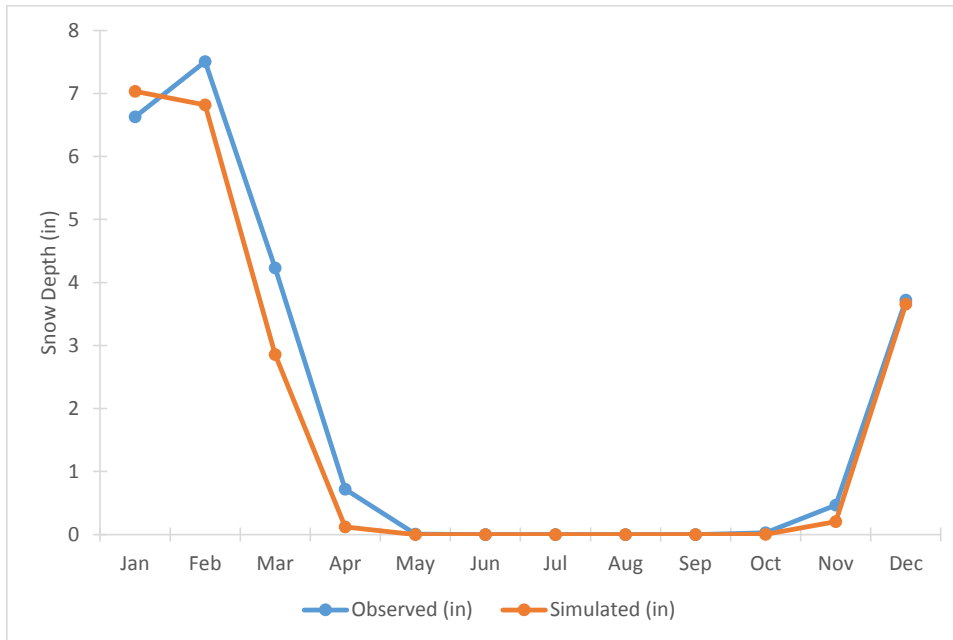


Figure 19. Mean monthly snow depth for weather region 4

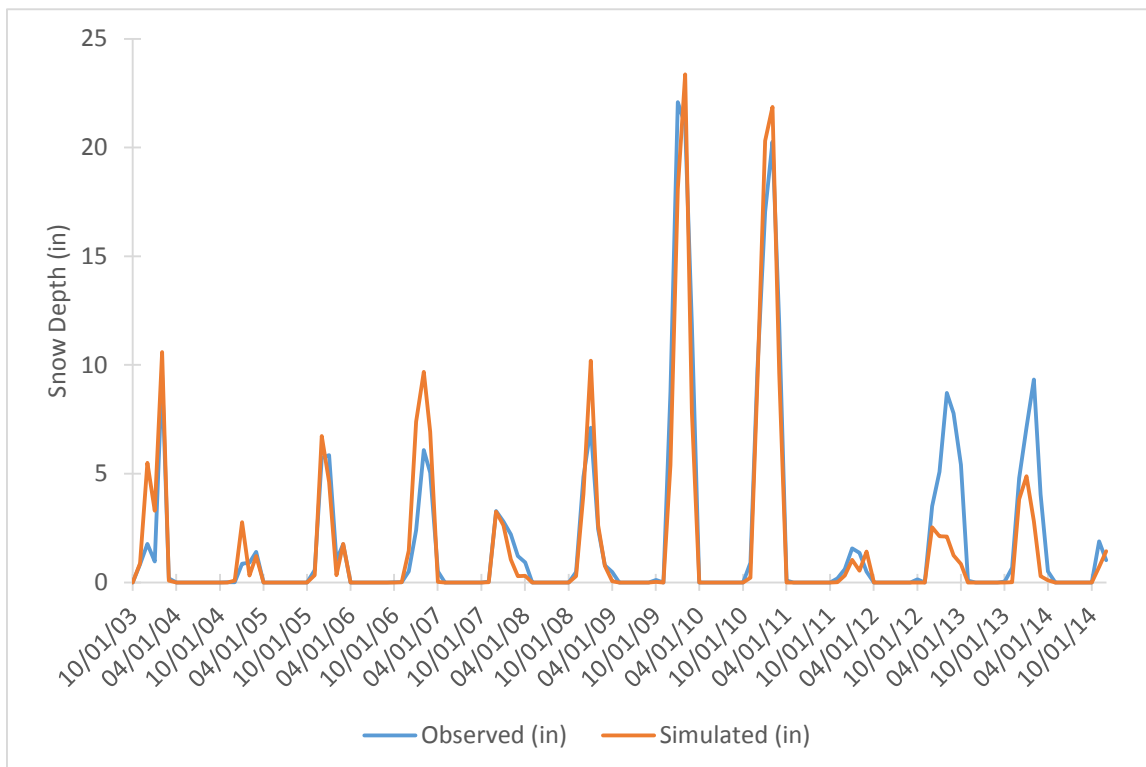


Figure 20. Mean monthly snow depth time-series for weather region 4

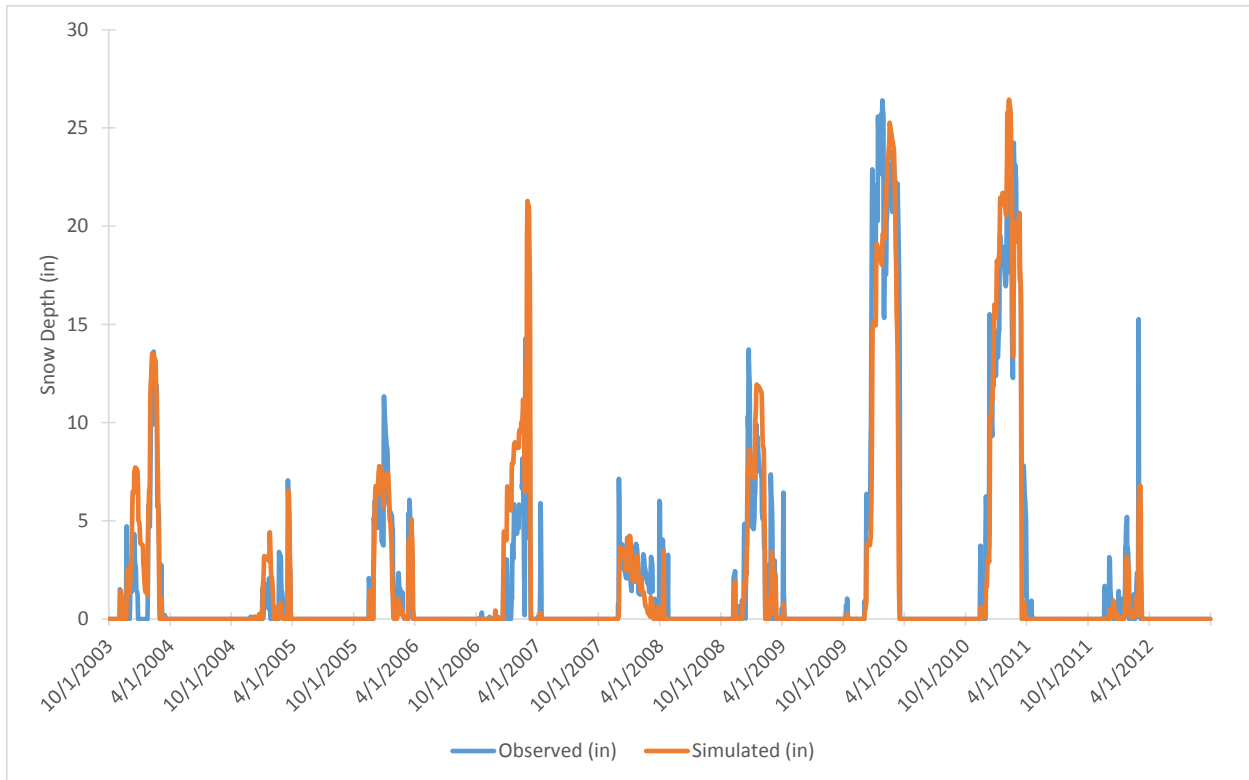


Figure 21. Mean daily snow depth time-series for weather region 4

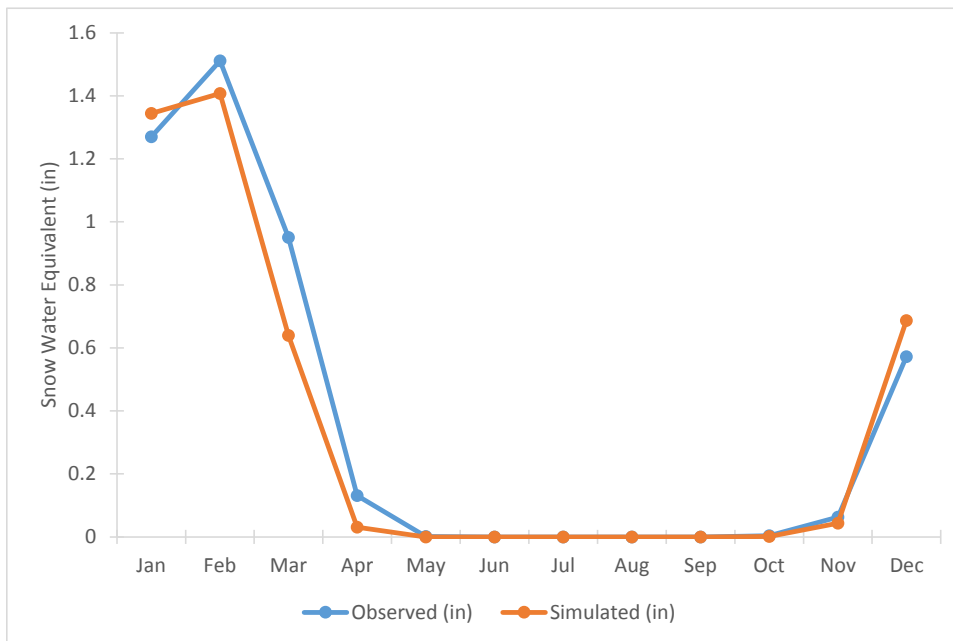
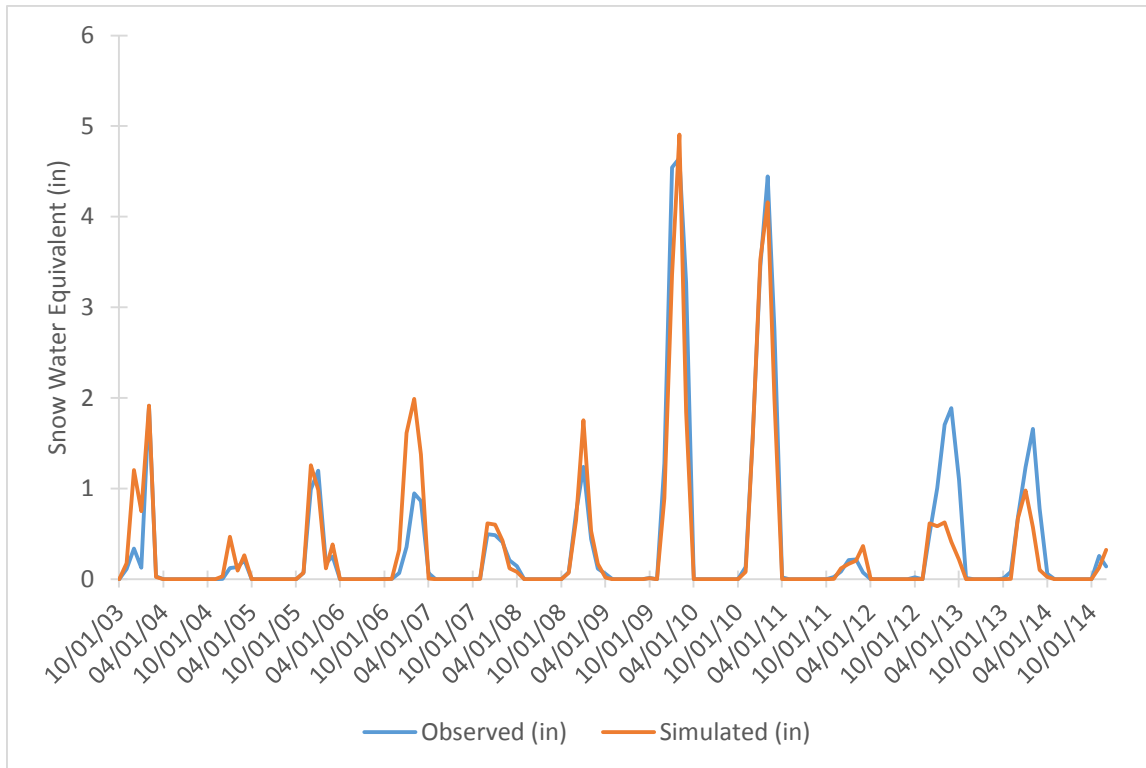
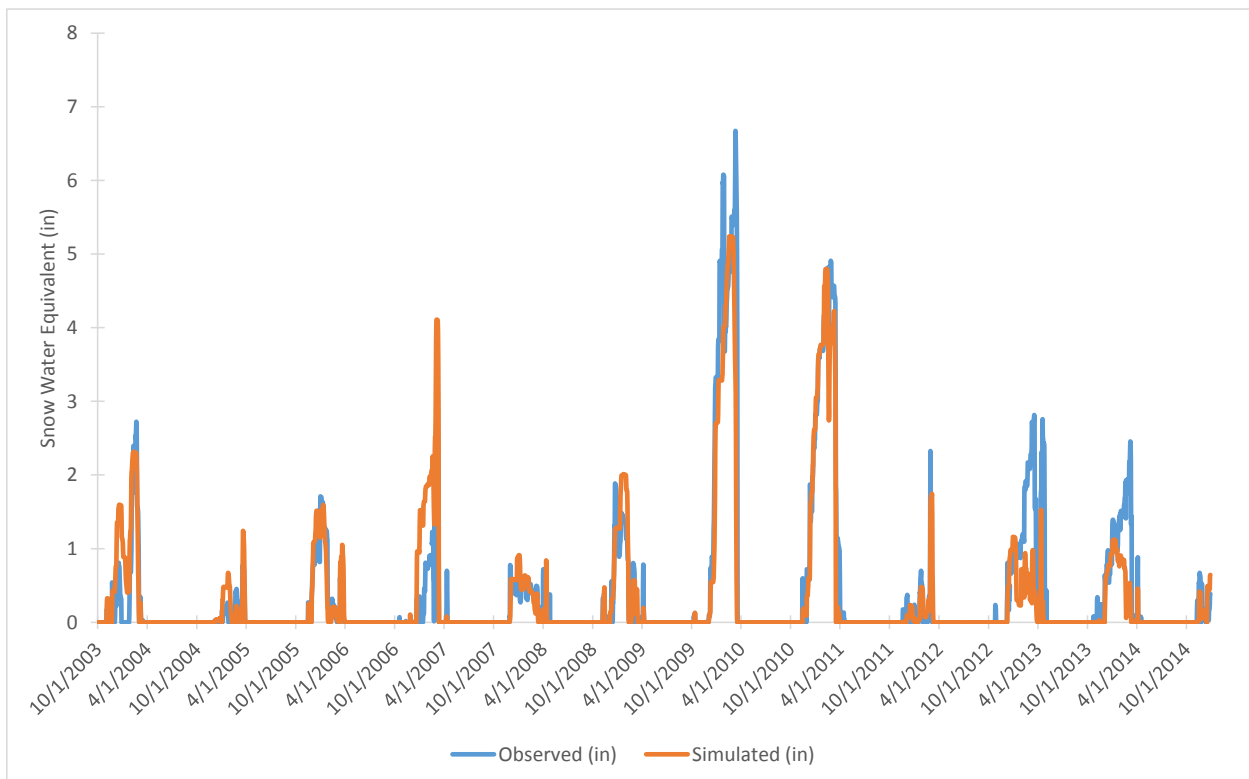


Figure 22. Mean monthly snow water equivalent for weather region 4



**Figure 23. Mean monthly snow water equivalent time-series for weather region 4**



**Figure 24. Mean daily snow water equivalent time-series for weather region 4**

## WEATHER REGION 5

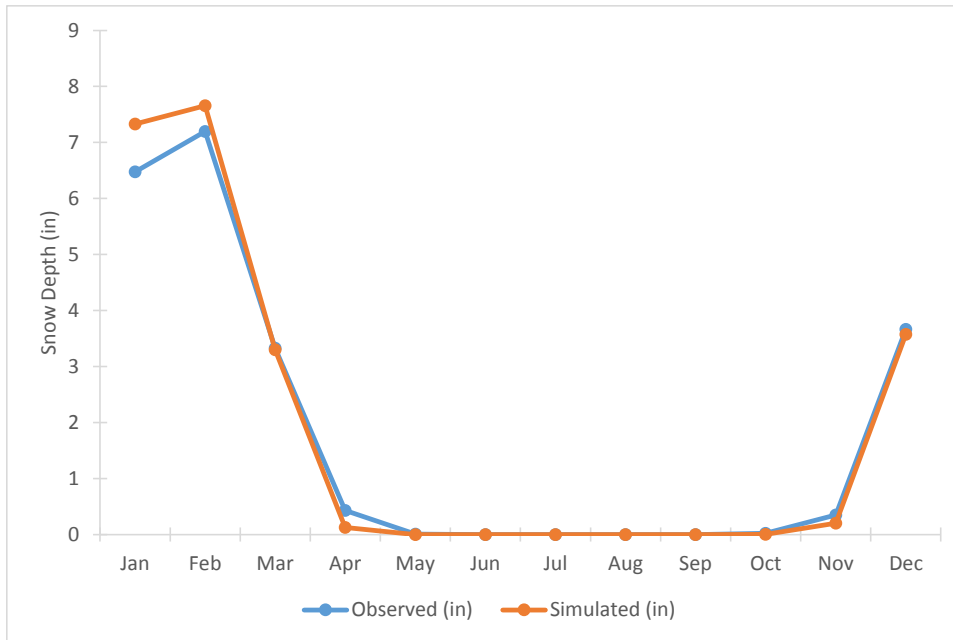


Figure 25. Mean monthly snow depth for weather region 5

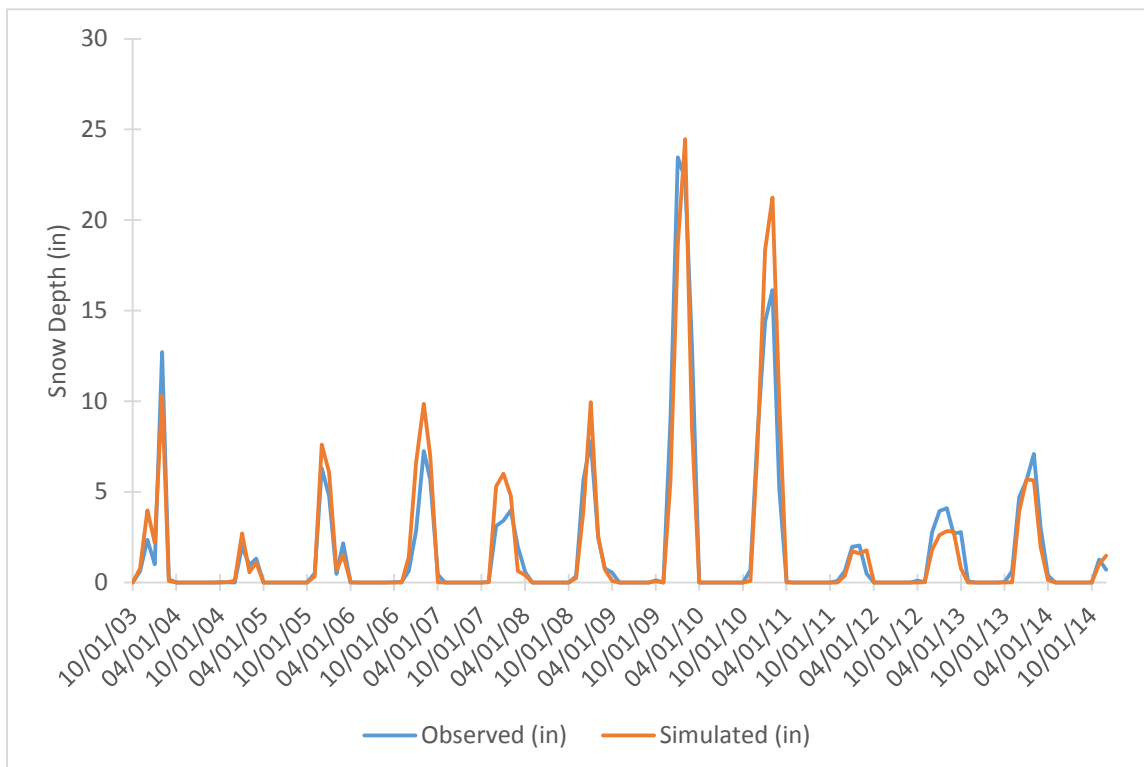


Figure 26. Mean monthly snow depth time-series for weather region 5

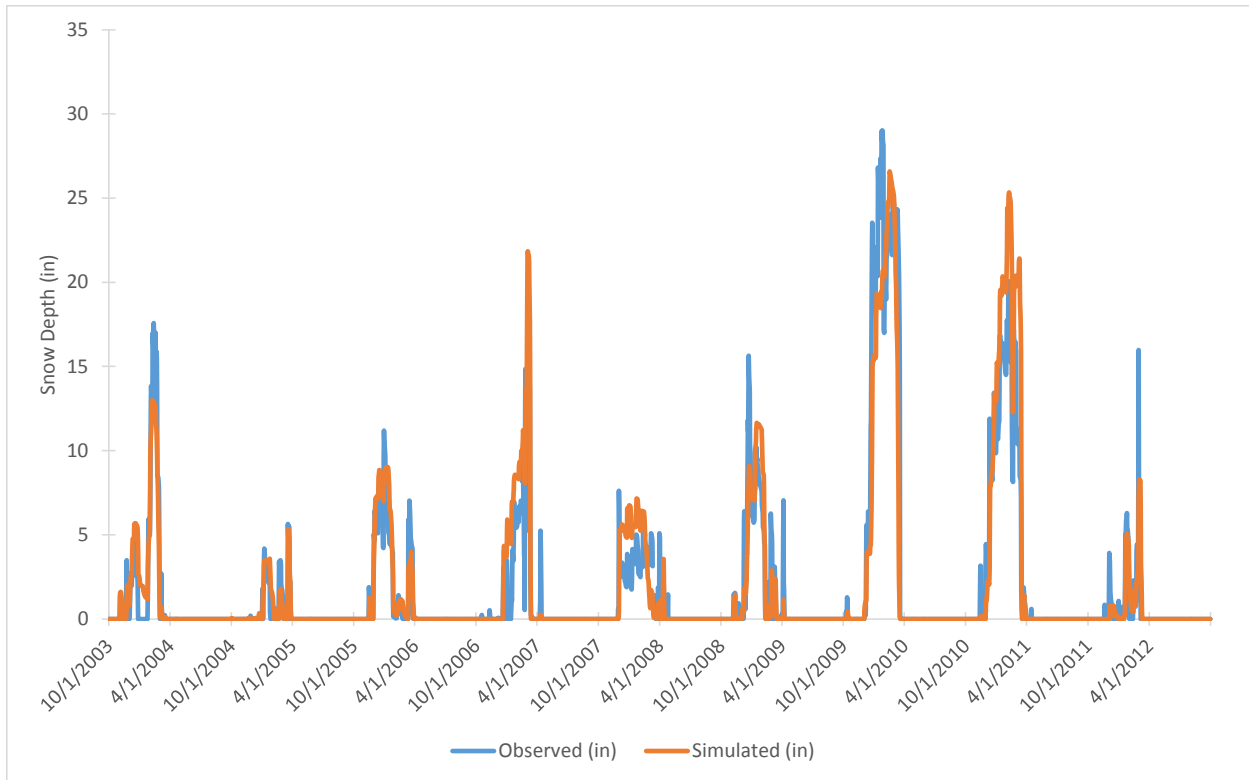


Figure 27. Mean daily snow depth time-series for weather region 5

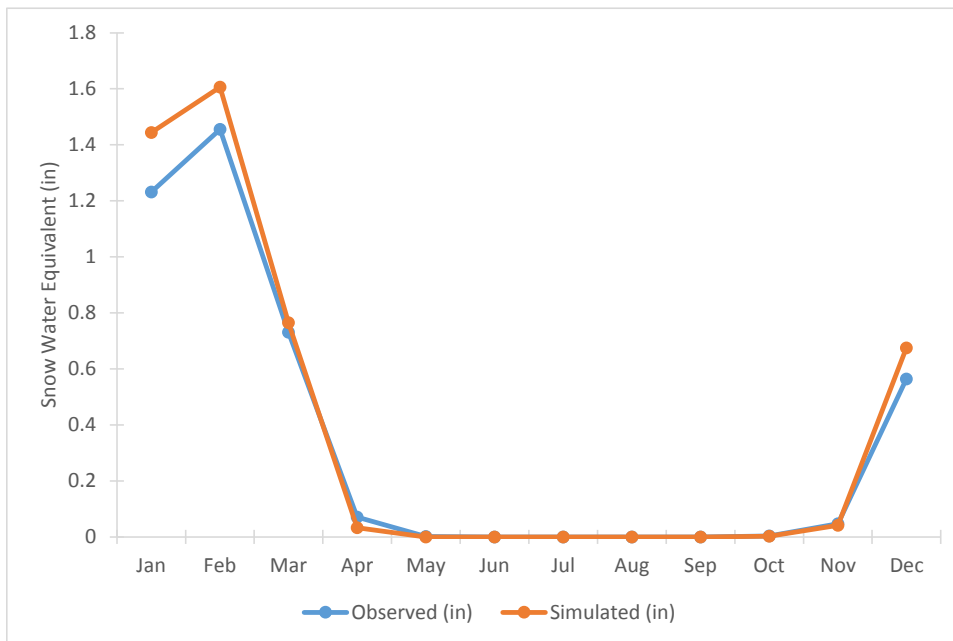
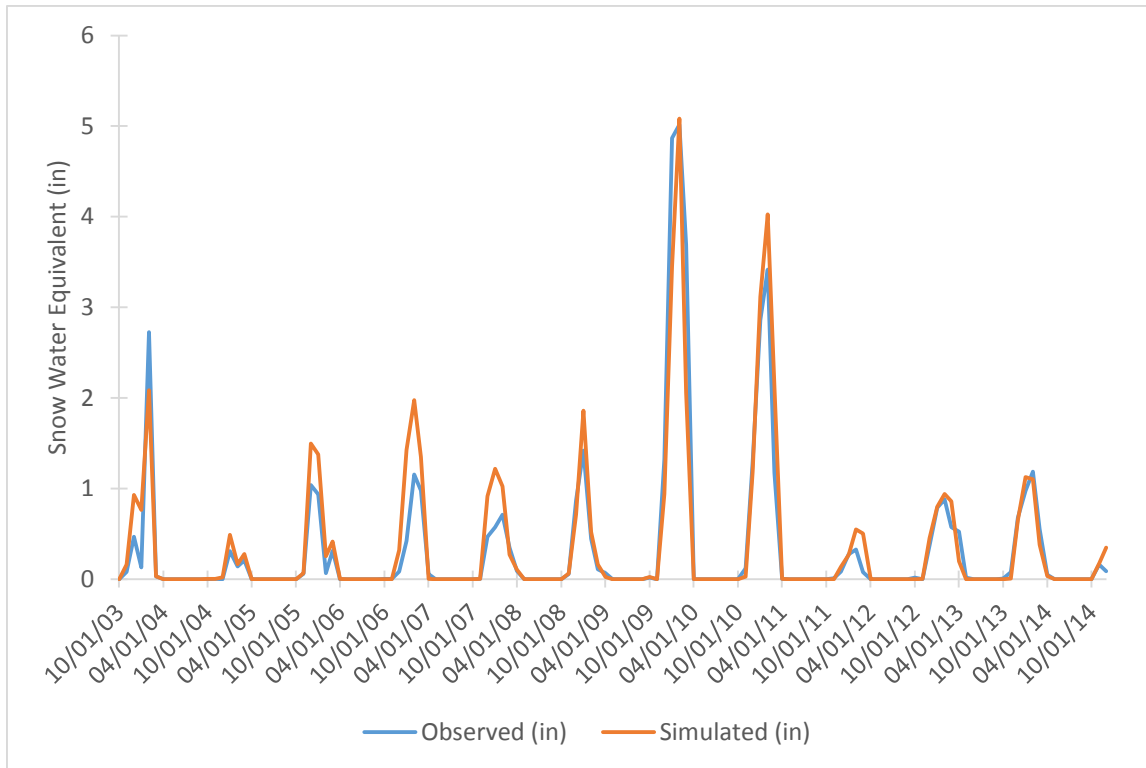
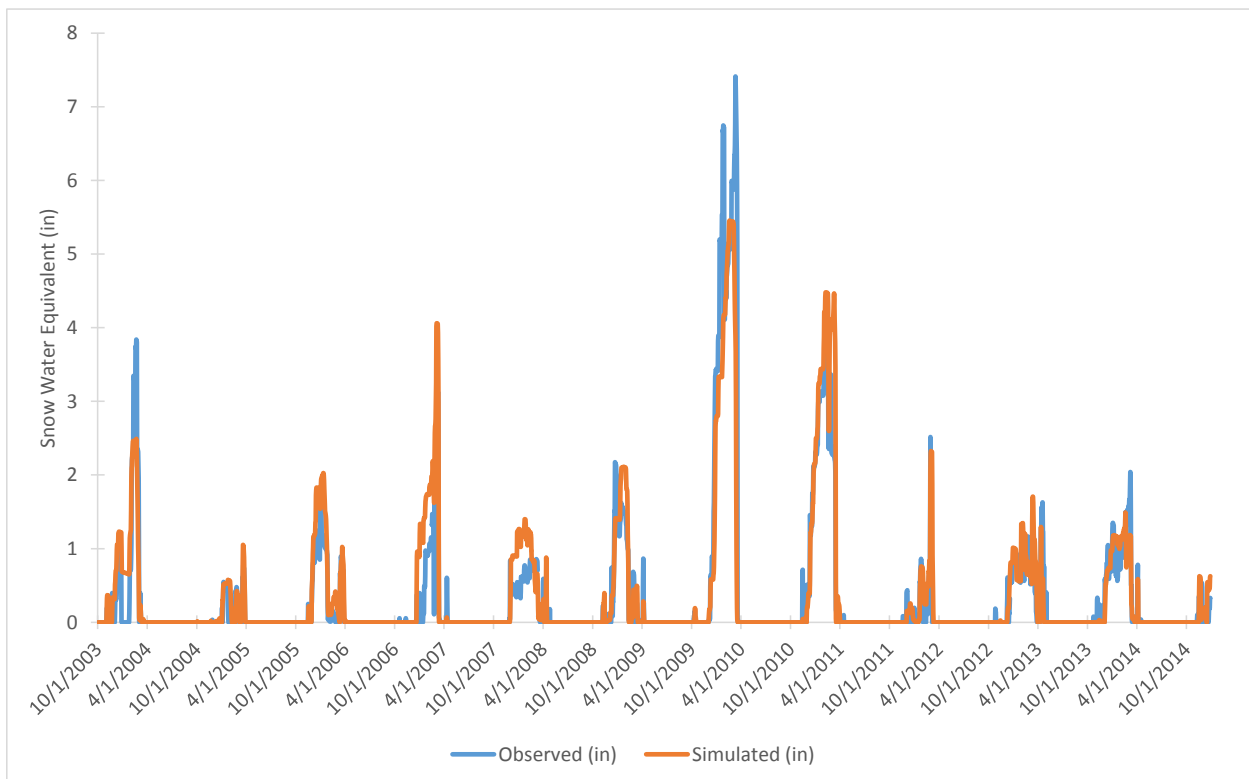


Figure 28. Mean monthly snow water equivalent for weather region 5





**Figure 29. Mean monthly snow water equivalent time-series for weather region 5**



**Figure 30. Mean daily snow water equivalent time-series for weather region 5**

## WEATHER REGION 6

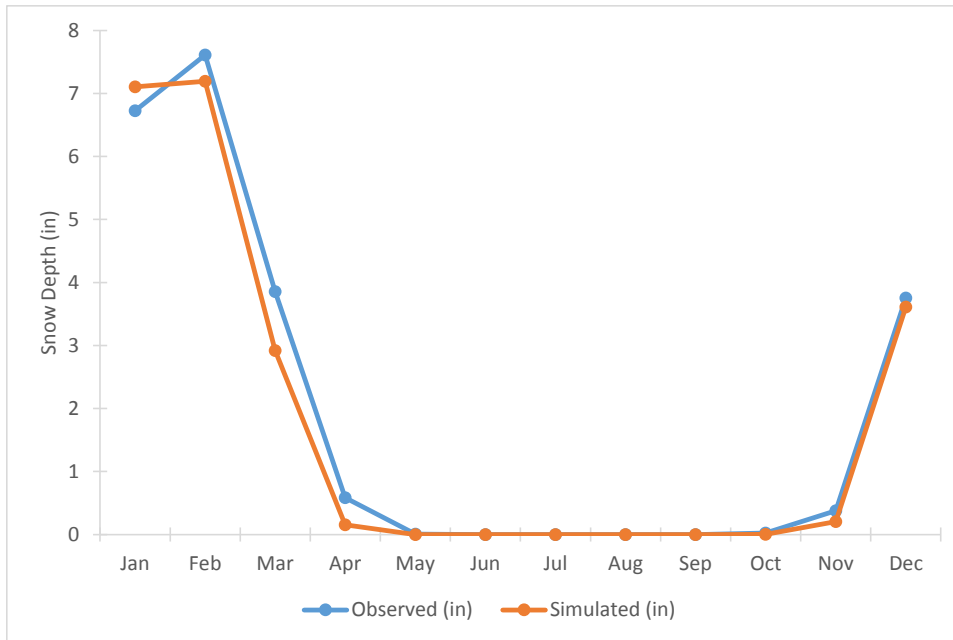


Figure 31. Mean monthly snow depth for weather region 6

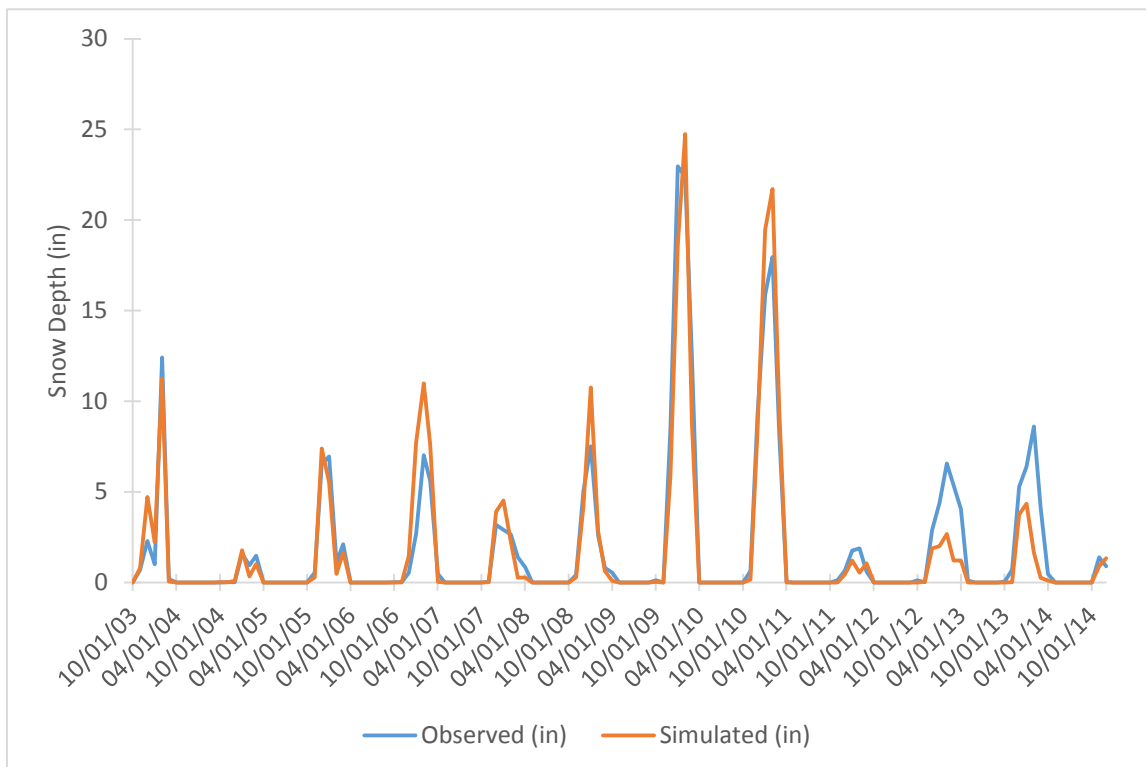


Figure 32. Mean monthly snow depth time-series for weather region 6

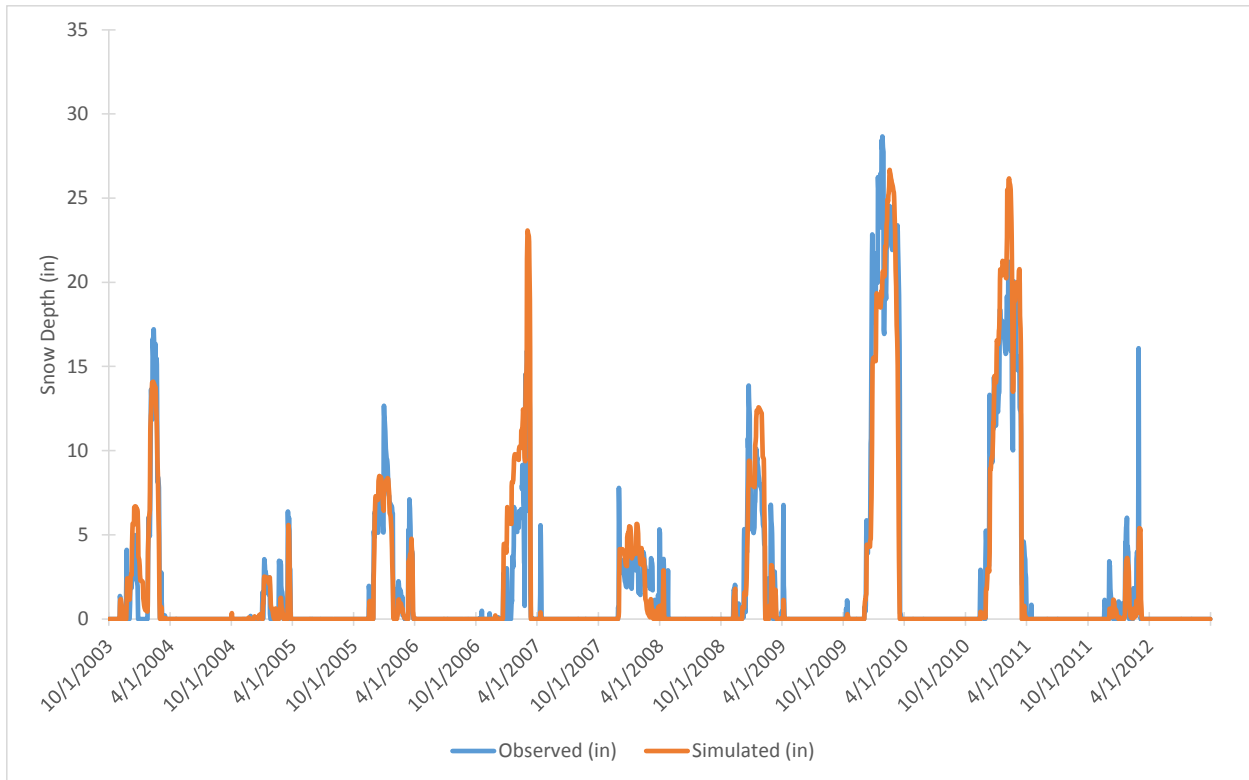


Figure 33. Mean daily snow depth time-series for weather region 6

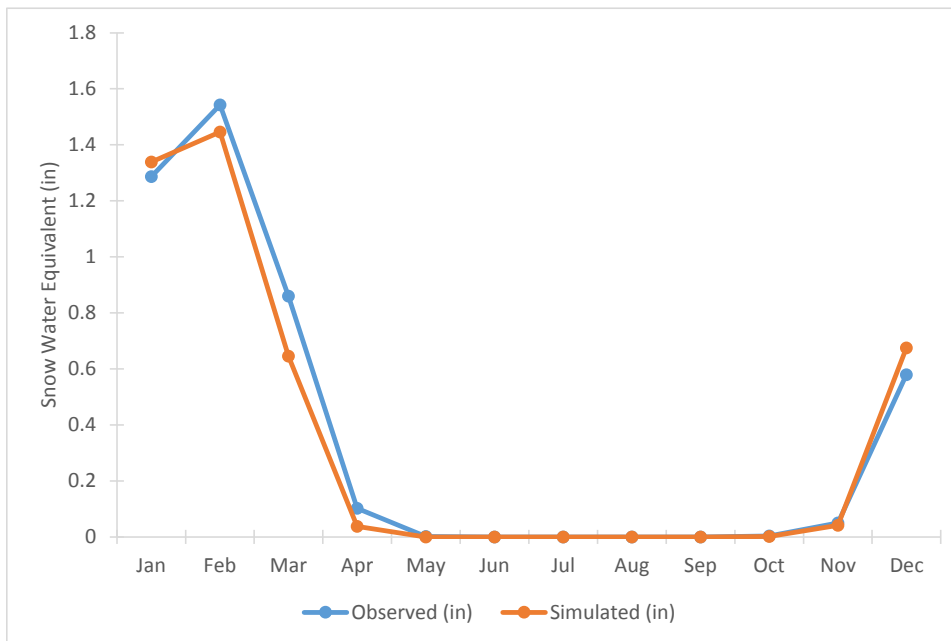
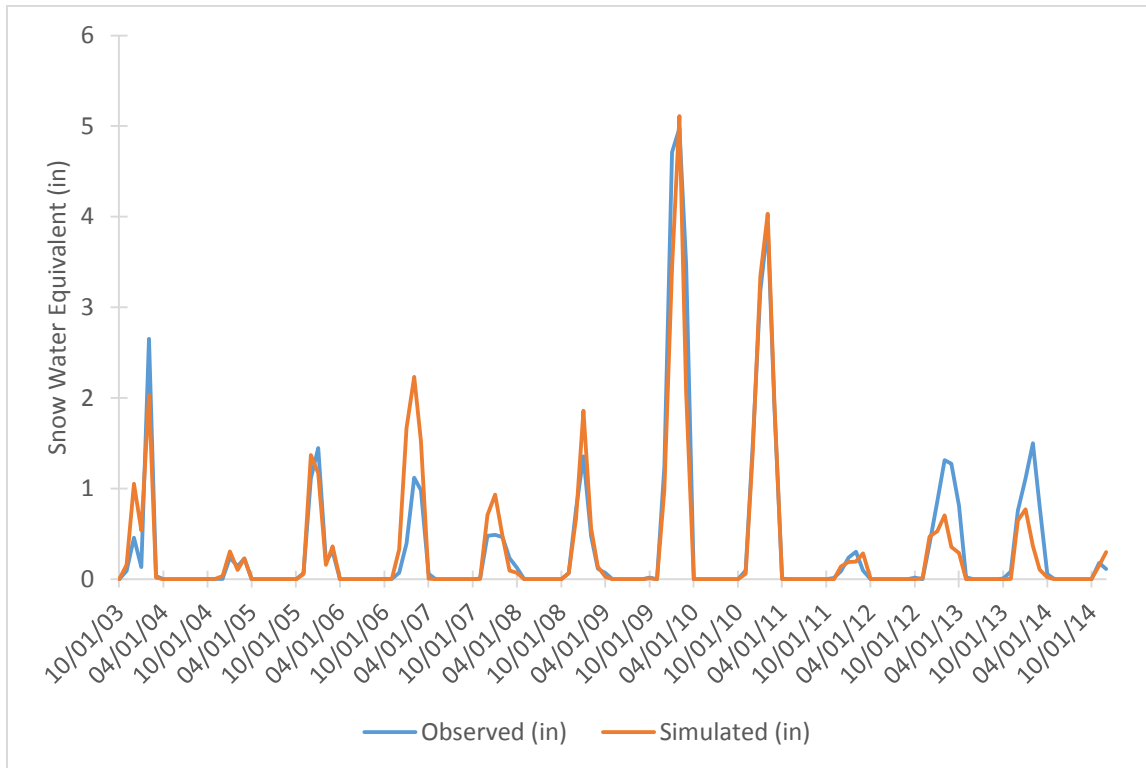
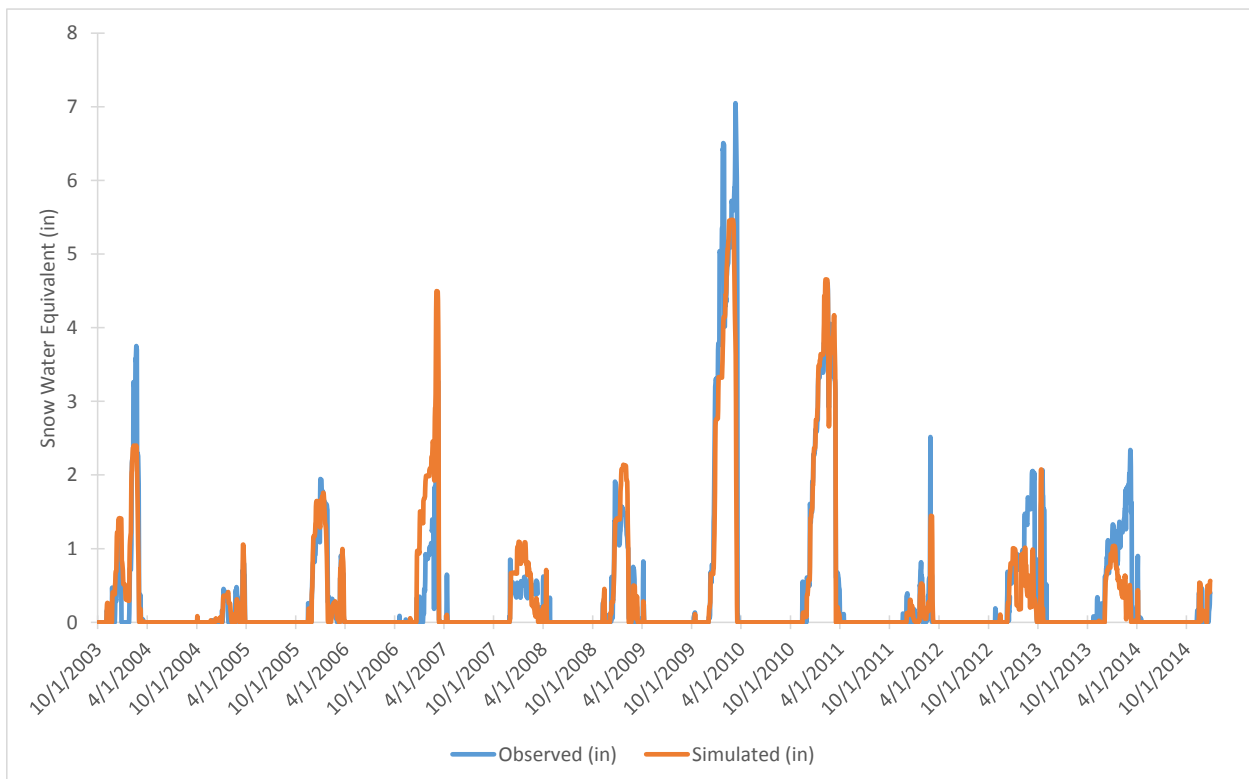


Figure 34. Mean monthly snow water equivalent for weather region 6



**Figure 35. Mean monthly snow water equivalent time-series for weather region 6**



**Figure 36. Mean daily snow water equivalent time-series for weather region 6**

## WEATHER REGION 7

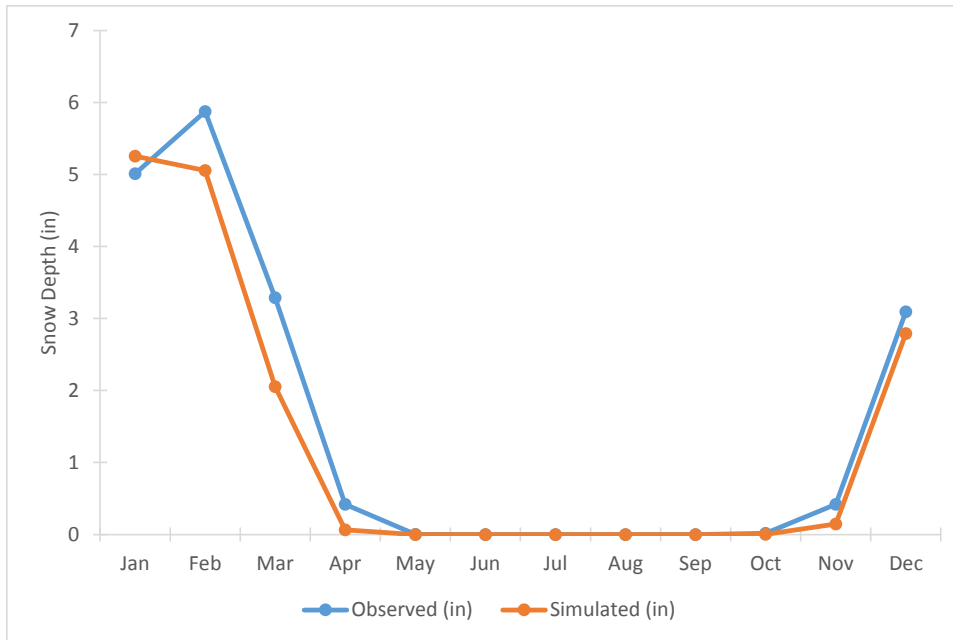


Figure 37. Mean monthly snow depth for weather region 7

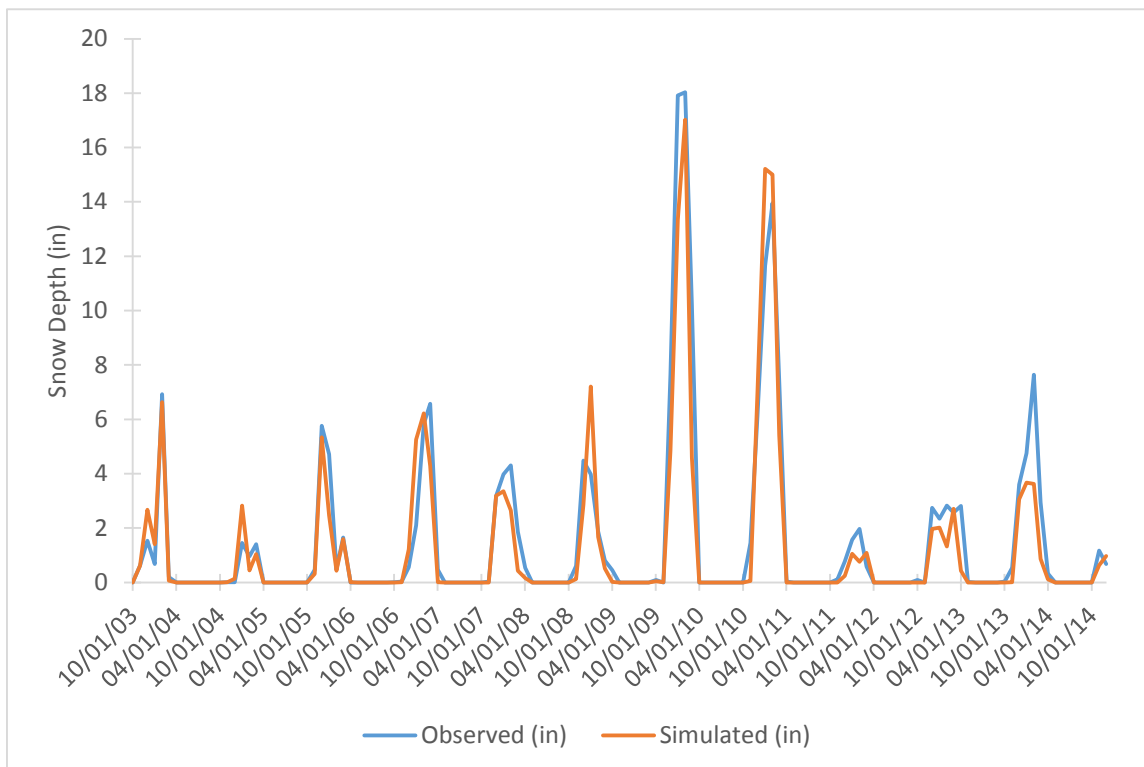


Figure 38. Mean monthly snow depth time-series for weather region 7

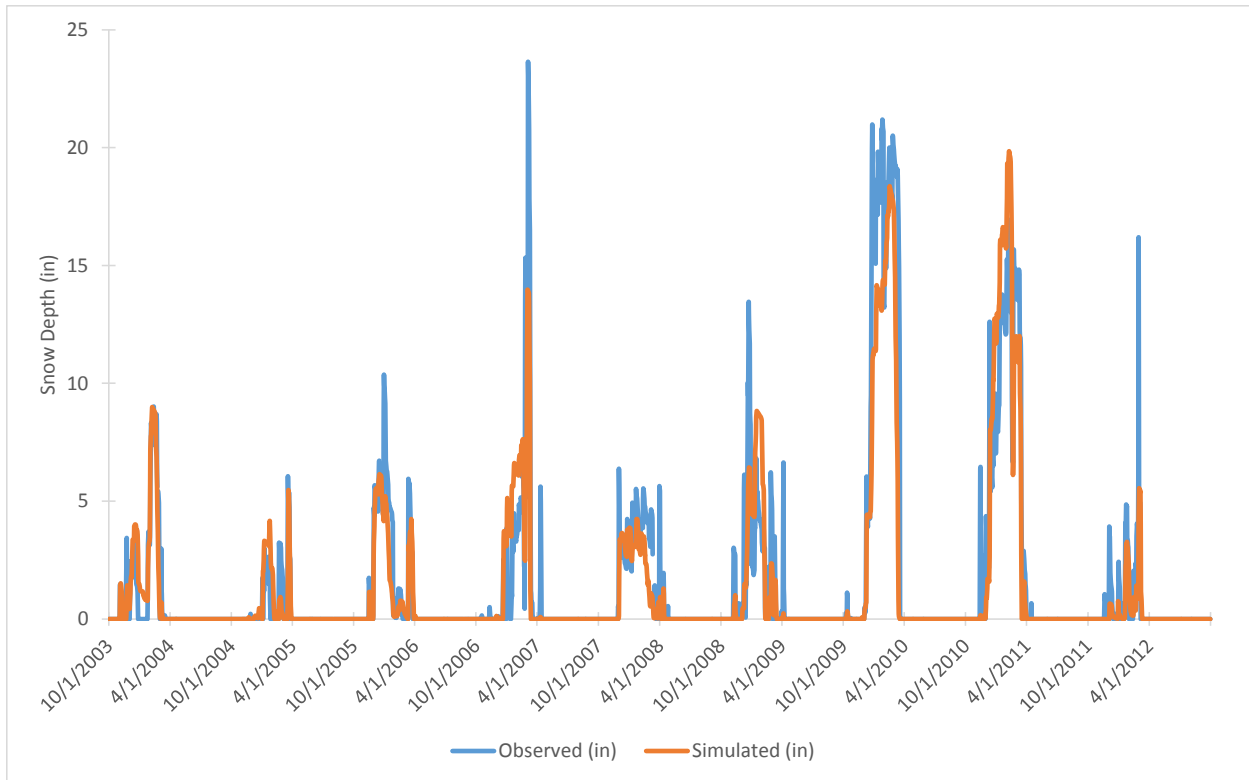


Figure 39. Mean daily snow depth time-series for weather region 7

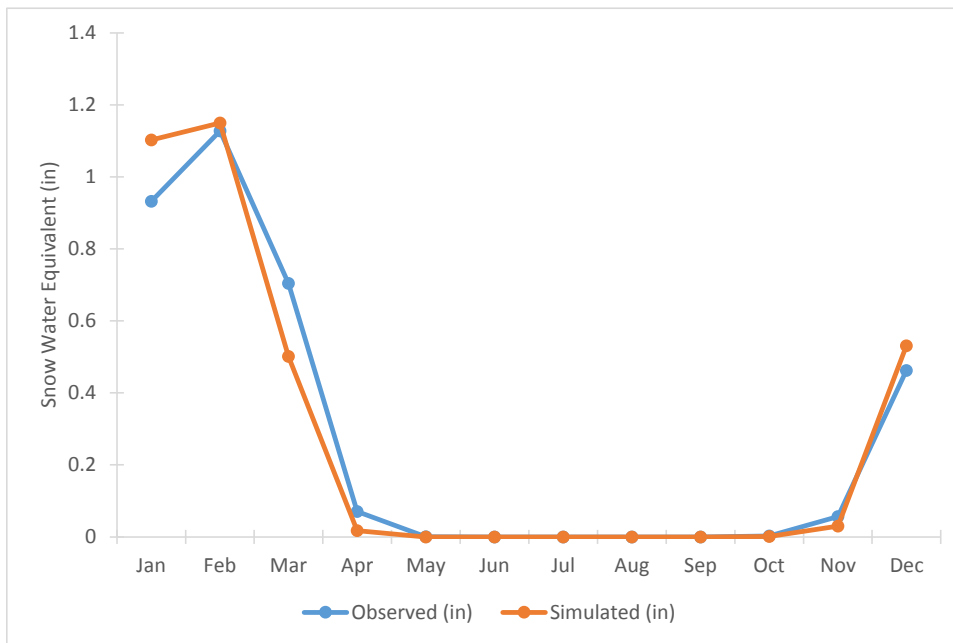
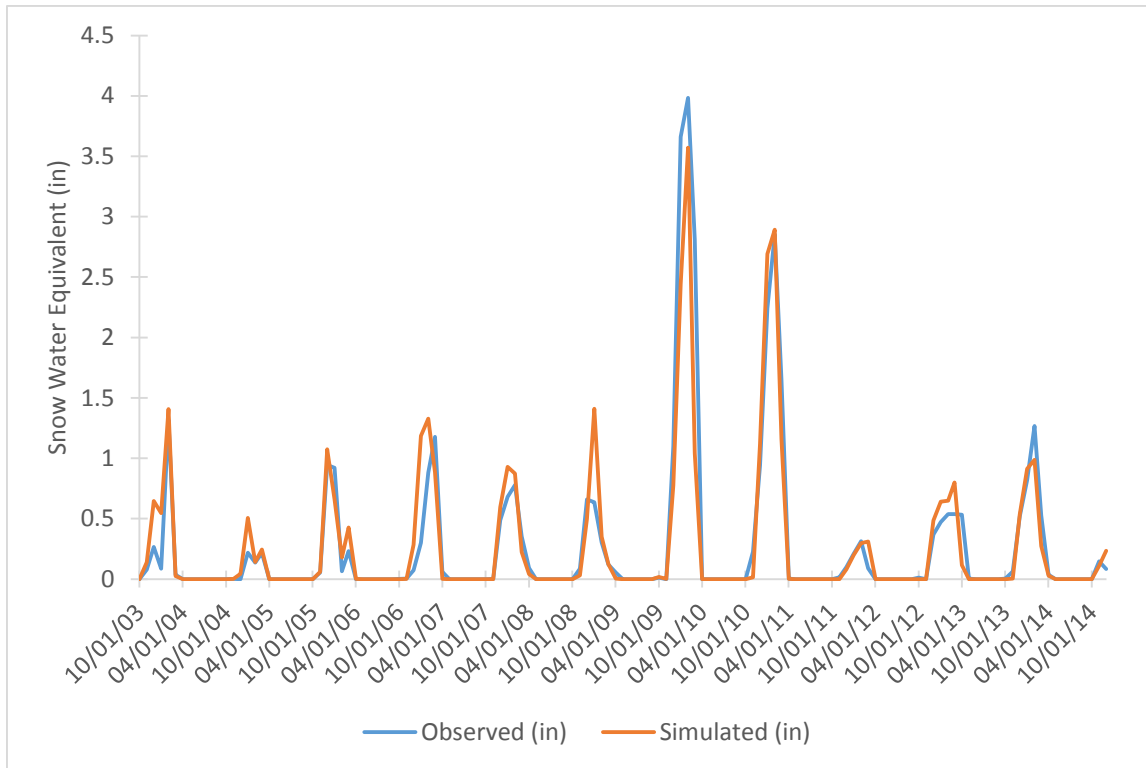
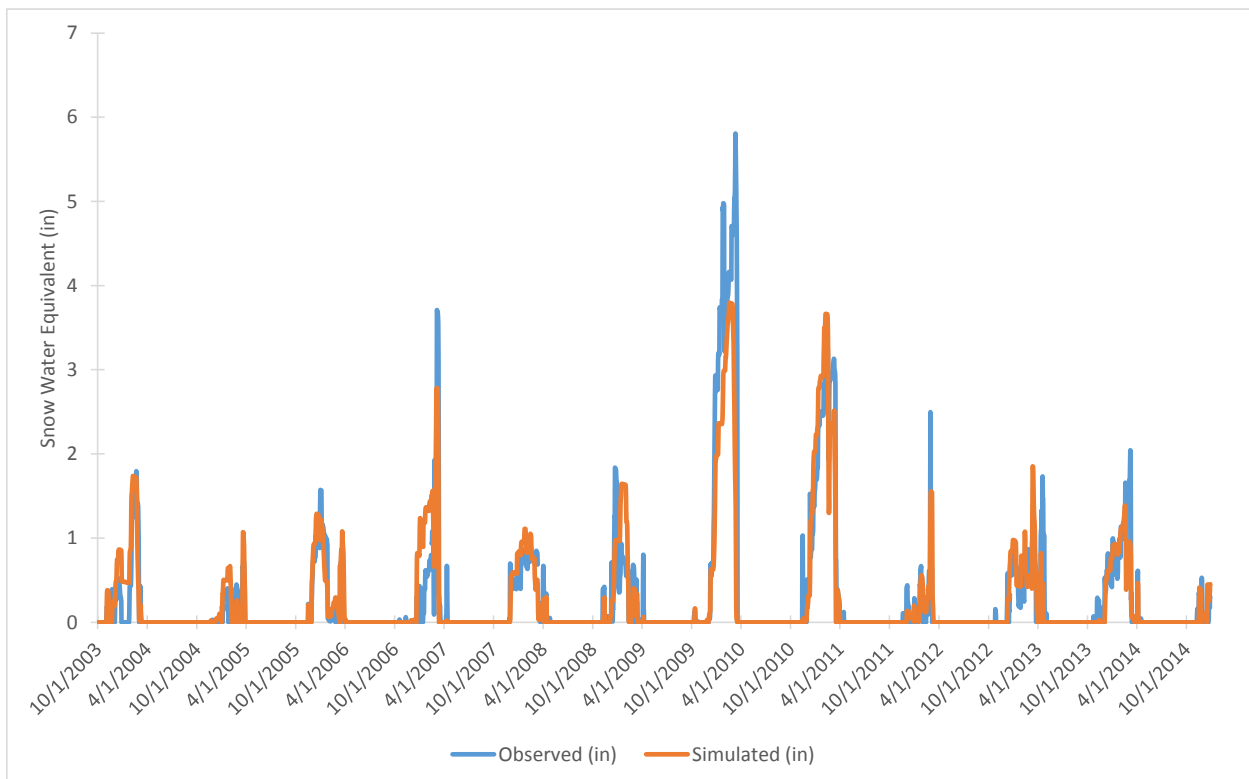


Figure 40. Mean monthly snow water equivalent for weather region 7



**Figure 41. Mean monthly snow water equivalent time-series for weather region 7**



**Figure 42. Mean daily snow water equivalent time-series for weather region 7**

## WEATHER REGION 8

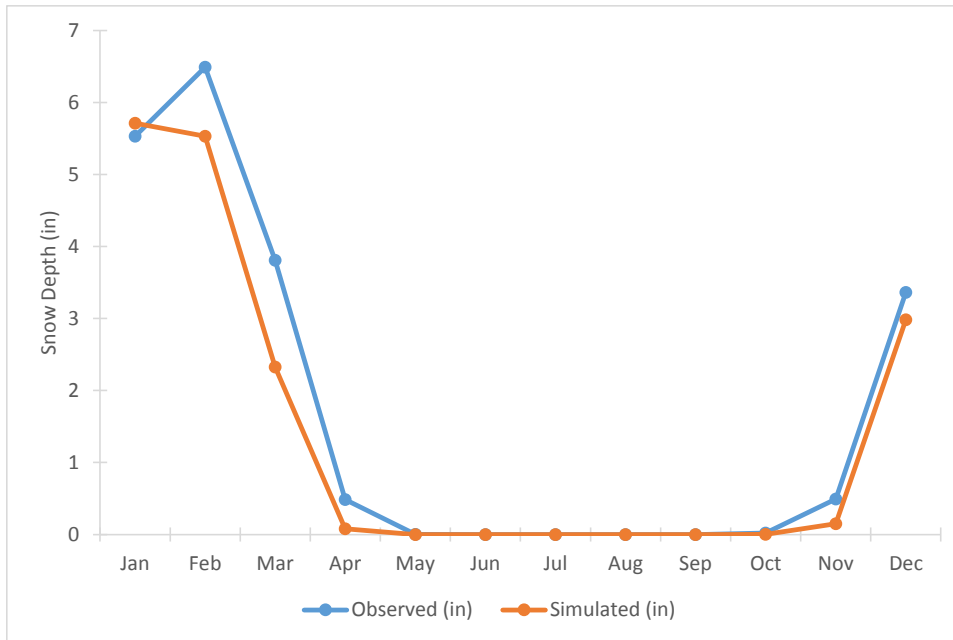


Figure 43. Mean monthly snow depth for weather region 8

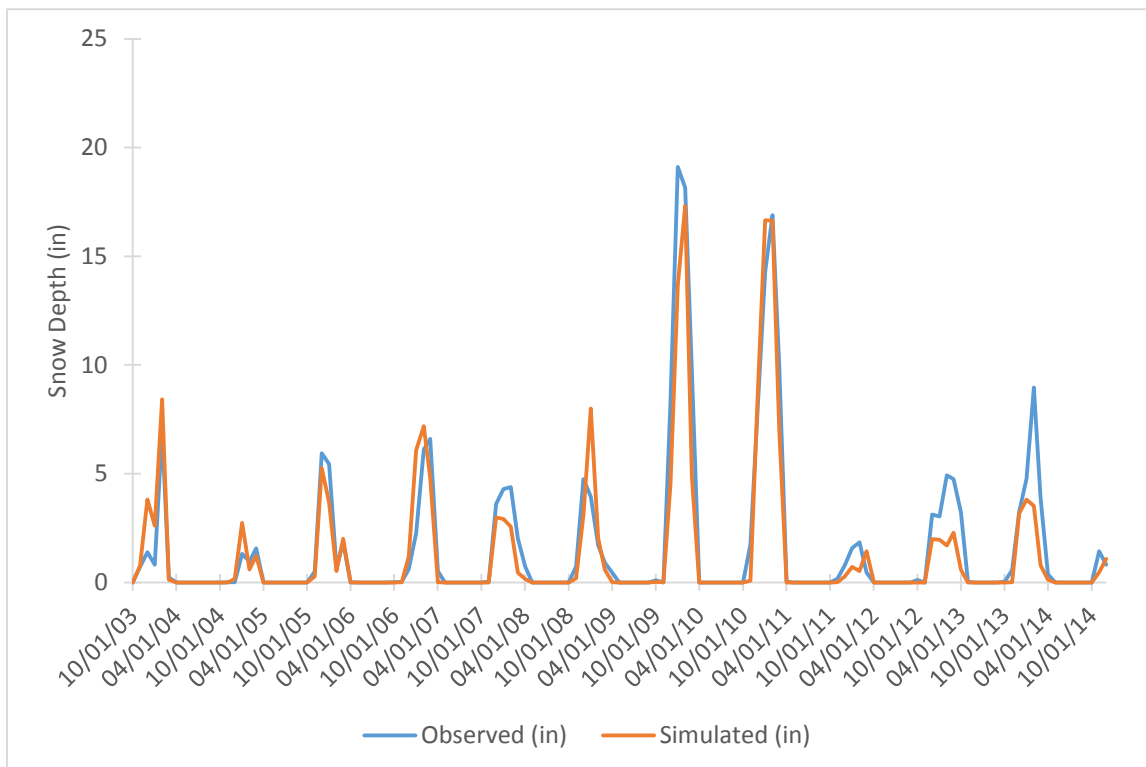


Figure 44. Mean monthly snow depth time-series for weather region 8



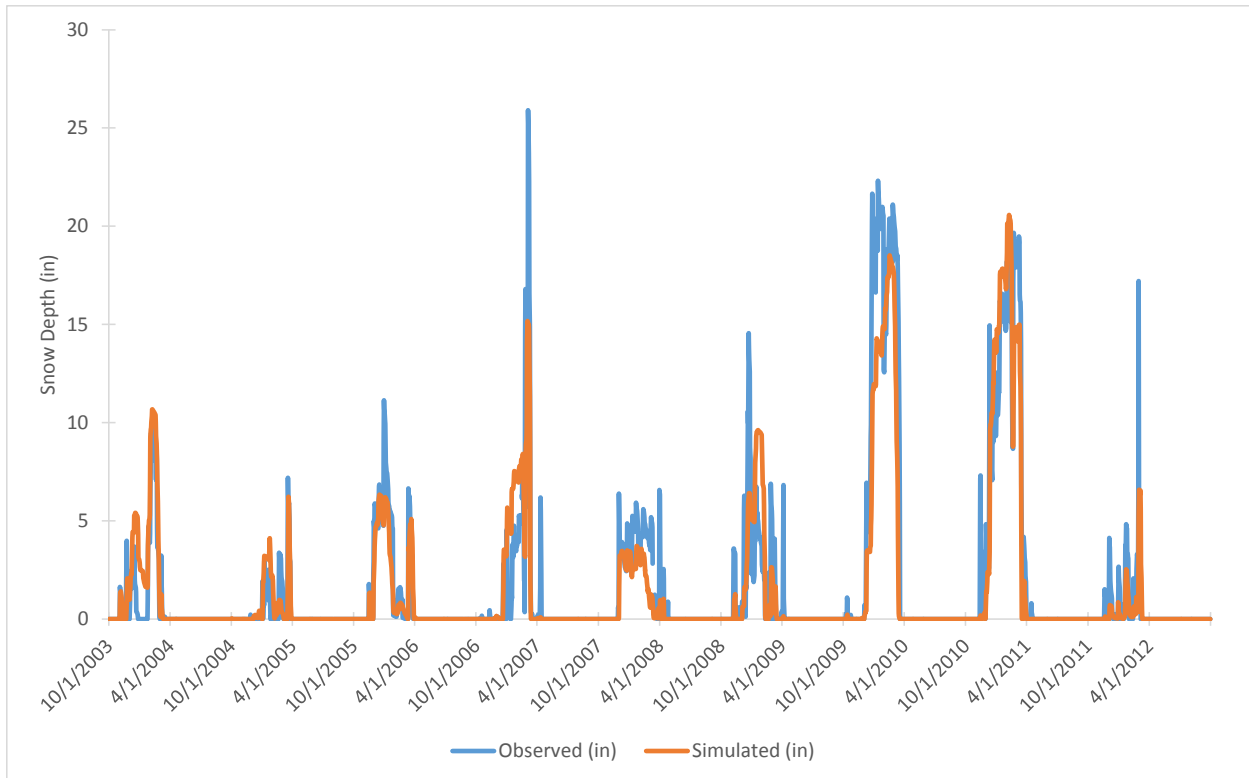


Figure 45. Mean daily snow depth time-series for weather region 8

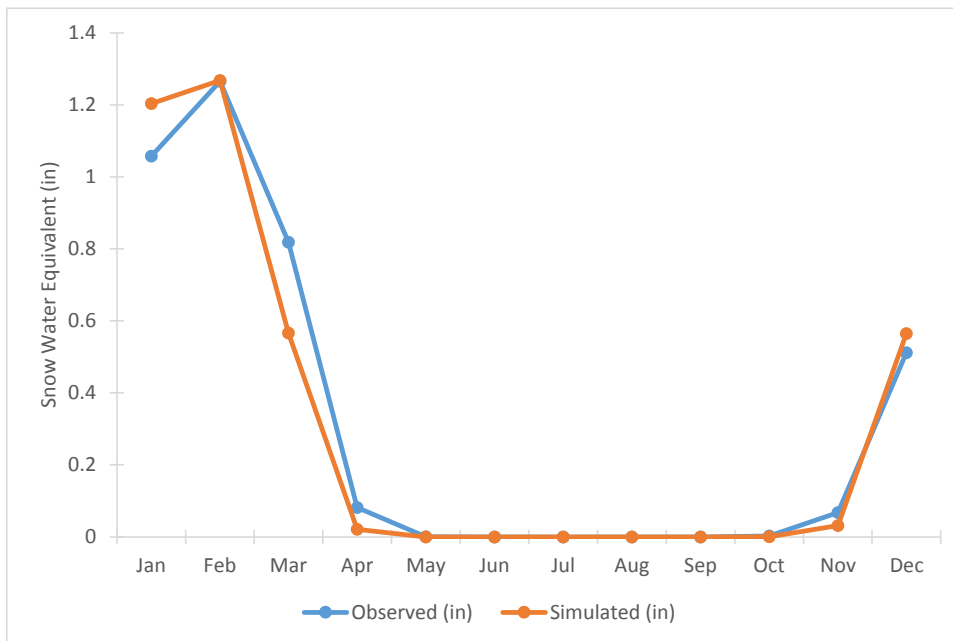
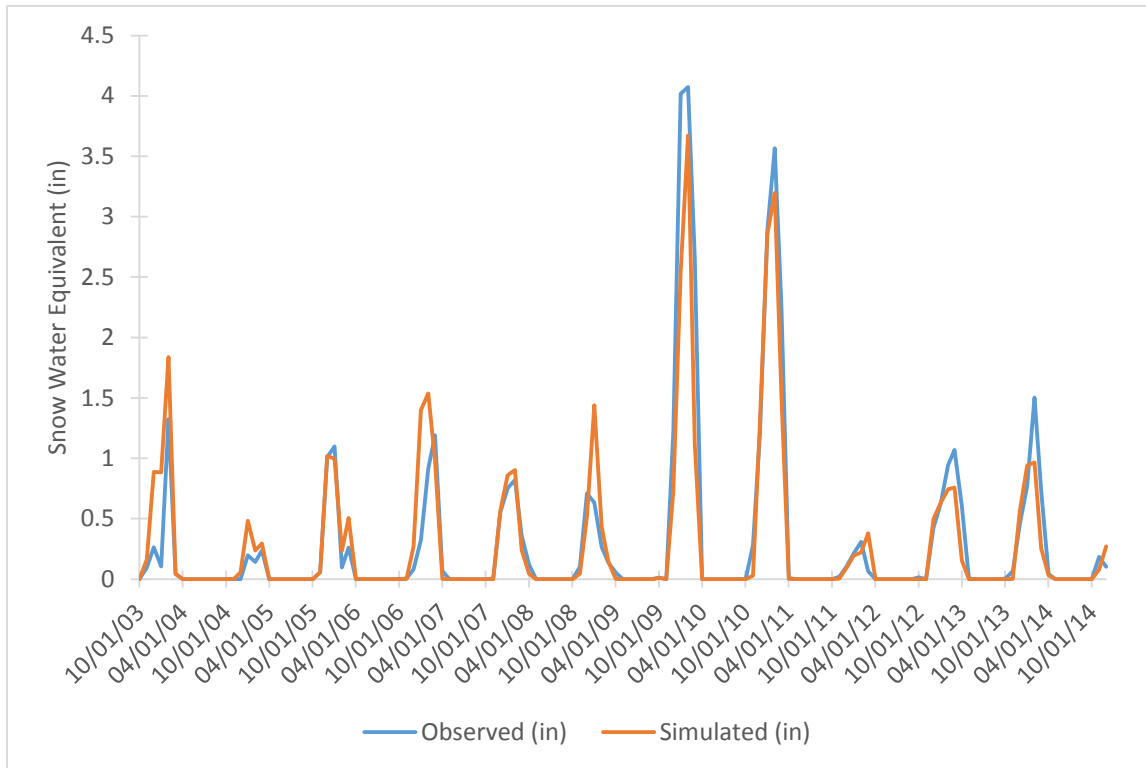
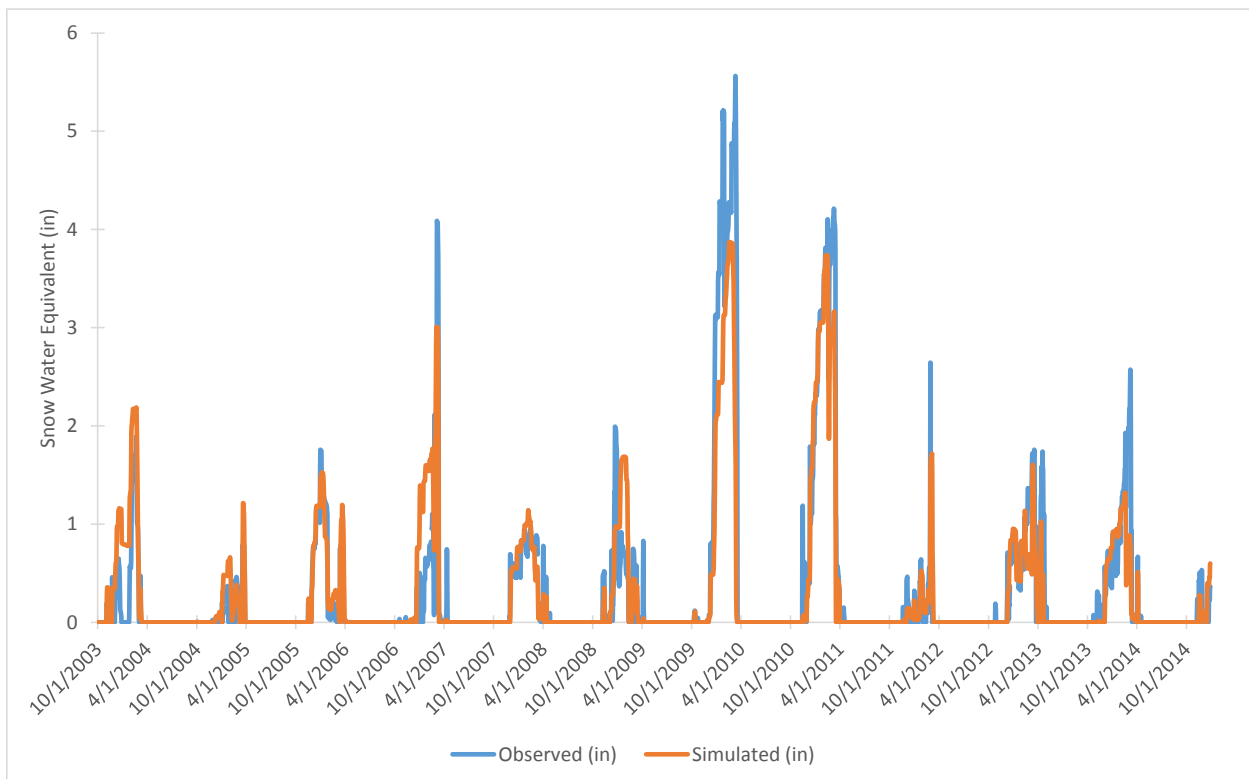


Figure 46. Mean monthly snow water equivalent for weather region 8



**Figure 47. Mean monthly snow water equivalent time-series for weather region 8**



**Figure 48. Mean daily snow water equivalent time-series for weather region 8**

## WEATHER REGION 9

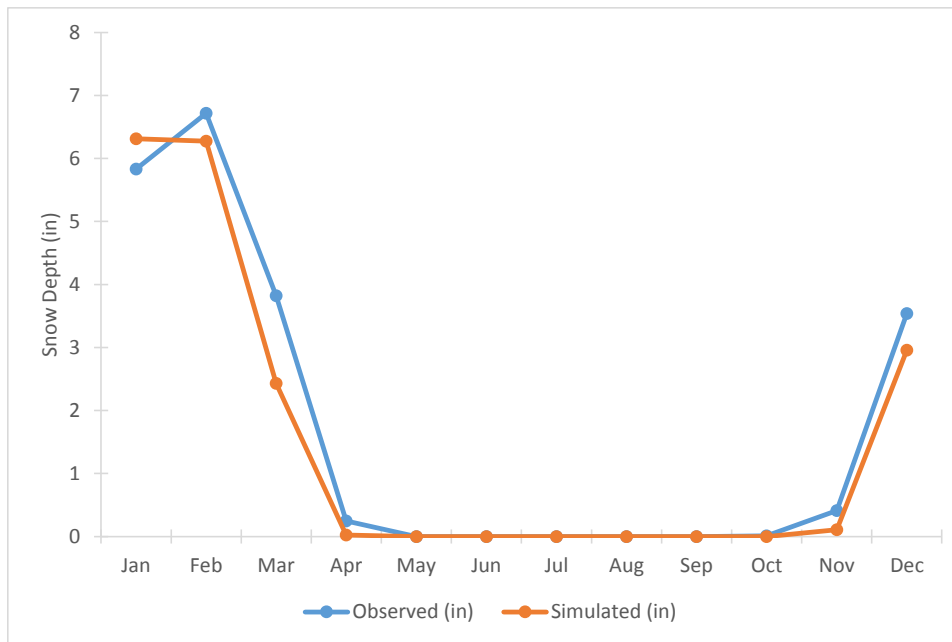


Figure 49. Mean monthly snow depth for weather region 9

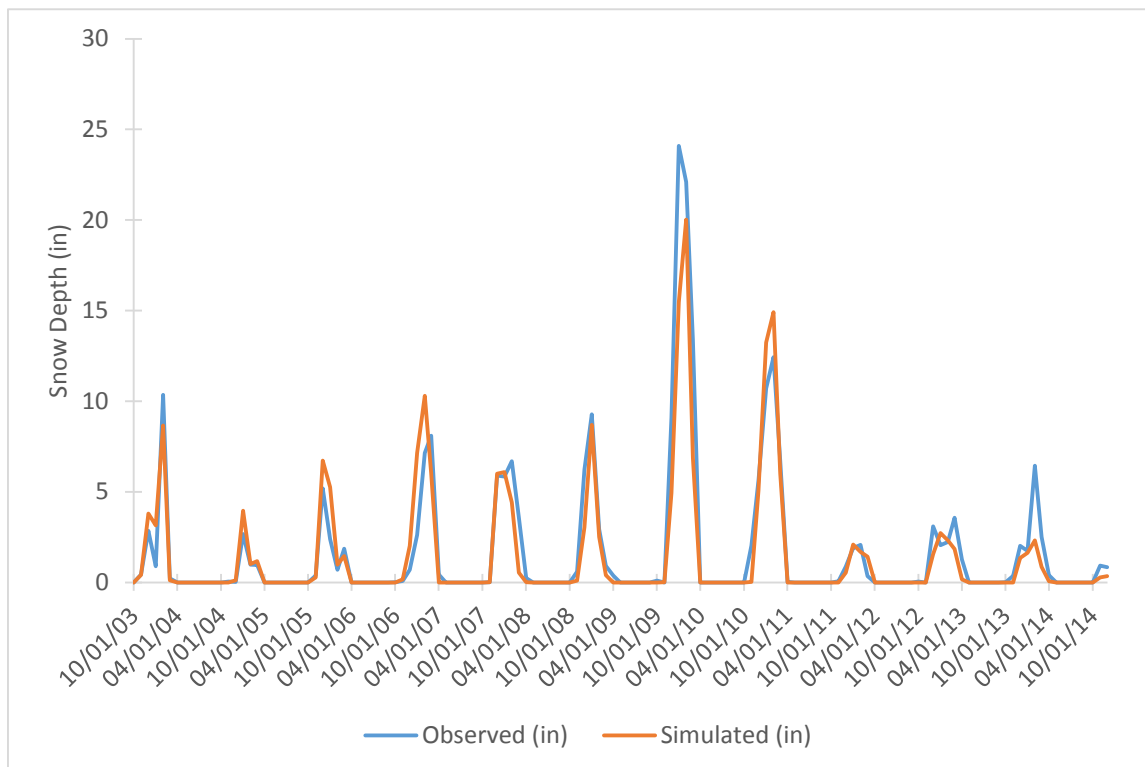


Figure 50. Mean monthly snow depth time-series for weather region 9

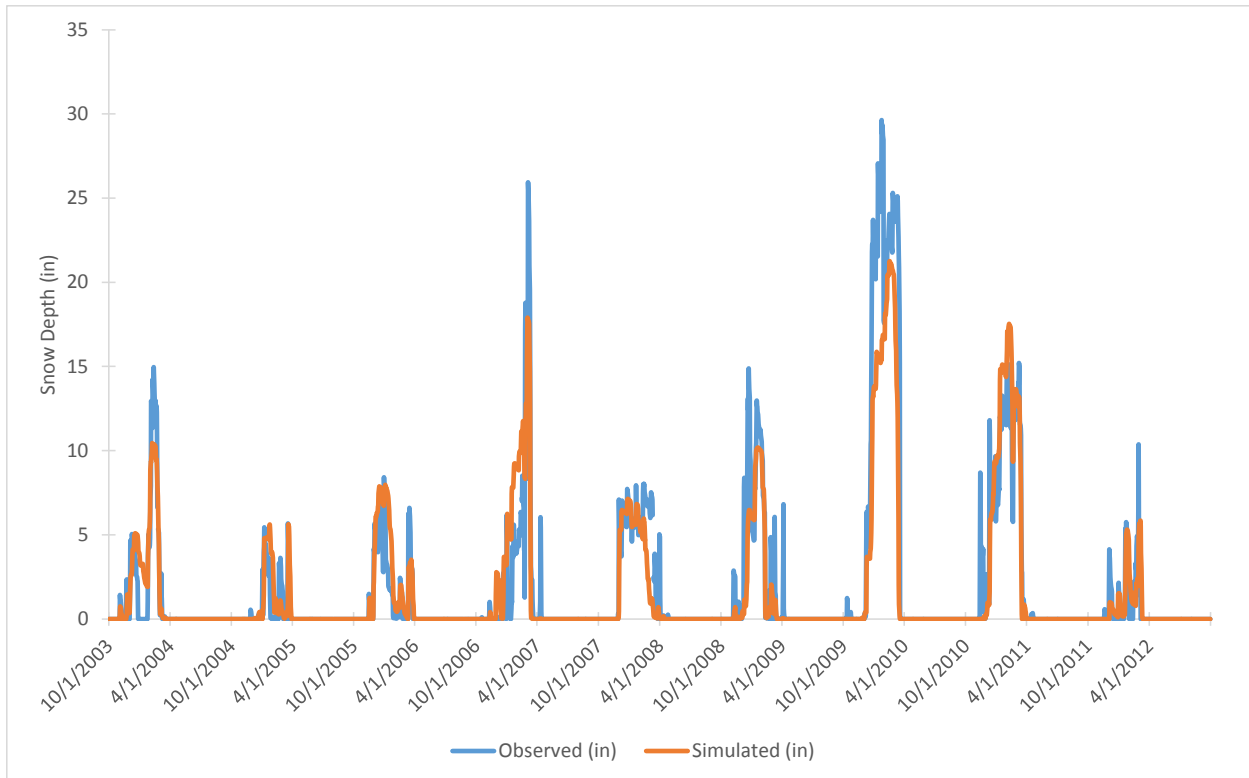


Figure 51. Mean daily snow depth time-series for weather region 9

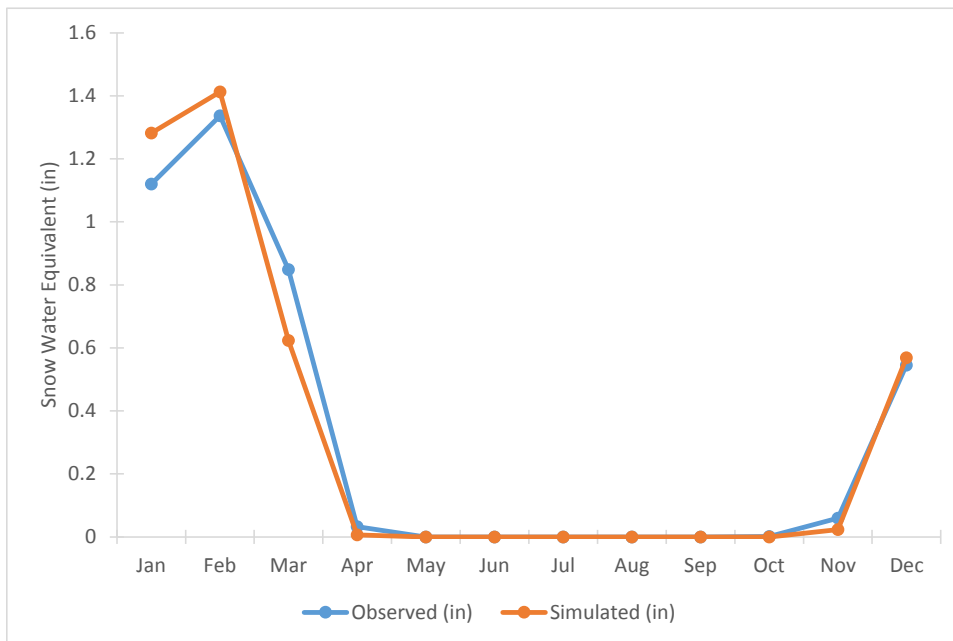
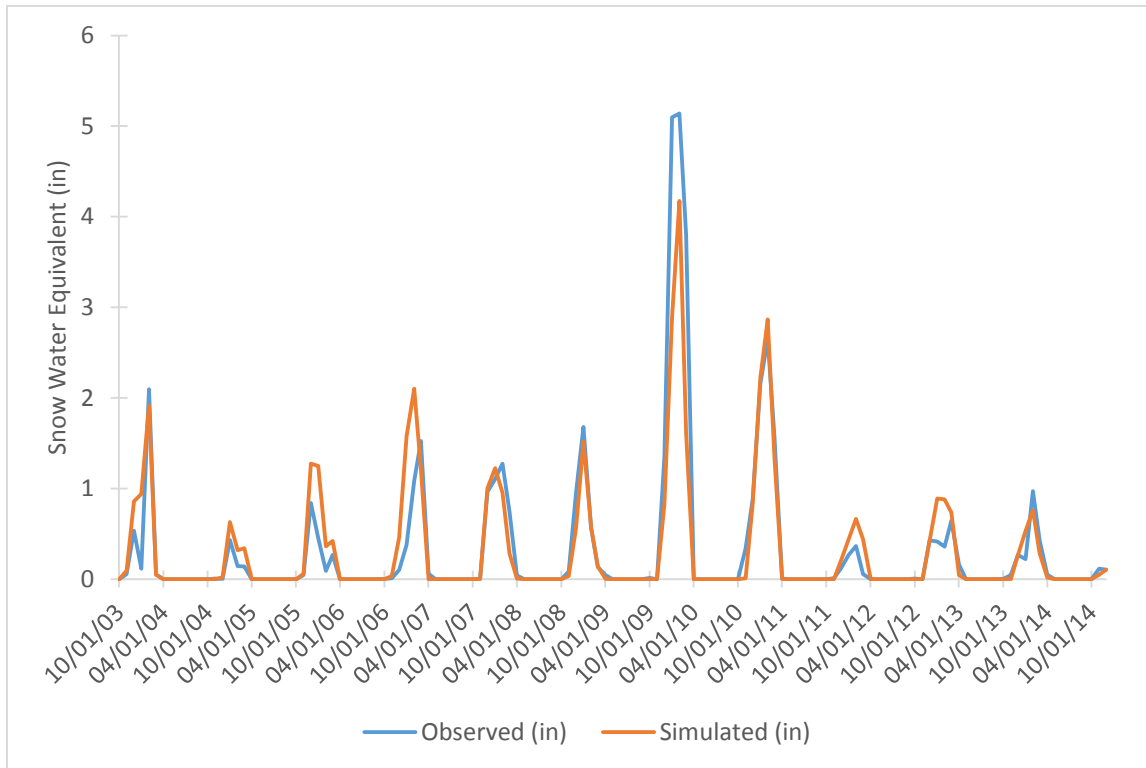
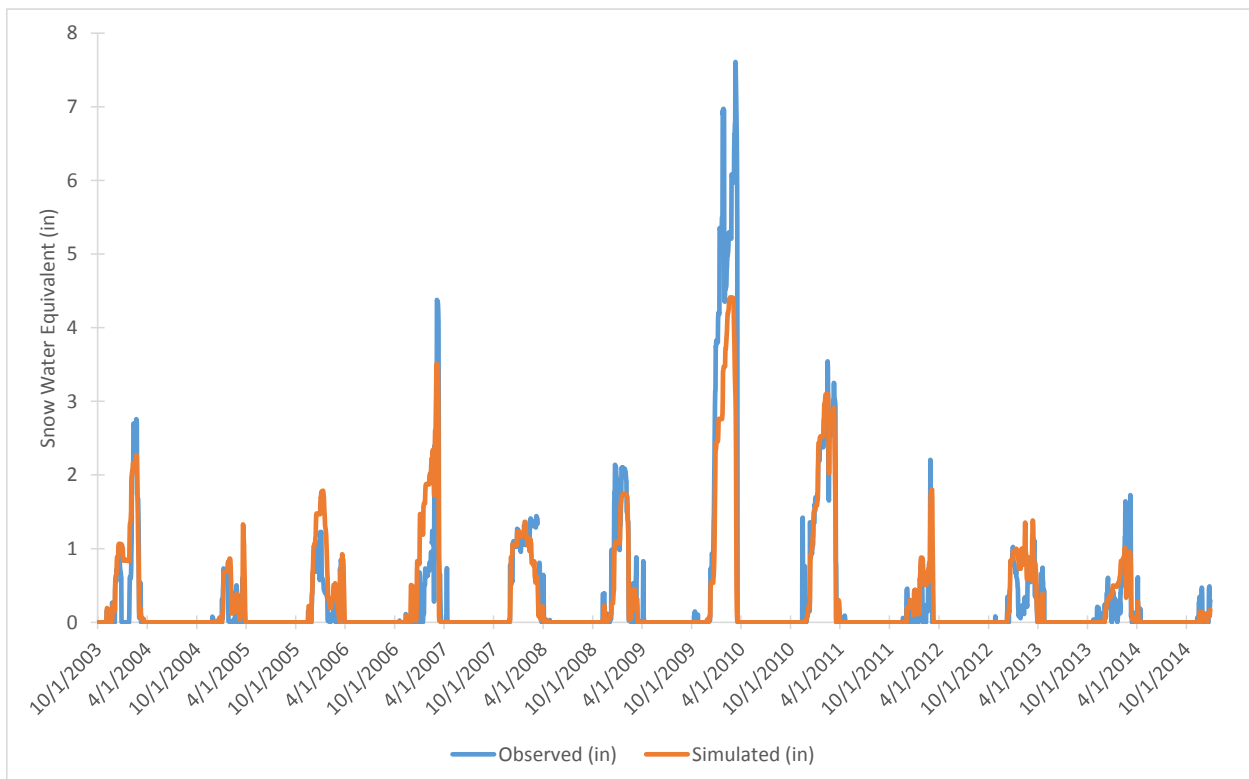


Figure 52. Mean monthly snow water equivalent for weather region 9



**Figure 53. Mean monthly snow water equivalent time-series for weather region 9**



**Figure 54. Mean daily snow water equivalent time-series for weather region 9**

## WEATHER REGION 10

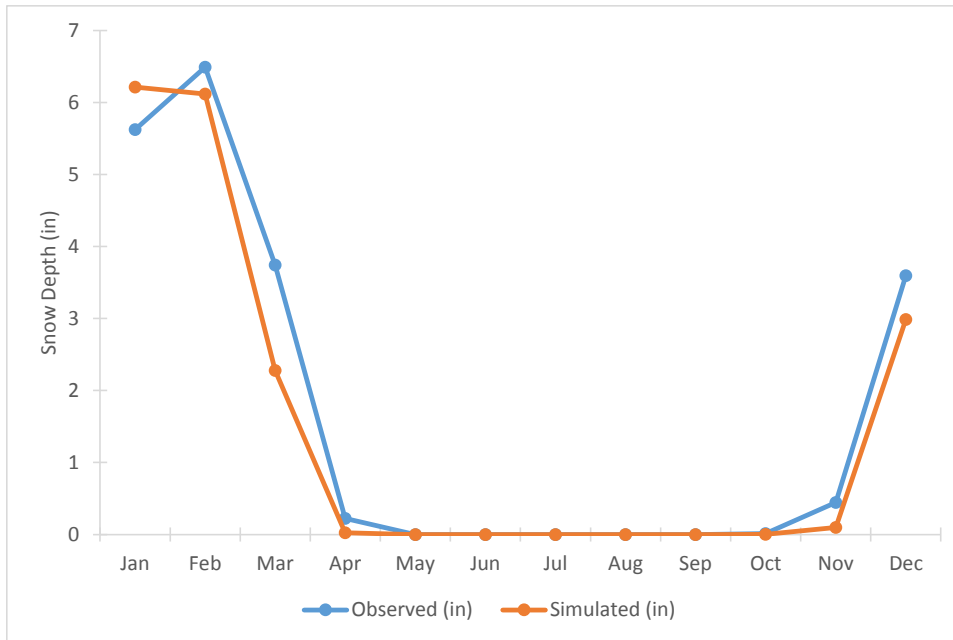


Figure 55. Mean monthly snow depth for weather region 10

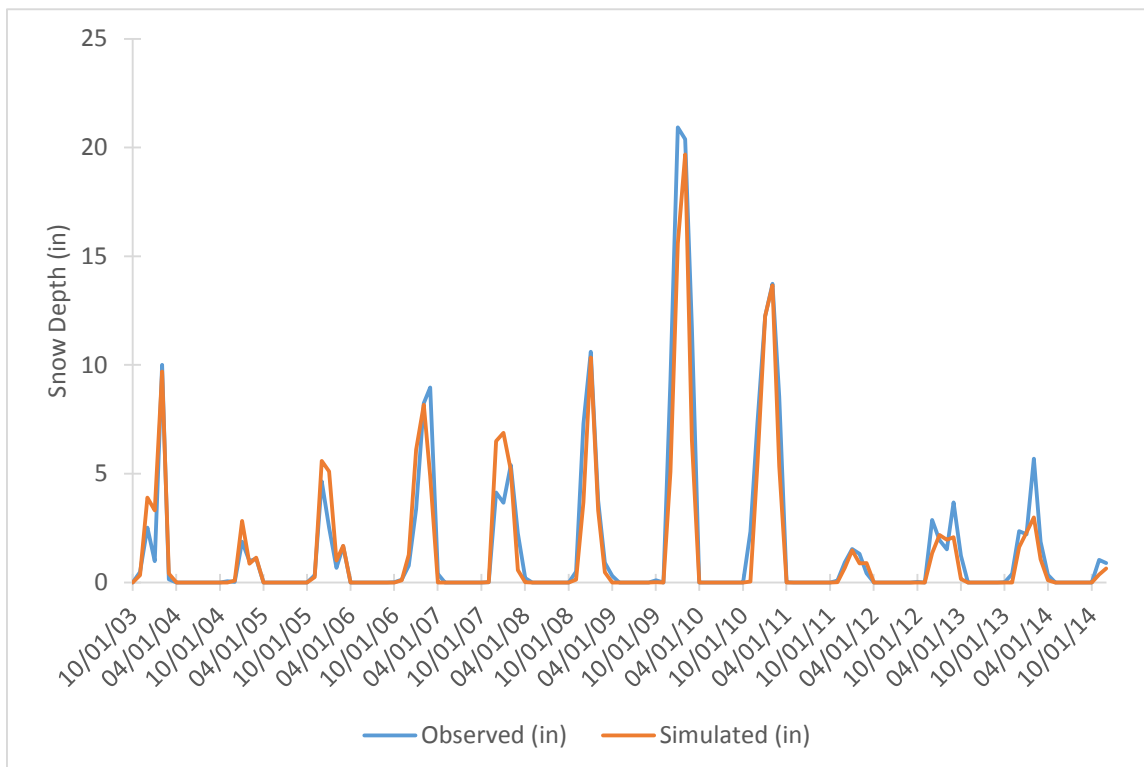


Figure 56. Mean monthly snow depth time-series for weather region 10

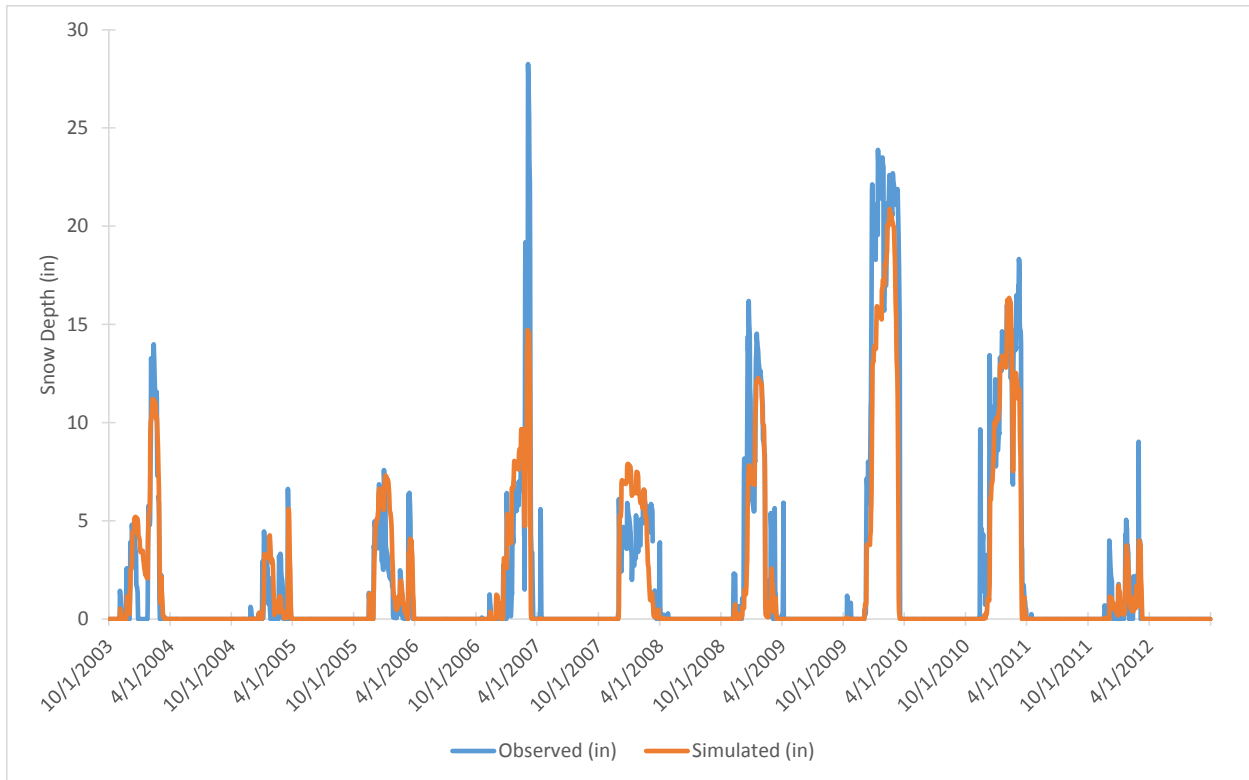


Figure 57. Mean daily snow depth time-series for weather region 10

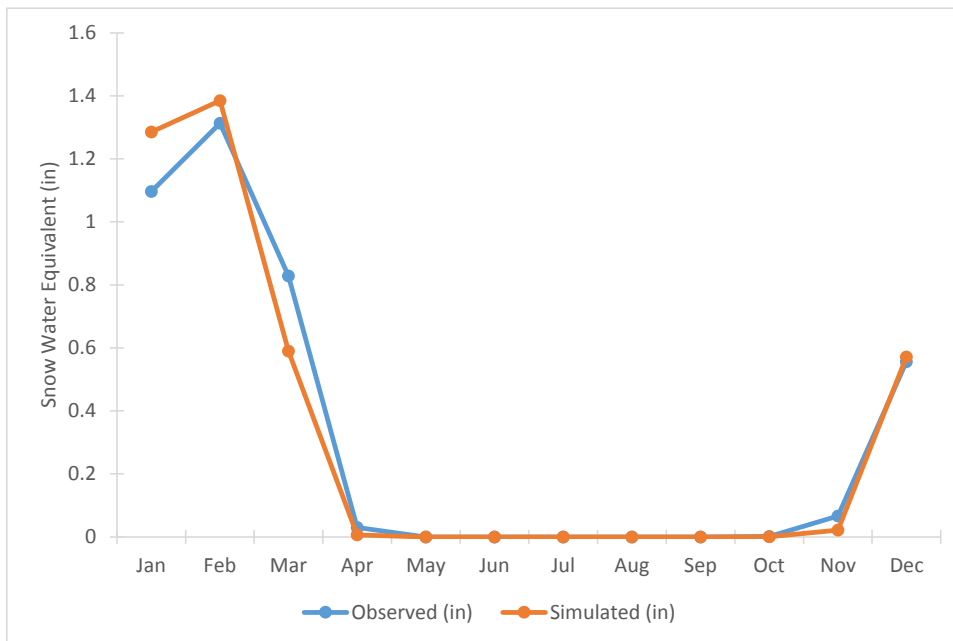
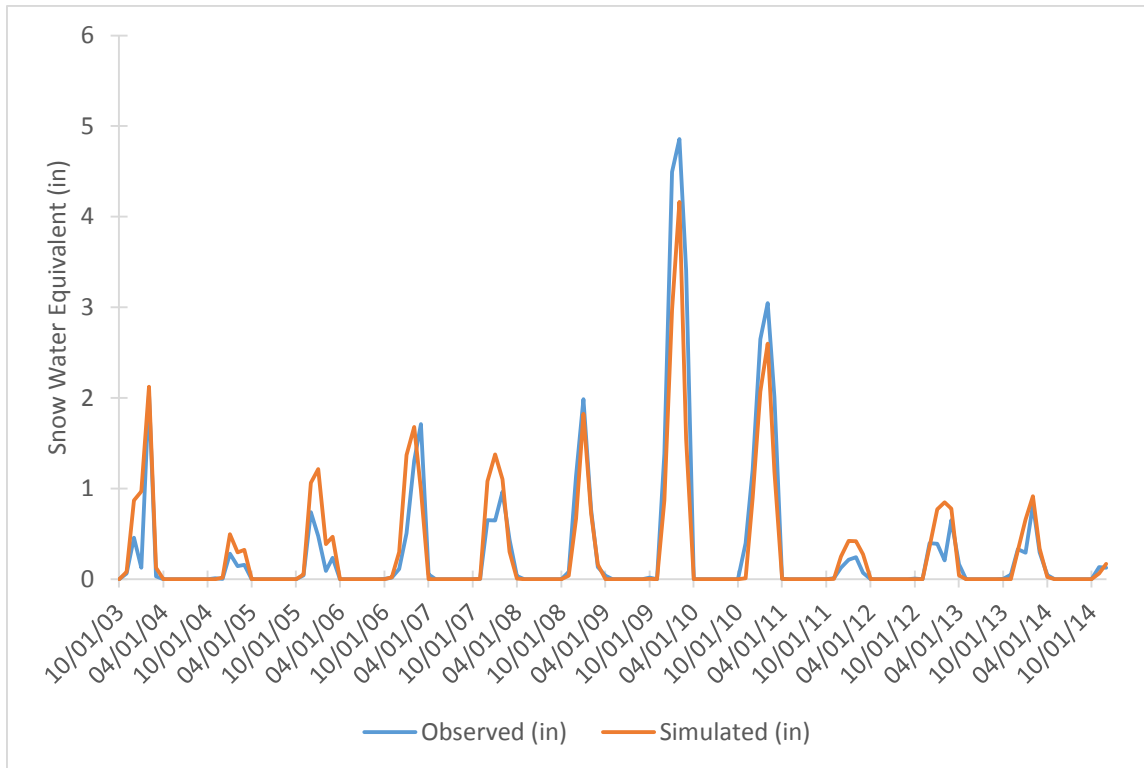
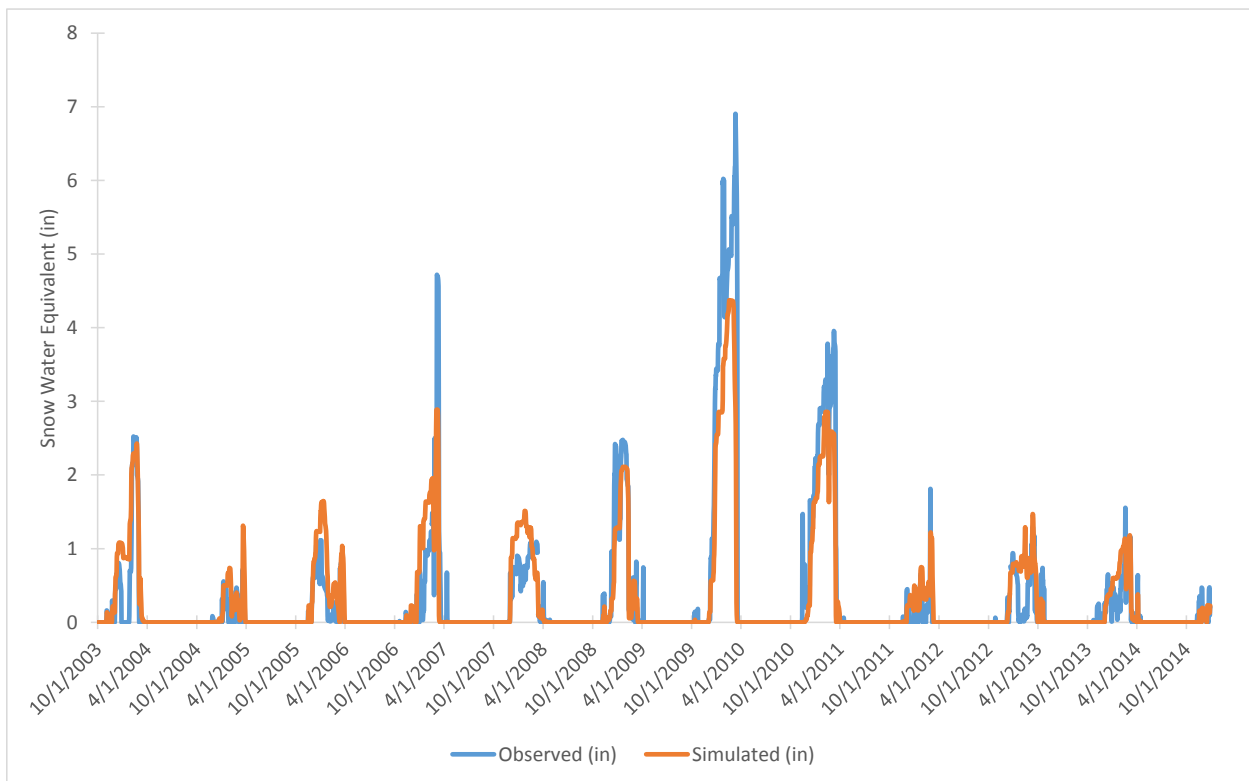


Figure 58. Mean monthly snow water equivalent for weather region 10



**Figure 59. Mean monthly snow water equivalent time-series for weather region 10**



**Figure 60. Mean daily snow water equivalent time-series for weather region 10**



# Appendix B. Detailed Flow Calibration Results

## LAKE SHETEK OUTLET NEAR CURRIE (HYDSTRA 51078001)

Table 1. Summary statistics at Lake Shetek Outlet near Currie

HSPF Simulated Flow		Observed Flow Gage	
<b>REACH OUTFLOW FROM DSN 1</b>  1.5-Year Analysis Period: 4/1/2003 - 9/30/2004 Flow volumes are (inches/year) for upstream drainage area		<b>Lake Shetek Outlet near Currie</b>  Manually Entered Data  Drainage Area (sq-mi): 129.9	
Total Simulated In-stream Flow:	<b>7.43</b>	Total Observed In-stream Flow:	<b>7.36</b>
Total of simulated highest 10% flows:	<b>3.30</b>	Total of Observed highest 10% flows:	<b>3.73</b>
Total of Simulated lowest 50% flows:	<b>0.45</b>	Total of Observed Lowest 50% flows:	<b>0.38</b>
Simulated Summer Flow Volume (months 7-9):	<b>1.47</b>	Observed Summer Flow Volume (7-9):	<b>1.13</b>
Simulated Fall Flow Volume (months 10-12):	<b>0.00</b>	Observed Fall Flow Volume (10-12):	<b>0.00</b>
Simulated Winter Flow Volume (months 1-3):	<b>0.00</b>	Observed Winter Flow Volume (1-3):	<b>0.00</b>
Simulated Spring Flow Volume (months 4-6):	<b>5.95</b>	Observed Spring Flow Volume (4-6):	<b>6.23</b>
Total Simulated Storm Volume:	<b>1.40</b>	Total Observed Storm Volume:	<b>2.11</b>
Simulated Summer Storm Volume (7-9):	<b>0.31</b>	Observed Summer Storm Volume (7-9):	<b>0.26</b>
<i>Errors (Simulated-Observed)</i>	<i>Error Statistics</i>	<i>Recommended Criteria</i>	
Error in total volume:	0.93	10	
Error in 50% lowest flows:	17.31	10	
Error in 10% highest flows:	-11.39	15	
Seasonal volume error - Summer:	30.26	30	
Seasonal volume error - Fall:	0.00	30	
Seasonal volume error - Winter:	0.00	30	Clear
Seasonal volume error - Spring:	-4.39	30	
Error in storm volumes:	-33.37	20	
Error in summer storm volumes:	16.53	50	
Nash-Sutcliffe Coefficient of Efficiency, E:	0.830	Model accuracy increases	
Baseline adjusted coefficient (Garrick), E':	0.636		
Monthly NSE	0.975		

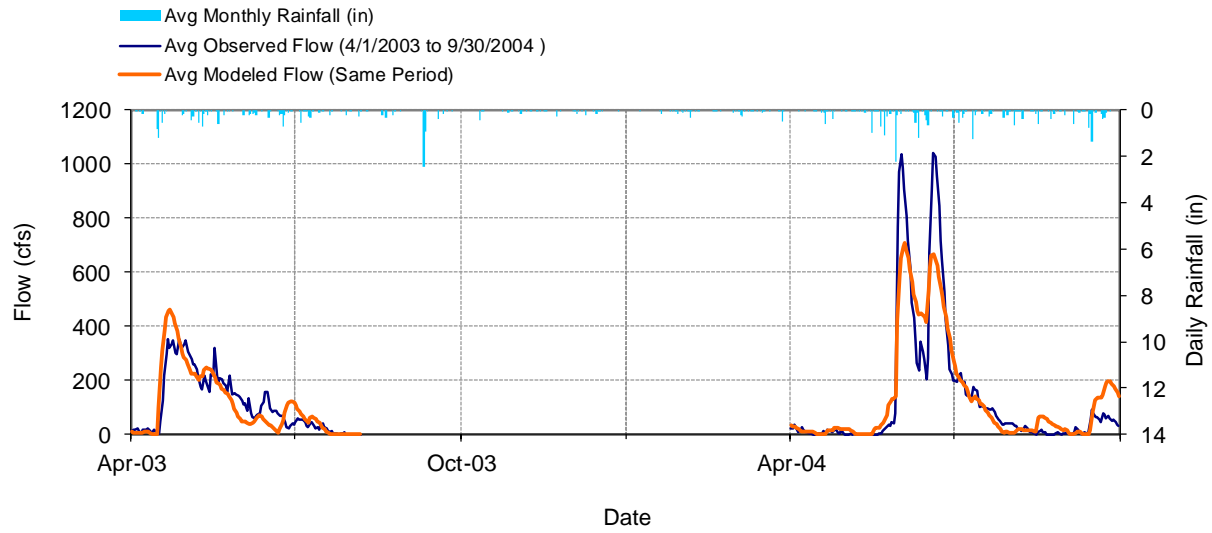


Figure 61. Mean daily flow at Lake Shetek Outlet near Currie

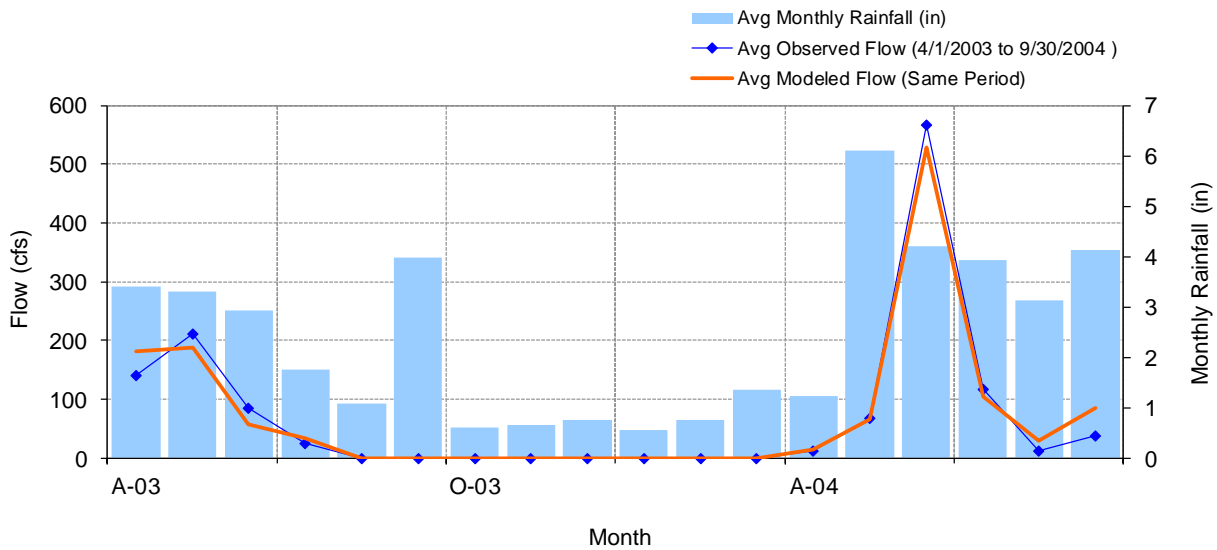


Figure 62. Mean monthly flow at Lake Shetek Outlet near Currie

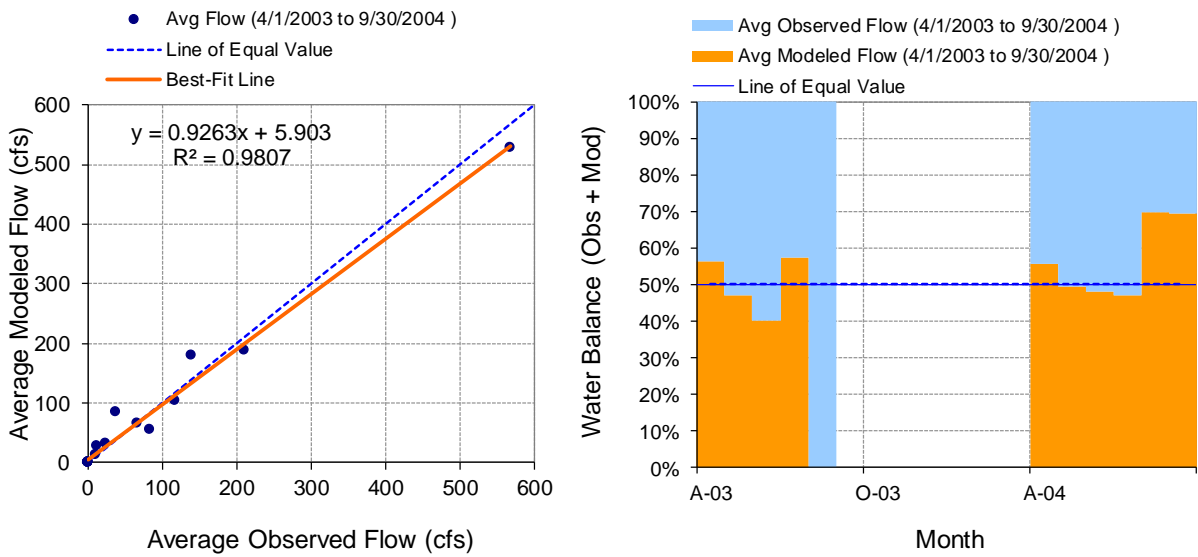


Figure 63. Monthly flow regression and temporal variation at Lake Shetek Outlet near Currie

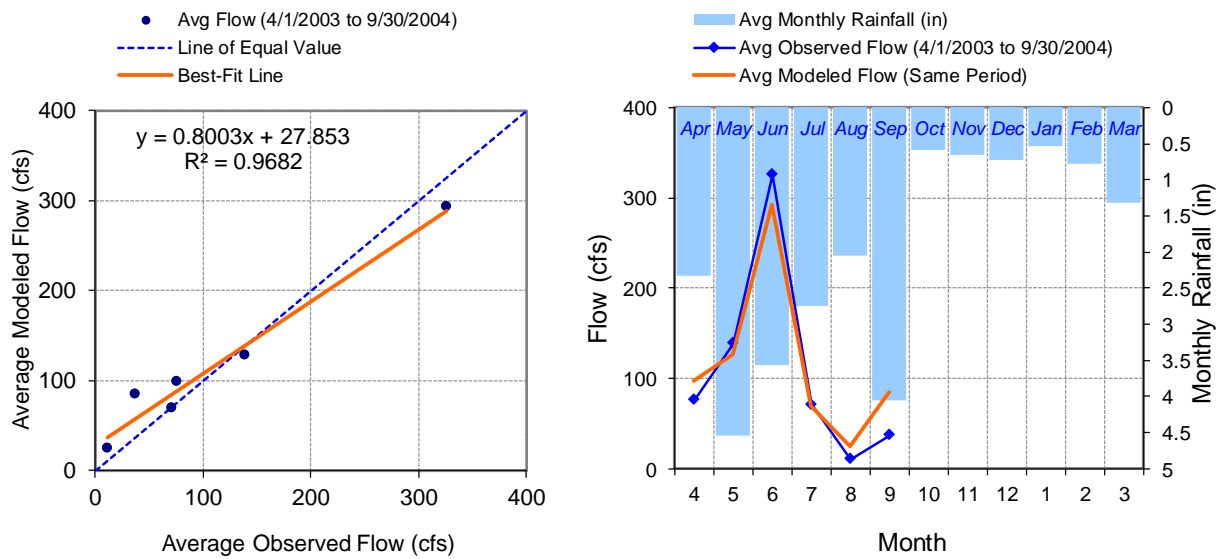


Figure 64. Seasonal regression and temporal aggregate at Lake Shetek Outlet near Currie

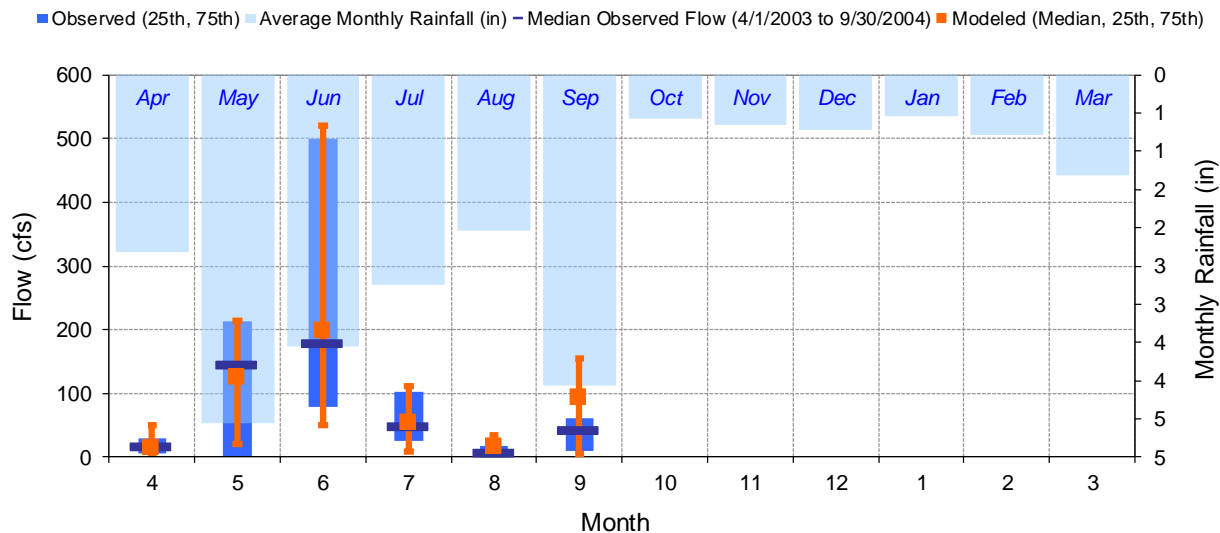


Figure 65. Seasonal medians and ranges at Lake Shetek Outlet near Currie

Table 2. Seasonal summary at Lake Shetek Outlet near Currie

MONTH	OBSERVED FLOW (CFS)				MODELED FLOW (CFS)			
	MEAN	MEDIAN	25TH	75TH	MEAN	MEDIAN	25TH	75TH
Apr	75.88	17.16	5.90	29.96	97.61	13.96	6.32	50.88
May	138.82	144.50	0.95	212.50	126.99	124.91	20.70	214.48
Jun	325.60	179.44	78.65	499.40	292.18	197.91	49.75	520.46
Jul	71.19	47.25	24.88	103.04	69.00	53.55	9.69	111.07
Aug	10.65	6.82	0.80	17.09	24.31	17.59	8.90	34.47
Sep	37.37	41.47	8.87	61.96	84.84	93.39	4.90	154.14
Oct	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nov	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dec	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

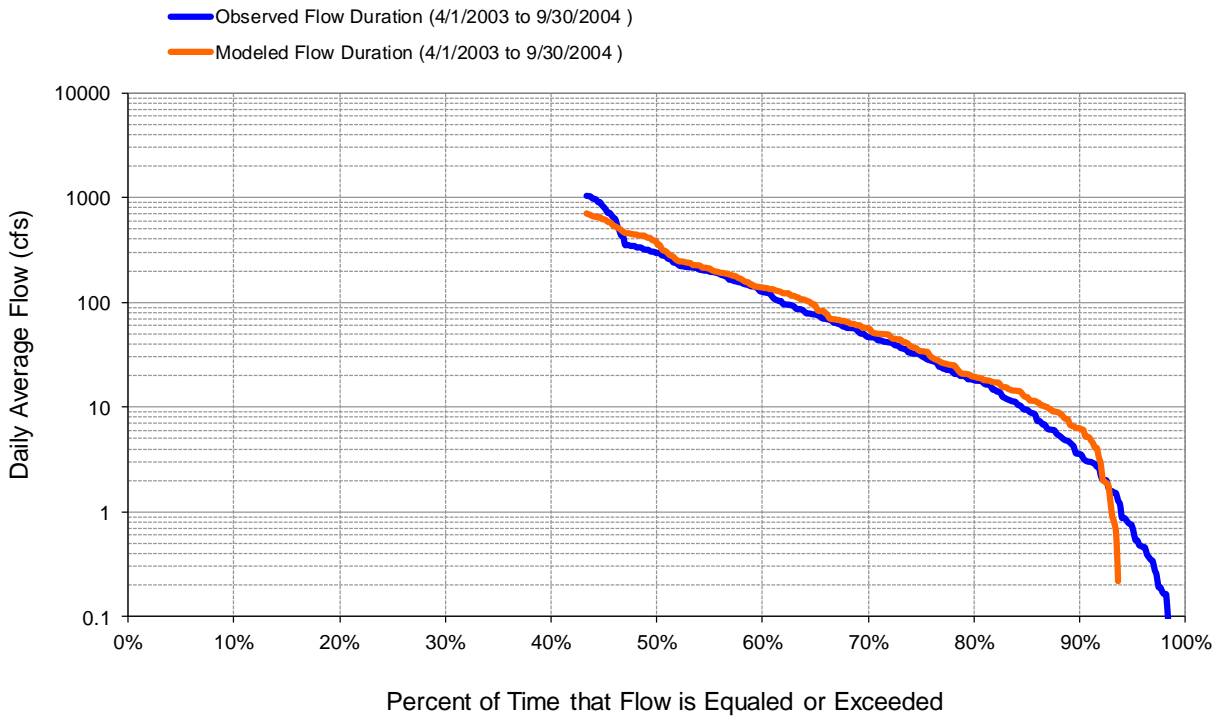


Figure 66. Flow exceedence at Lake Shetek Outlet near Currie

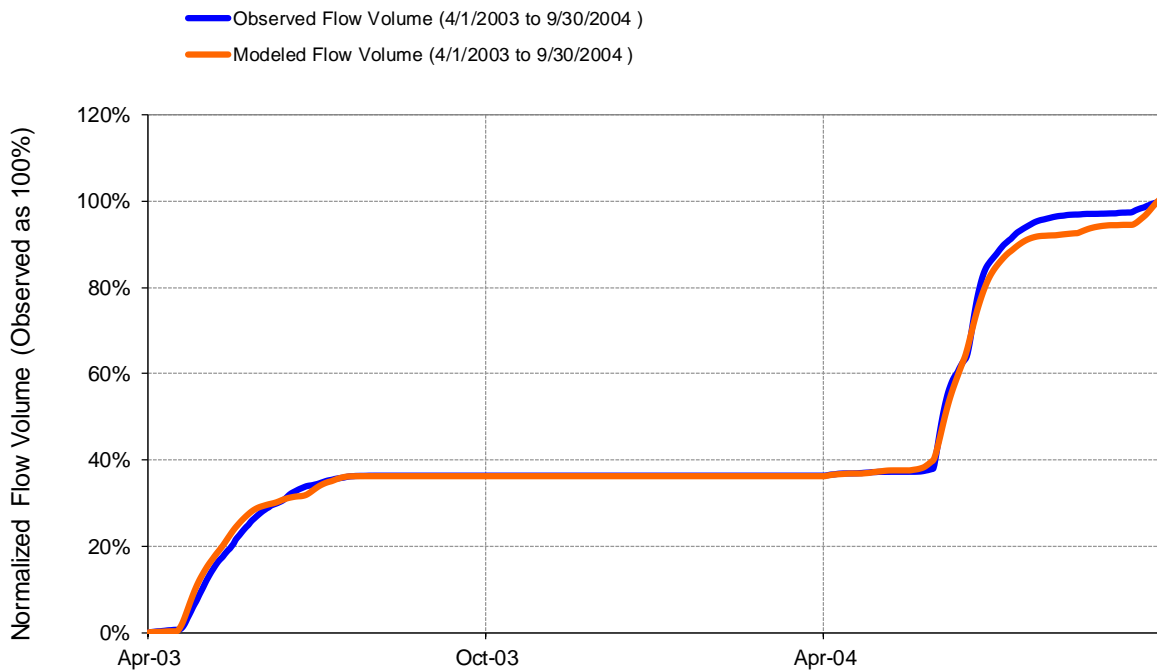


Figure 67. Flow accumulation at Lake Shetek Outlet near Currie

## BEAVER CREEK NEAR CURRIE (HYDSTRA 51069001)

**Table 3. Summary statistics at Beaver Creek near Currie**

HSPF Simulated Flow		Observed Flow Gage	
<b>REACH OUTFLOW FROM DSN 2</b>  5.6-Year Analysis Period: 3/1/2003 - 10/31/2008 Flow volumes are (inches/year) for upstream drainage area		<b>Beaver Creek near Currie</b>  Manually Entered Data  Drainage Area (sq-mi): 177.3	
Total Simulated In-stream Flow:	<b>3.31</b>	Total Observed In-stream Flow:	<b>3.04</b>
Total of simulated highest 10% flows:	<b>1.63</b>	Total of Observed highest 10% flows:	<b>1.53</b>
Total of Simulated lowest 50% flows:	<b>0.33</b>	Total of Observed Lowest 50% flows:	<b>0.22</b>
Simulated Summer Flow Volume (months 7-9):	<b>0.62</b>	Observed Summer Flow Volume (7-9):	<b>0.27</b>
Simulated Fall Flow Volume (months 10-12):	<b>0.38</b>	Observed Fall Flow Volume (10-12):	<b>0.23</b>
Simulated Winter Flow Volume (months 1-3):	<b>0.10</b>	Observed Winter Flow Volume (1-3):	<b>0.10</b>
Simulated Spring Flow Volume (months 4-6):	<b>2.22</b>	Observed Spring Flow Volume (4-6):	<b>2.43</b>
Total Simulated Storm Volume:	<b>1.06</b>	Total Observed Storm Volume:	<b>0.97</b>
Simulated Summer Storm Volume (7-9):	<b>0.15</b>	Observed Summer Storm Volume (7-9):	<b>0.06</b>
<i>Errors (Simulated-Observed)</i>	<i>Error Statistics</i>	<i>Recommended Criteria</i>	
Error in total volume:	9.12	10	
Error in 50% lowest flows:	46.76	10	
Error in 10% highest flows:	6.37	15	
Seasonal volume error - Summer:	127.40	30	
Seasonal volume error - Fall:	66.84	30	Clear
Seasonal volume error - Winter:	-7.99	30	
Seasonal volume error - Spring:	-8.82	30	
Error in storm volumes:	9.73	20	
Error in summer storm volumes:	165.92	50	
Nash-Sutcliffe Coefficient of Efficiency, E:	0.718	Model accuracy increases	
Baseline adjusted coefficient (Garrick), E':	0.526		
Monthly NSE	0.904		

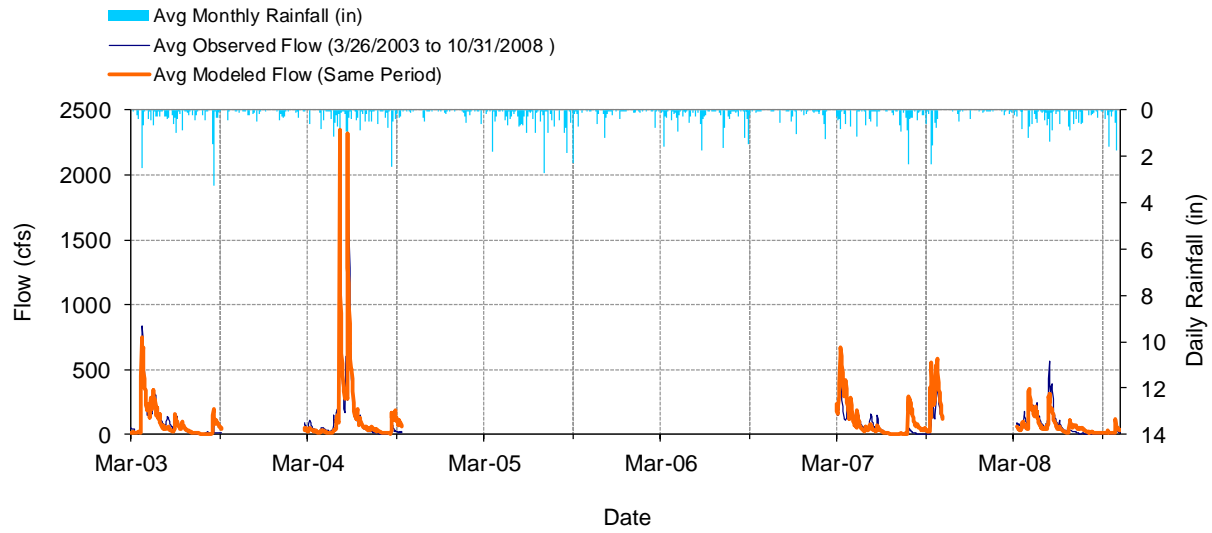


Figure 68. Mean daily flow at Beaver Creek near Currie

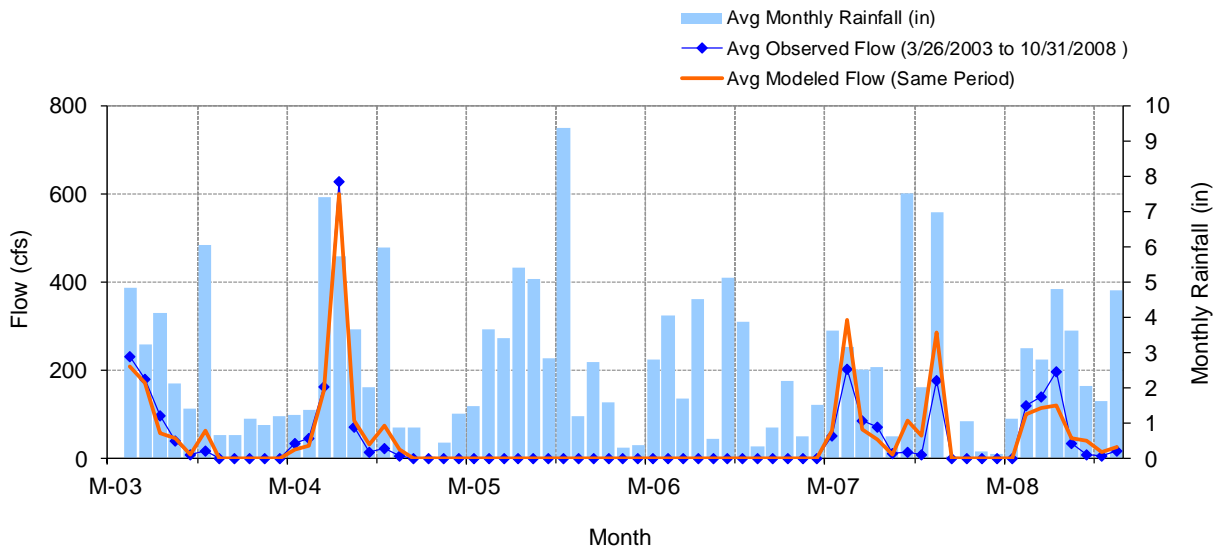


Figure 69. Mean monthly flow at Beaver Creek near Currie

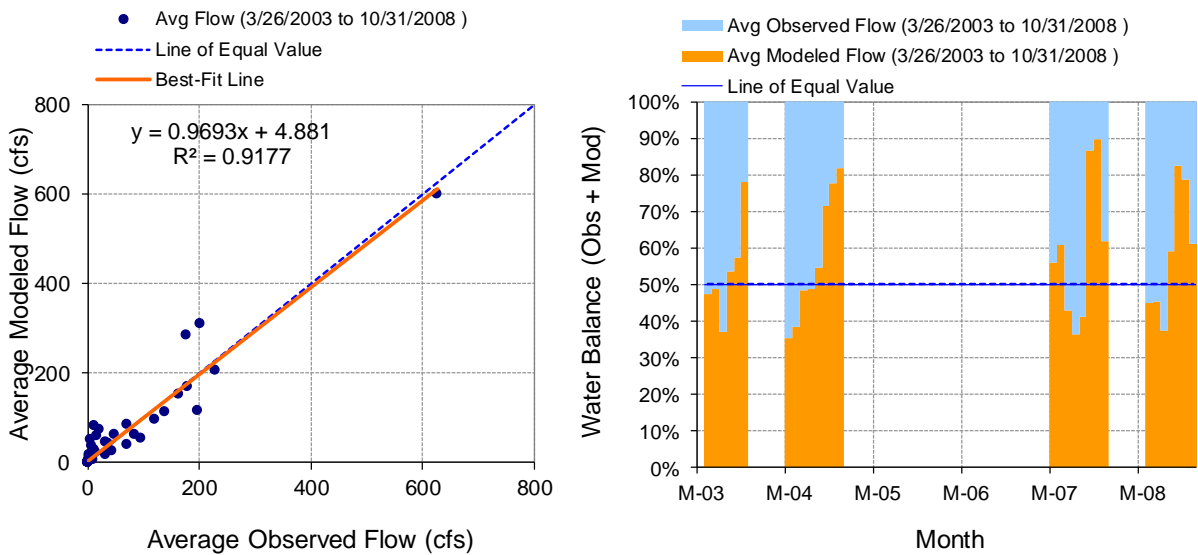


Figure 70. Monthly flow regression and temporal variation at Beaver Creek near Currie

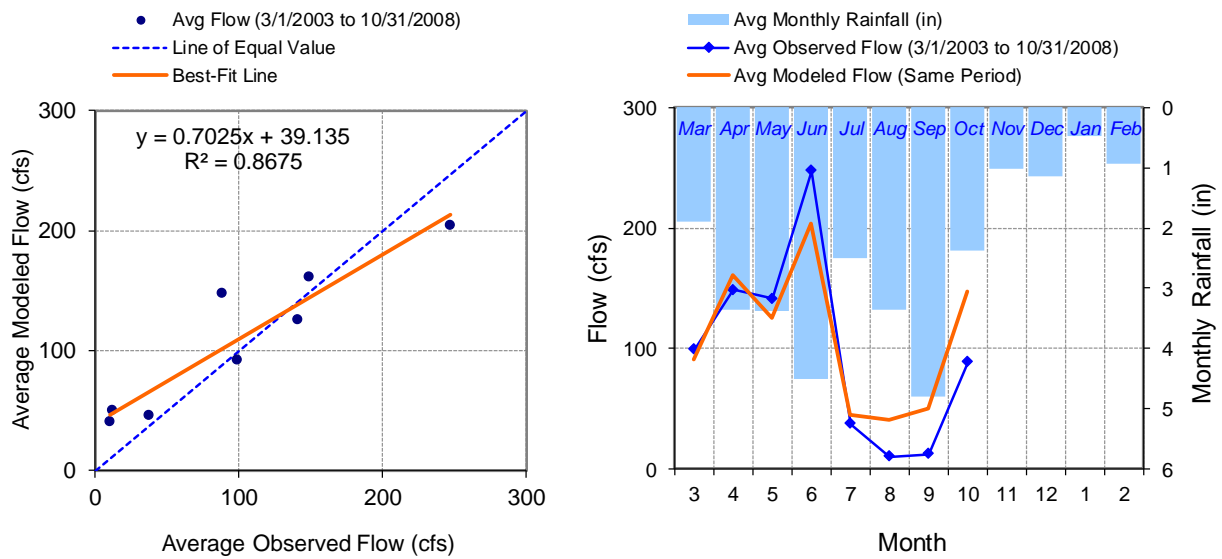


Figure 71. Seasonal regression and temporal aggregate at Beaver Creek near Currie



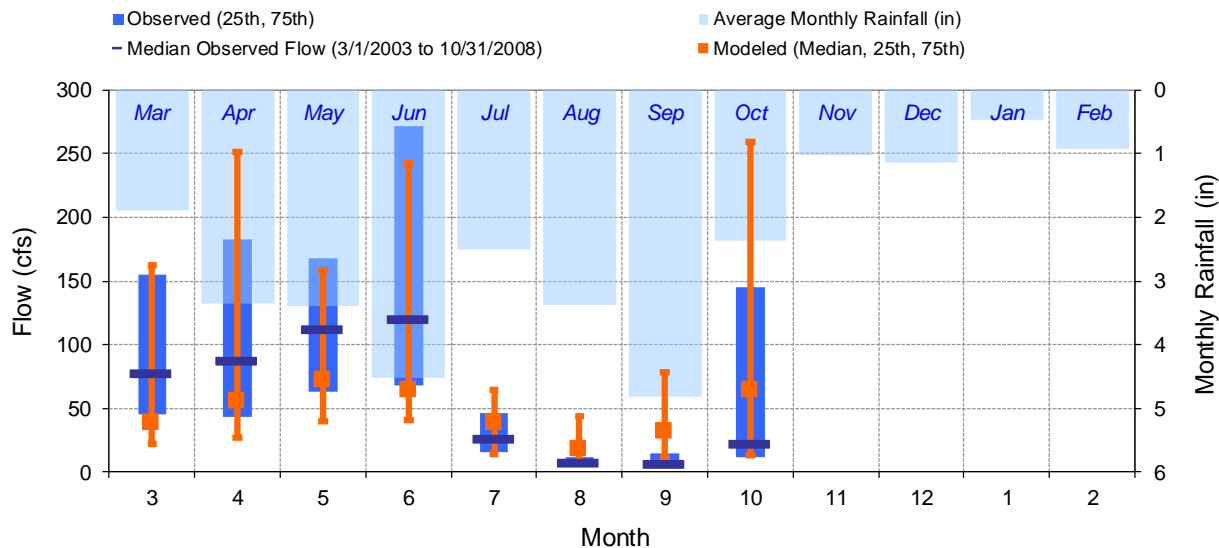
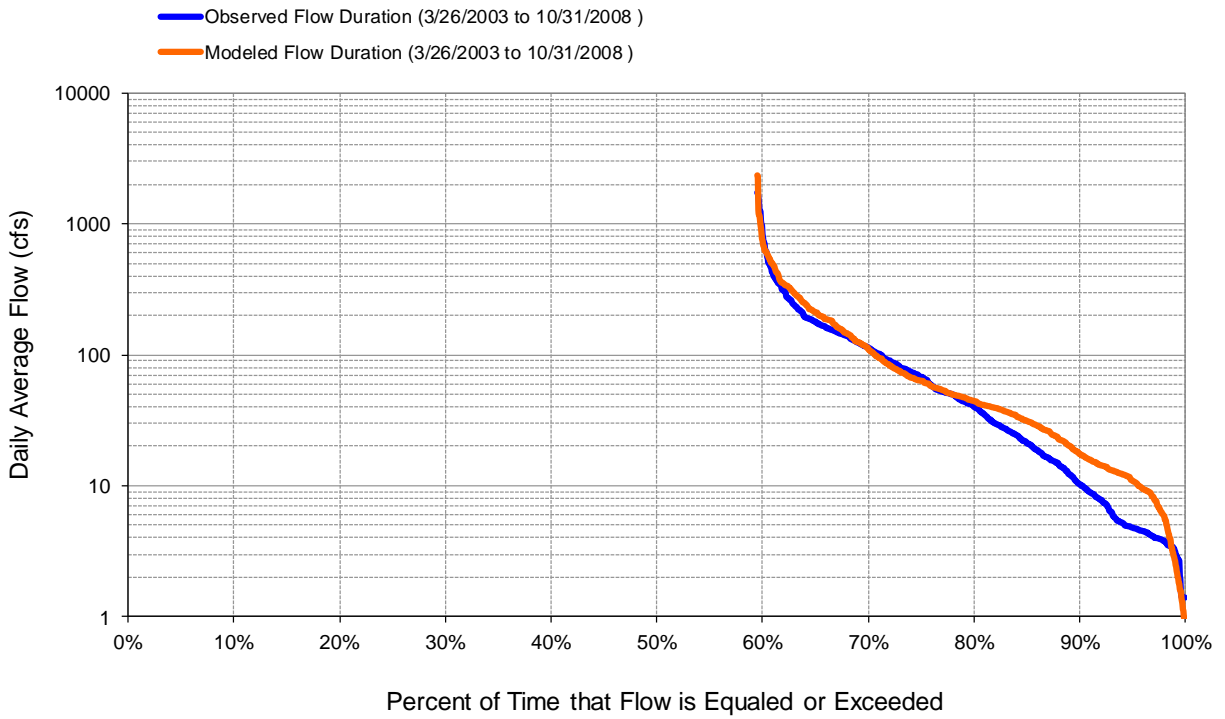


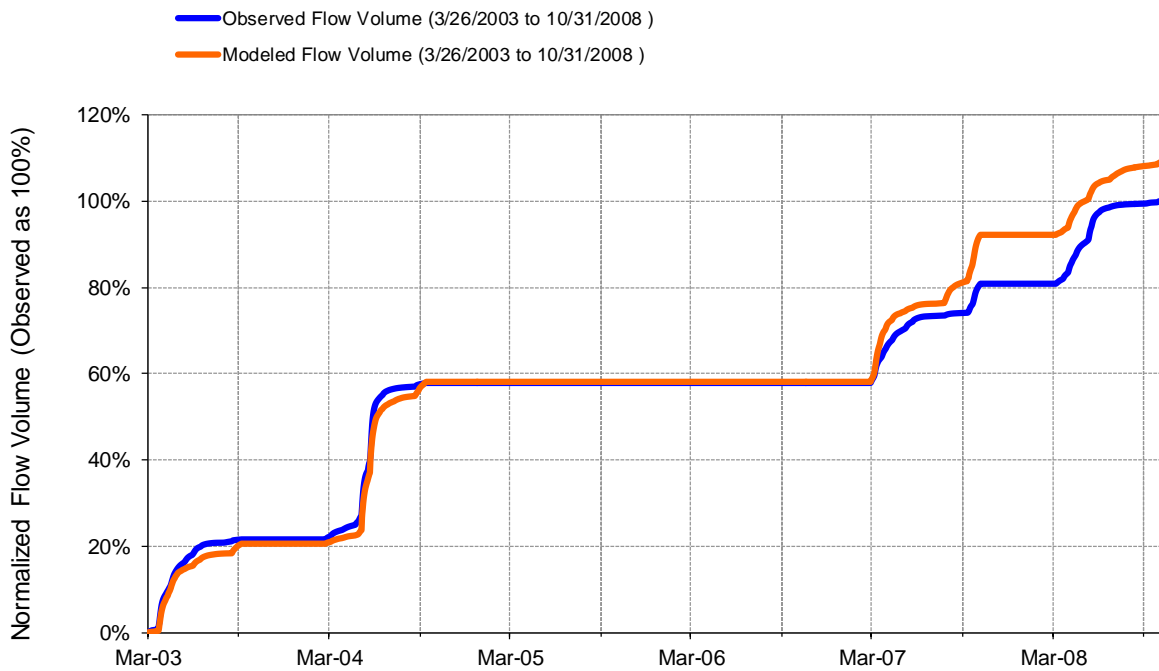
Figure 72. Seasonal medians and ranges at Beaver Creek near Currie

Table 4. Seasonal summary at Beaver Creek near Currie

MONTH	OBSERVED FLOW (CFS)				MODELED FLOW (CFS)			
	MEAN	MEDIAN	25TH	75TH	MEAN	MEDIAN	25TH	75TH
Mar	98.93	77.10	45.08	154.82	91.02	39.26	22.45	162.09
Apr	148.53	87.00	43.86	183.10	160.70	55.33	26.75	250.88
May	141.17	112.34	63.25	167.77	125.50	72.42	39.48	158.30
Jun	247.36	119.47	68.46	272.00	203.58	64.96	41.14	242.54
Jul	37.32	26.55	16.05	46.84	45.04	38.61	14.39	64.85
Aug	9.82	7.54	4.40	12.23	40.23	18.58	8.22	43.47
Sep	12.02	6.38	4.10	14.26	50.00	32.01	11.69	78.63
Oct	88.34	22.00	12.16	144.75	147.38	65.06	13.17	258.92
Nov	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dec	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00



**Figure 73. Flow exceedance at Beaver Creek near Currie**



**Figure 74. Flow accumulation at Beaver Creek near Currie**

## LIME CREEK NEAR LIME CREEK (HYDSTRA 51055001)

**Table 5. Summary statistics at Lime Creek near Lime Creek**

HSPF Simulated Flow		Observed Flow Gage	
<b>REACH OUTFLOW FROM DSN 4</b>  1.42-Year Analysis Period: 4/1/2003 - 8/31/2004 Flow volumes are (inches/year) for upstream drainage area		<b>Lime Creek near Lime Creek</b>  Manually Entered Data  Drainage Area (sq-mi): 97.7	
Total Simulated In-stream Flow:	<b>4.78</b>	Total Observed In-stream Flow:	<b>4.45</b>
Total of simulated highest 10% flows:	<b>1.85</b>	Total of Observed highest 10% flows:	<b>1.72</b>
Total of Simulated lowest 50% flows:	<b>0.71</b>	Total of Observed Lowest 50% flows:	<b>0.39</b>
Simulated Summer Flow Volume (months 7-9):	<b>1.46</b>	Observed Summer Flow Volume (7-9):	<b>0.70</b>
Simulated Fall Flow Volume (months 10-12):	<b>0.00</b>	Observed Fall Flow Volume (10-12):	<b>0.00</b>
Simulated Winter Flow Volume (months 1-3):	<b>0.08</b>	Observed Winter Flow Volume (1-3):	<b>0.12</b>
Simulated Spring Flow Volume (months 4-6):	<b>3.23</b>	Observed Spring Flow Volume (4-6):	<b>3.63</b>
Total Simulated Storm Volume:	<b>1.33</b>	Total Observed Storm Volume:	<b>1.10</b>
Simulated Summer Storm Volume (7-9):	<b>0.38</b>	Observed Summer Storm Volume (7-9):	<b>0.15</b>
<i>Errors (Simulated-Observed)</i>	<i>Error Statistics</i>	<i>Recommended Criteria</i>	
Error in total volume:	7.27	10	
Error in 50% lowest flows:	82.52	10	
Error in 10% highest flows:	7.76	15	
Seasonal volume error - Summer:	109.07	30	
Seasonal volume error - Fall:	0.00	30	Clear
Seasonal volume error - Winter:	-32.87	30	
Seasonal volume error - Spring:	-11.02	30	
Error in storm volumes:	20.93	20	
Error in summer storm volumes:	148.18	50	
Nash-Sutcliffe Coefficient of Efficiency, E:	0.664	Model accuracy increases	
Baseline adjusted coefficient (Garrick), E':	0.458		
Monthly NSE	0.775		

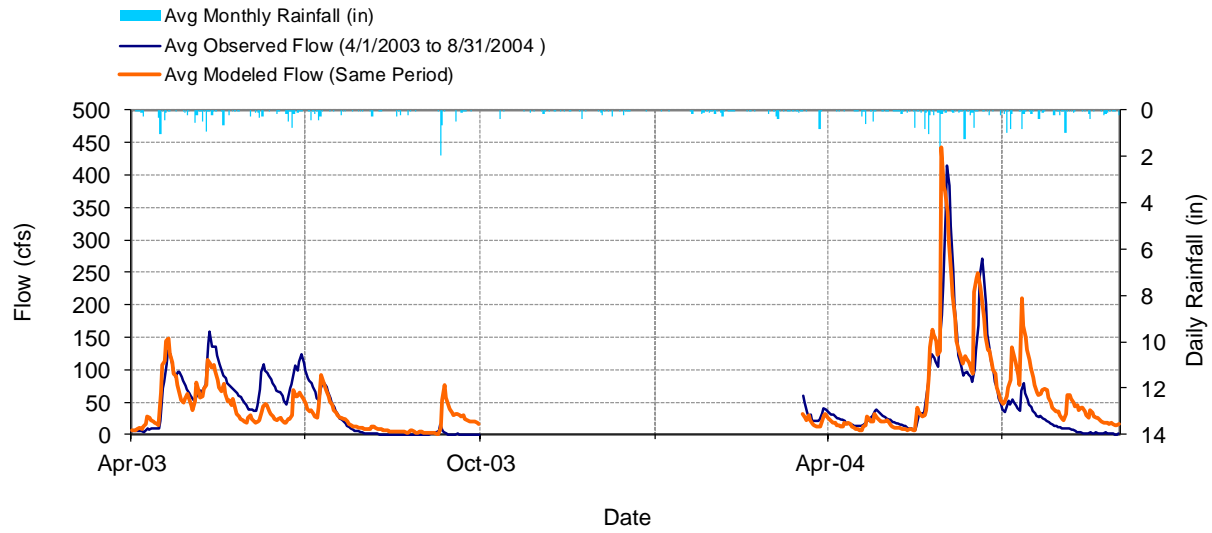


Figure 75. Mean daily flow at Lime Creek near Lime Creek

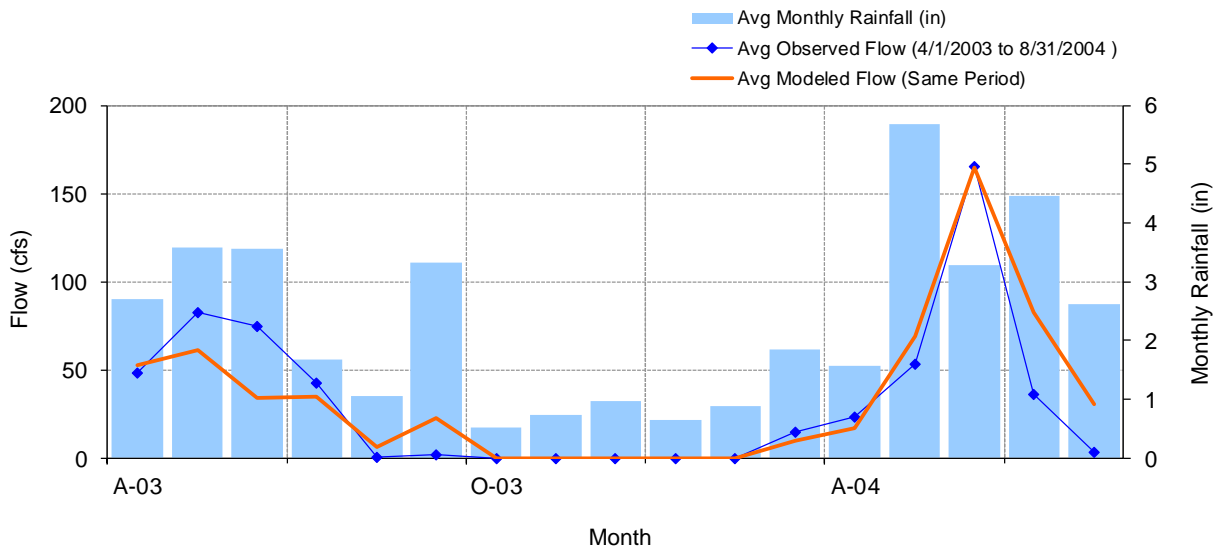


Figure 76. Mean monthly flow at Lime Creek near Lime Creek

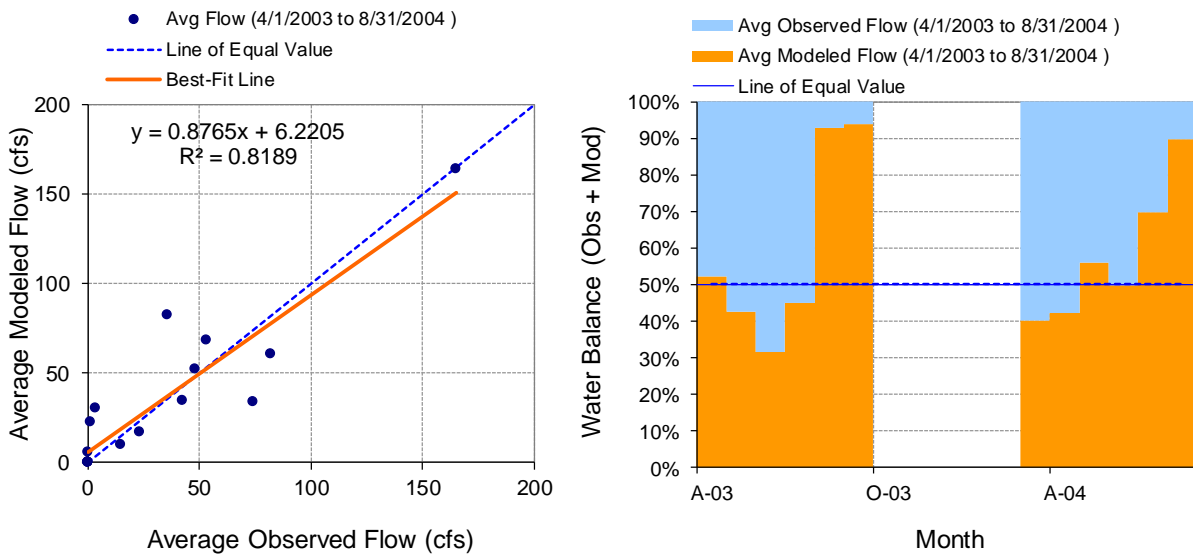


Figure 77. Monthly flow regression and temporal variation at Lime Creek near Lime Creek

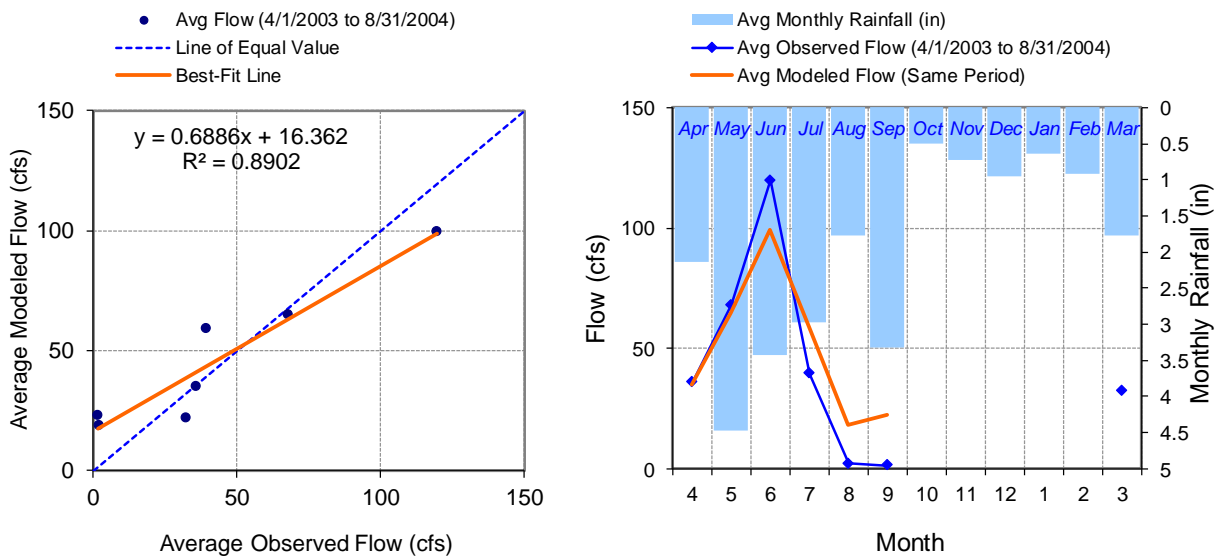


Figure 78. Seasonal regression and temporal aggregate at Lime Creek near Lime Creek

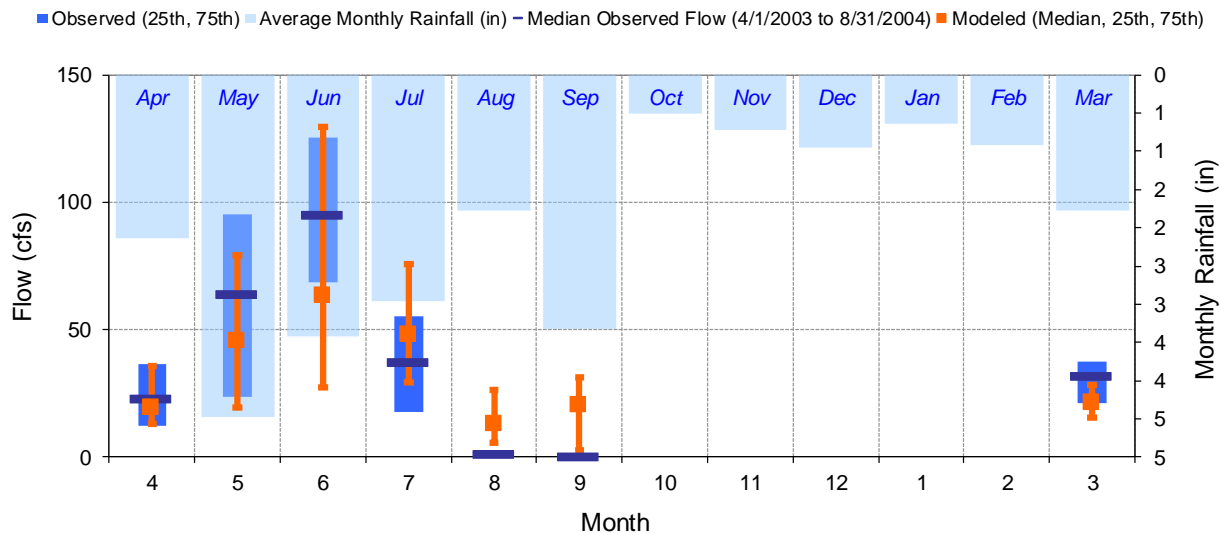


Figure 79. Seasonal medians and ranges at Lime Creek near Lime Creek

Table 6. Seasonal summary at Lime Creek near Lime Creek

MONTH	OBSERVED FLOW (CFS)				MODELED FLOW (CFS)			
	MEAN	MEDIAN	25TH	75TH	MEAN	MEDIAN	25TH	75TH
Apr	35.83	22.70	12.26	36.74	34.81	19.44	13.11	35.65
May	67.96	63.84	23.52	95.43	64.71	45.83	19.45	79.30
Jun	119.79	95.09	68.65	125.45	99.30	63.39	27.50	129.68
Jul	39.44	37.02	17.84	55.45	58.87	48.17	29.52	75.79
Aug	2.00	0.98	0.14	2.40	18.35	13.21	5.55	26.21
Sep	1.46	0.25	0.13	1.15	22.57	20.42	2.87	31.10
Oct	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nov	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dec	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	32.51	32.01	21.40	37.50	21.82	21.66	15.33	28.41

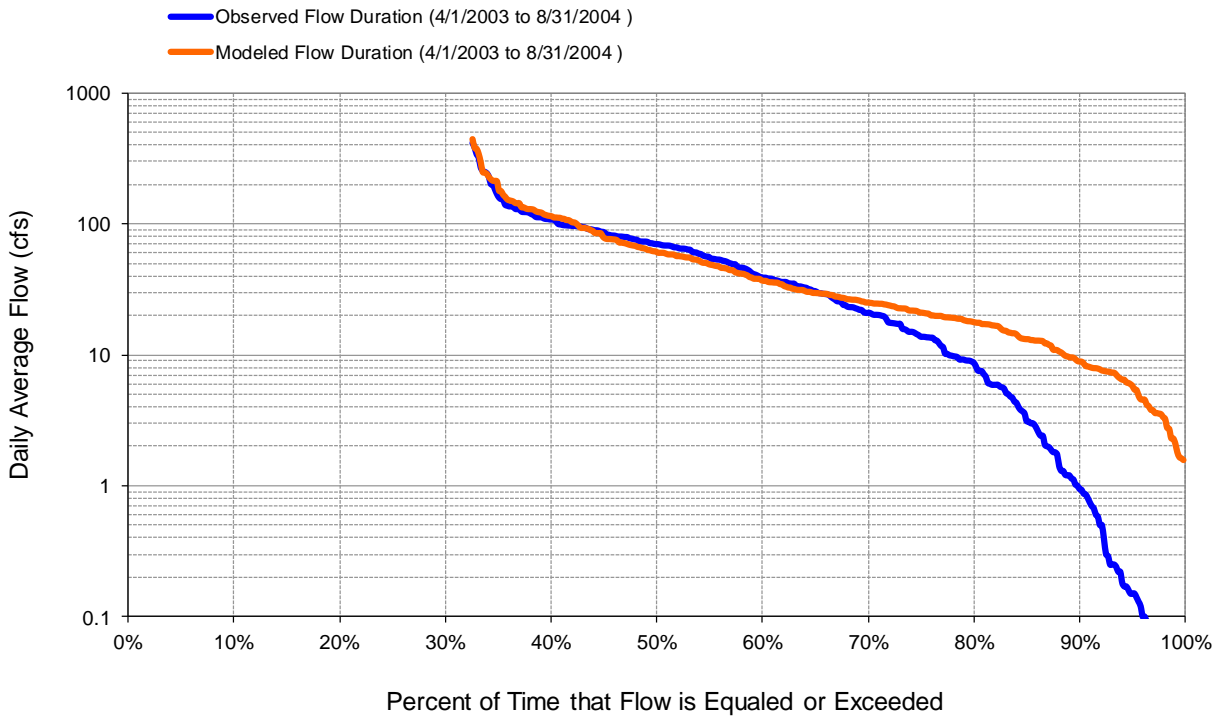


Figure 80. Flow exceedence at Lime Creek near Lime Creek

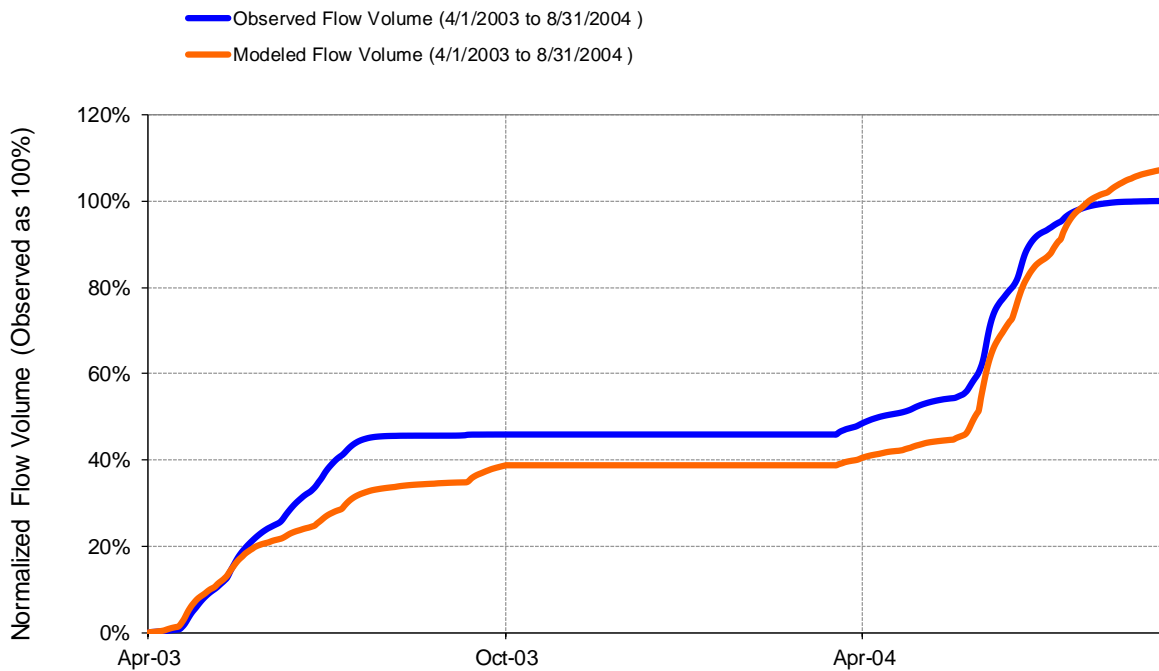


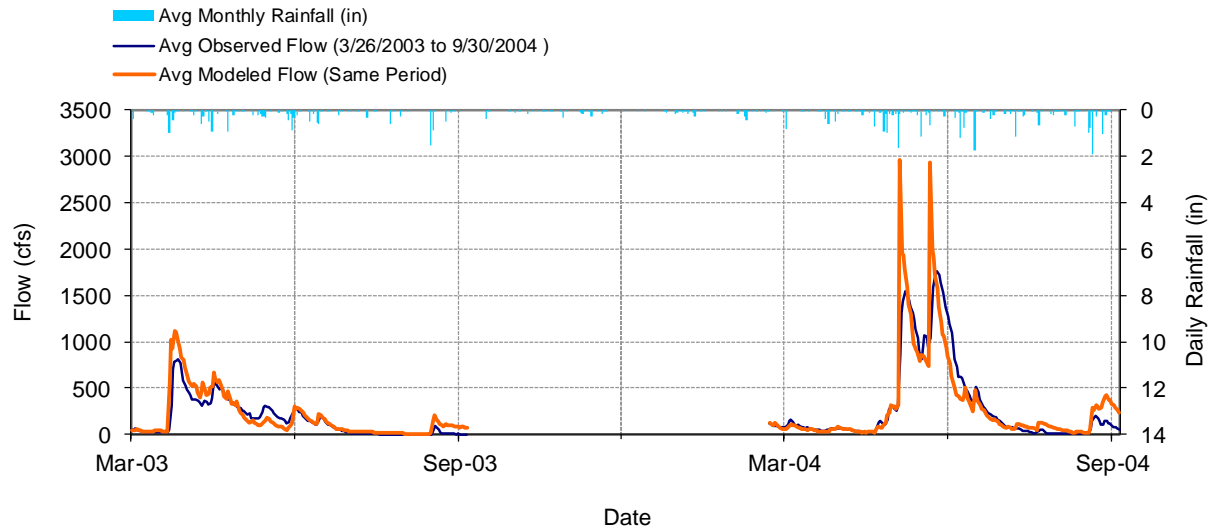
Figure 81. Flow accumulation at Lime Creek near Lime Creek

## WEST FORK DES MOINES RIVER NEAR AVOCA (HYDSTRA 51065001)

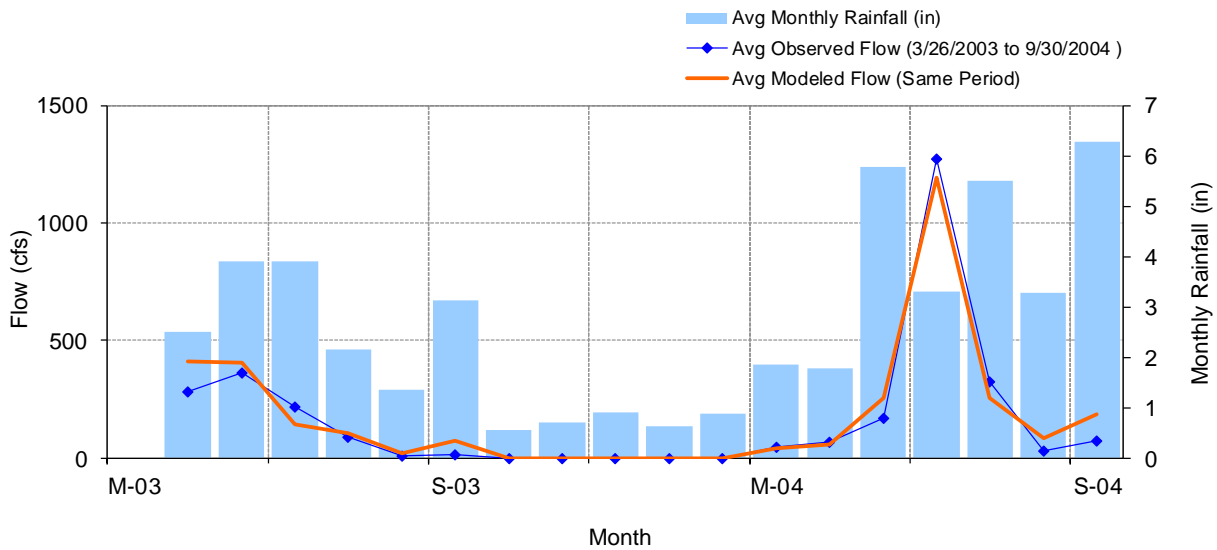
**Table 7. Summary statistics at West Fork Des Moines River near Avoca**

HSPF Simulated Flow		Observed Flow Gage	
<b>REACH OUTFLOW FROM DSN 3</b>  1.52-Year Analysis Period: 3/1/2003 - 9/30/2004 Flow volumes are (inches/year) for upstream drainage area		<b>West Fork Des Moines River near Avoca</b>  Manually Entered Data  Drainage Area (sq-mi): 356.7	
Total Simulated In-stream Flow:	<b>6.73</b>	Total Observed In-stream Flow:	<b>6.17</b>
Total of simulated highest 10% flows:	<b>3.35</b>	Total of Observed highest 10% flows:	<b>3.18</b>
Total of Simulated lowest 50% flows:	<b>0.62</b>	Total of Observed Lowest 50% flows:	<b>0.39</b>
Simulated Summer Flow Volume (months 7-9):	<b>1.50</b>	Observed Summer Flow Volume (7-9):	<b>1.13</b>
Simulated Fall Flow Volume (months 10-12):	<b>0.00</b>	Observed Fall Flow Volume (10-12):	<b>0.00</b>
Simulated Winter Flow Volume (months 1-3):	<b>0.11</b>	Observed Winter Flow Volume (1-3):	<b>0.12</b>
Simulated Spring Flow Volume (months 4-6):	<b>5.12</b>	Observed Spring Flow Volume (4-6):	<b>4.91</b>
Total Simulated Storm Volume:	<b>2.28</b>	Total Observed Storm Volume:	<b>1.68</b>
Simulated Summer Storm Volume (7-9):	<b>0.41</b>	Observed Summer Storm Volume (7-9):	<b>0.32</b>
<i>Errors (Simulated-Observed)</i>	<i>Error Statistics</i>	<i>Recommended Criteria</i>	
Error in total volume:	9.14	10	
Error in 50% lowest flows:	57.11	10	
Error in 10% highest flows:	5.48	15	
Seasonal volume error - Summer:	32.45	30	
Seasonal volume error - Fall:	0.00	30	Clear
Seasonal volume error - Winter:	-9.53	30	
Seasonal volume error - Spring:	4.21	30	
Error in storm volumes:	35.71	20	
Error in summer storm volumes:	28.30	50	
Nash-Sutcliffe Coefficient of Efficiency, E:	0.704	Model accuracy increases	
Baseline adjusted coefficient (Garrick), E':	0.653		
Monthly NSE	0.958		

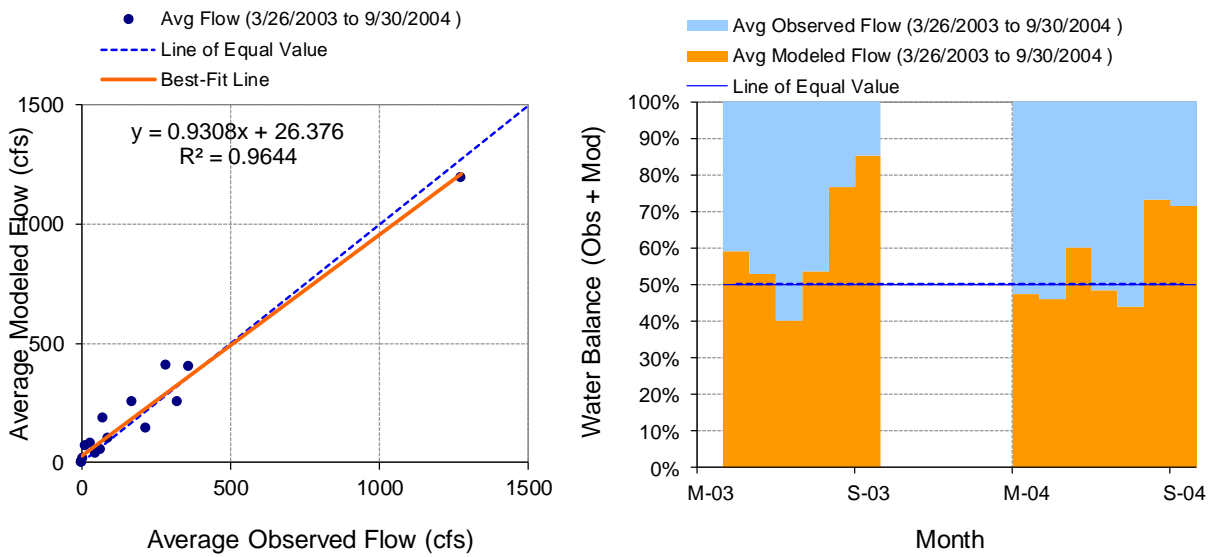




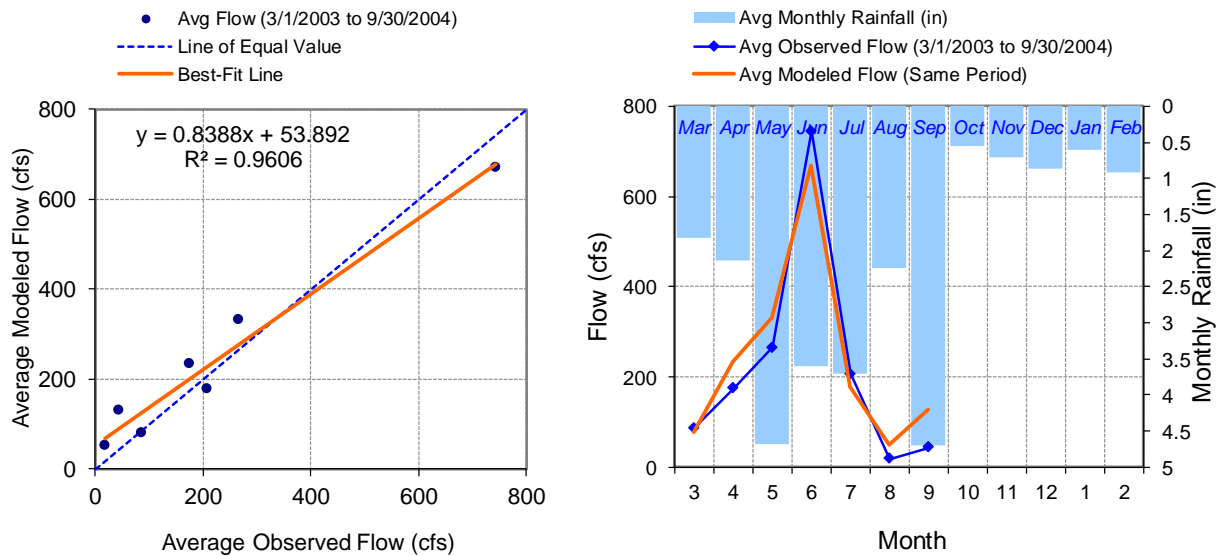
**Figure 82. Mean daily flow at West Fork Des Moines River near Avoca**



**Figure 83. Mean monthly flow at West Fork Des Moines River near Avoca**



**Figure 84. Monthly flow regression and temporal variation at West Fork Des Moines River near Avoca**



**Figure 85. Seasonal regression and temporal aggregate at West Fork Des Moines River near Avoca**

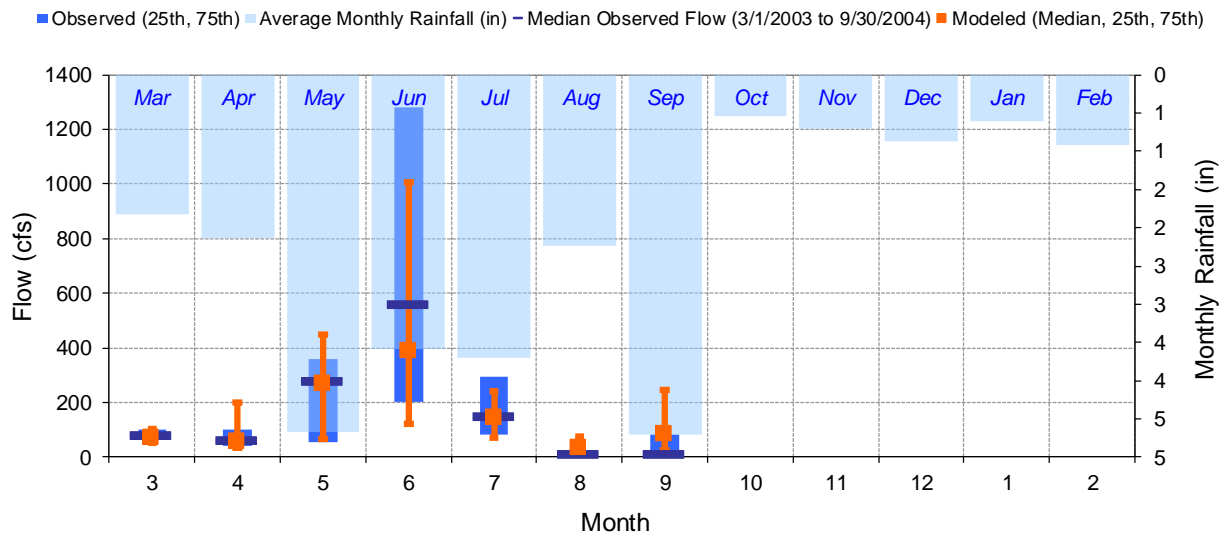


Figure 86. Seasonal medians and ranges at West Fork Des Moines River near Avoca

Table 8. Seasonal summary at West Fork Des Moines River near Avoca

MONTH	OBSERVED FLOW (CFS)				MODELED FLOW (CFS)			
	MEAN	MEDIAN	25TH	75TH	MEAN	MEDIAN	25TH	75TH
Mar	86.24	79.42	63.20	100.43	78.02	71.93	51.52	104.78
Apr	174.60	63.76	38.98	102.27	233.41	55.52	32.49	201.61
May	265.21	276.97	55.45	358.75	330.18	267.12	64.16	447.08
Jun	744.82	559.89	203.00	1281.94	669.14	387.47	123.36	1005.47
Jul	206.64	147.76	81.59	295.21	178.05	147.10	72.77	241.66
Aug	17.89	9.67	3.65	18.96	50.15	35.84	17.54	77.65
Sep	43.54	11.22	3.80	80.58	129.15	83.49	23.80	244.92
Oct	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nov	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dec	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

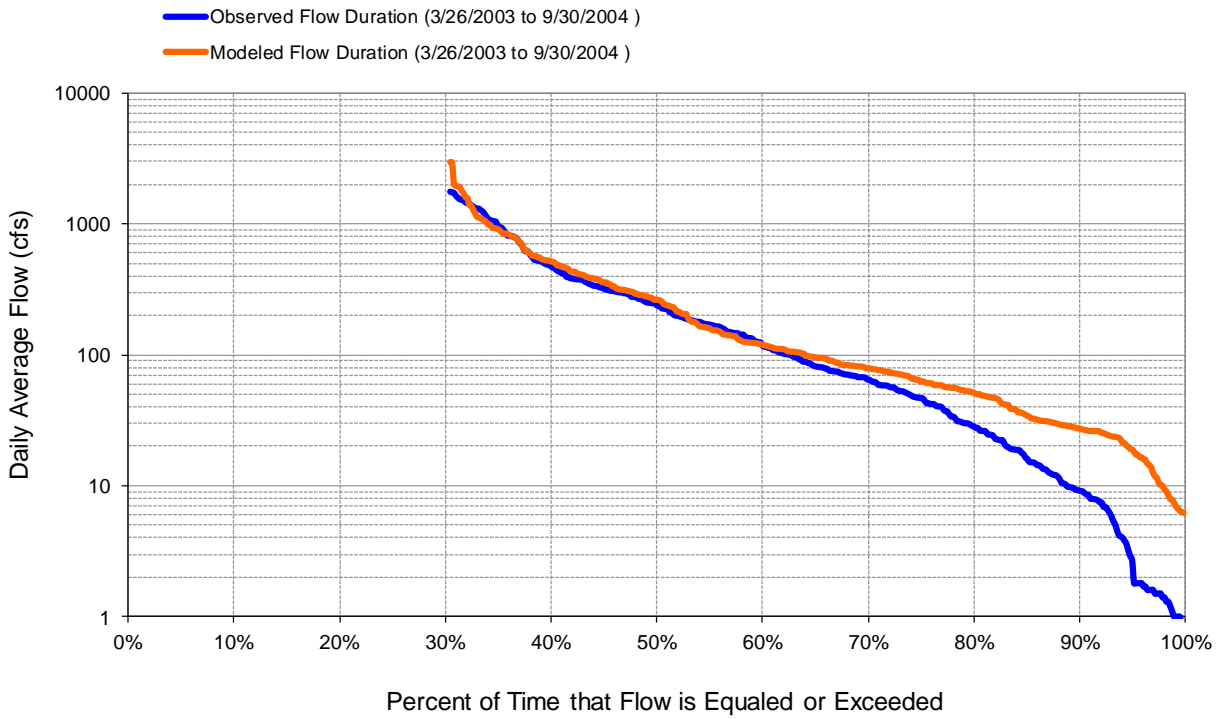


Figure 87. Flow exceedence at West Fork Des Moines River near Avoca

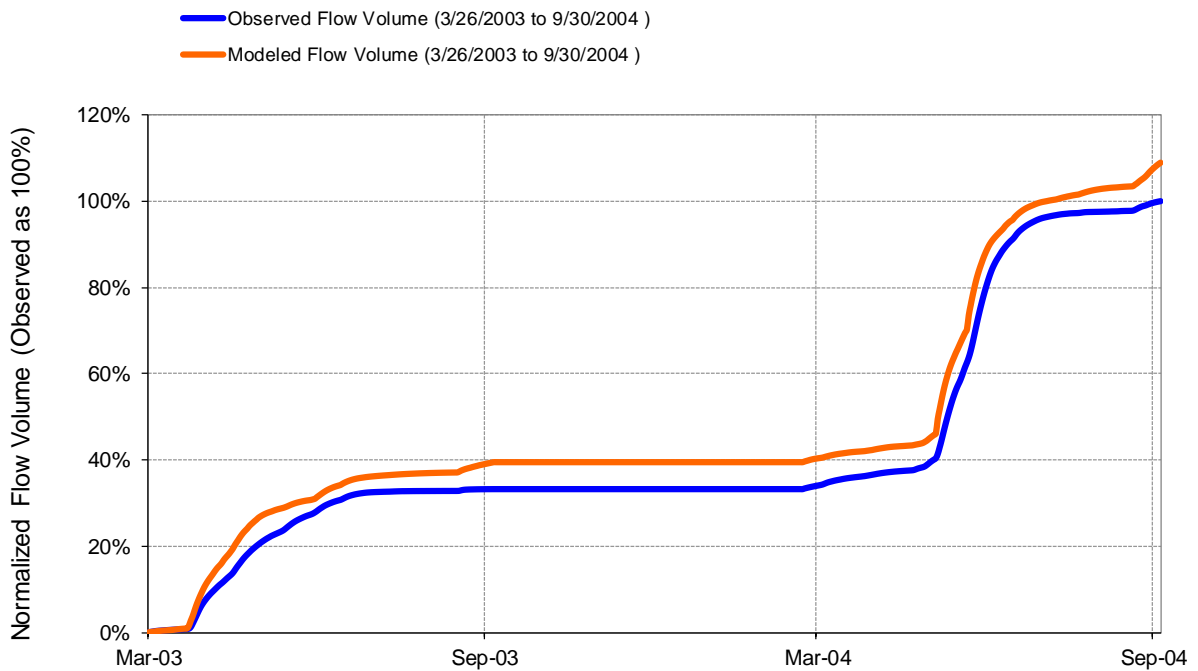


Figure 88. Flow accumulation at West Fork Des Moines River near Avoca

# WEST FORK DES MOINES RIVER NEAR HERON LAKE (HYDSTRA 51021001)

**Table 9. Summary statistics at West Fork Des Moines River near Heron Lake**

HSPF Simulated Flow		Observed Flow Gage	
<b>REACH OUTFLOW FROM DSN 6</b>  1.52-Year Analysis Period: 3/1/2003 - 9/30/2004 Flow volumes are (inches/year) for upstream drainage area		<b>West Fork Des Moines River near Heron Lake</b>  Manually Entered Data  Drainage Area (sq-mi): 556.6	
Total Simulated In-stream Flow:	<b>6.05</b>	Total Observed In-stream Flow:	<b>5.18</b>
Total of simulated highest 10% flows:	<b>2.51</b>	Total of Observed highest 10% flows:	<b>2.31</b>
Total of Simulated lowest 50% flows:	<b>0.81</b>	Total of Observed Lowest 50% flows:	<b>0.40</b>
Simulated Summer Flow Volume (months 7-9):	<b>1.75</b>	Observed Summer Flow Volume (7-9):	<b>1.26</b>
Simulated Fall Flow Volume (months 10-12):	<b>0.00</b>	Observed Fall Flow Volume (10-12):	<b>0.00</b>
Simulated Winter Flow Volume (months 1-3):	<b>0.13</b>	Observed Winter Flow Volume (1-3):	<b>0.12</b>
Simulated Spring Flow Volume (months 4-6):	<b>4.17</b>	Observed Spring Flow Volume (4-6):	<b>3.79</b>
Total Simulated Storm Volume:	<b>1.32</b>	Total Observed Storm Volume:	<b>1.22</b>
Simulated Summer Storm Volume (7-9):	<b>0.30</b>	Observed Summer Storm Volume (7-9):	<b>0.29</b>
<i>Errors (Simulated-Observed)</i>	<i>Error Statistics</i>	<i>Recommended Criteria</i>	
Error in total volume:	16.85	10	
Error in 50% lowest flows:	100.72	10	
Error in 10% highest flows:	9.00	15	
Seasonal volume error - Summer:	38.20	30	
Seasonal volume error - Fall:	0.00	30	
Seasonal volume error - Winter:	3.00	30	Clear
Seasonal volume error - Spring:	10.18	30	
Error in storm volumes:	7.77	20	
Error in summer storm volumes:	3.21	50	
Nash-Sutcliffe Coefficient of Efficiency, E':	0.835	Model accuracy increases	
Baseline adjusted coefficient (Garrick), E'':	0.658		
Monthly NSE	0.949		

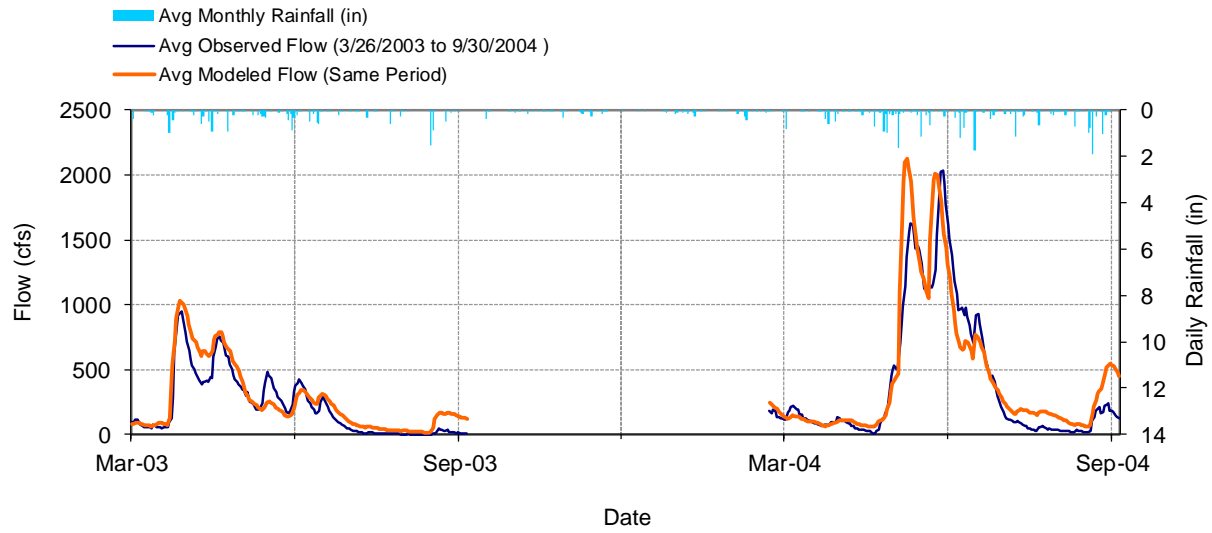


Figure 89. Mean daily flow at West Fork Des Moines River near Heron Lake

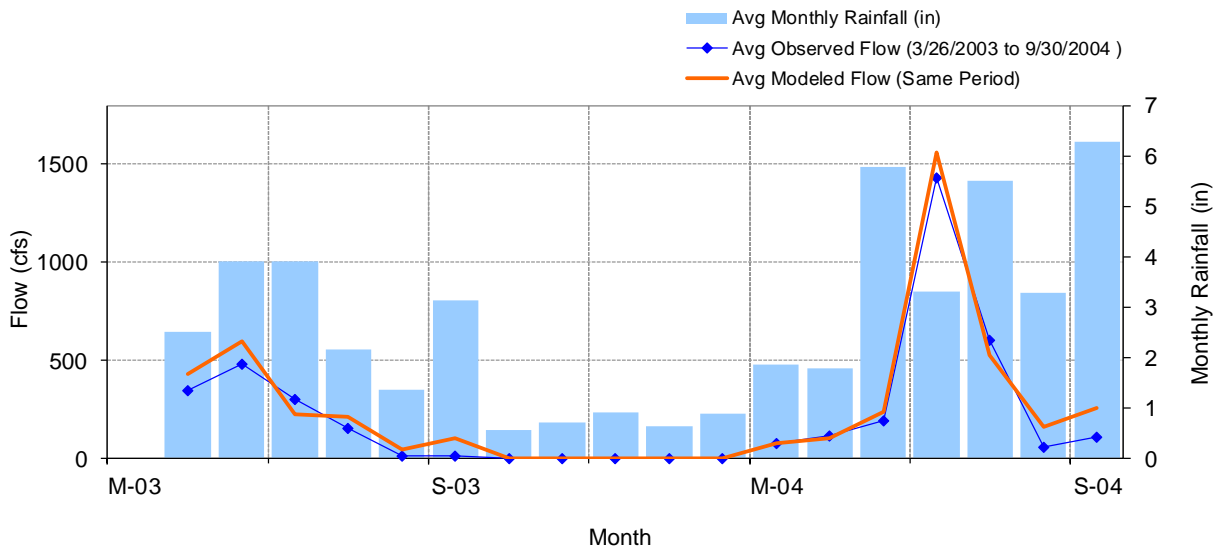
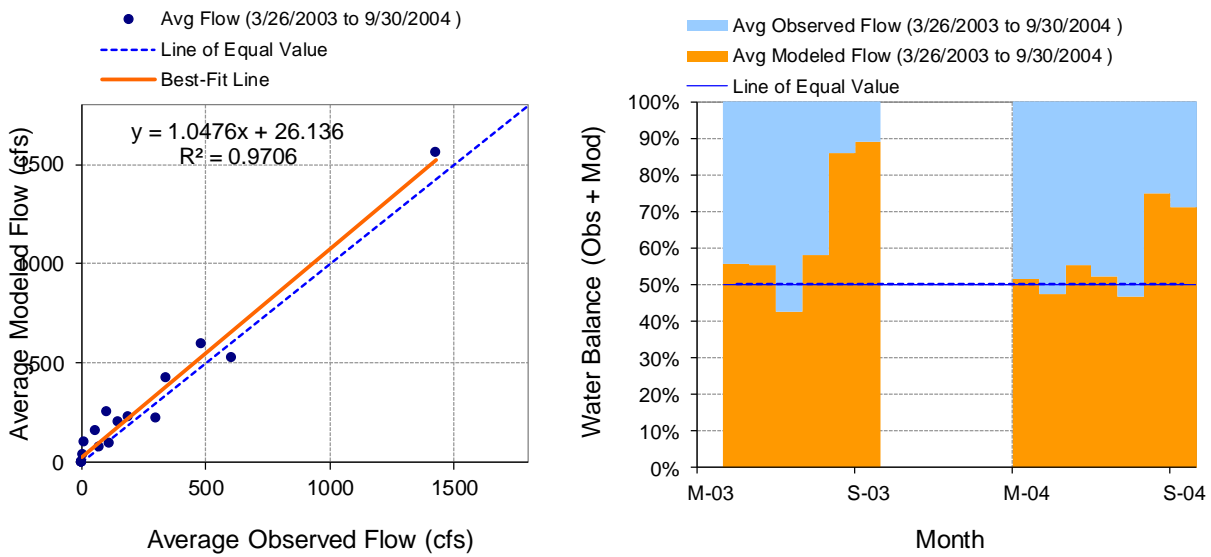
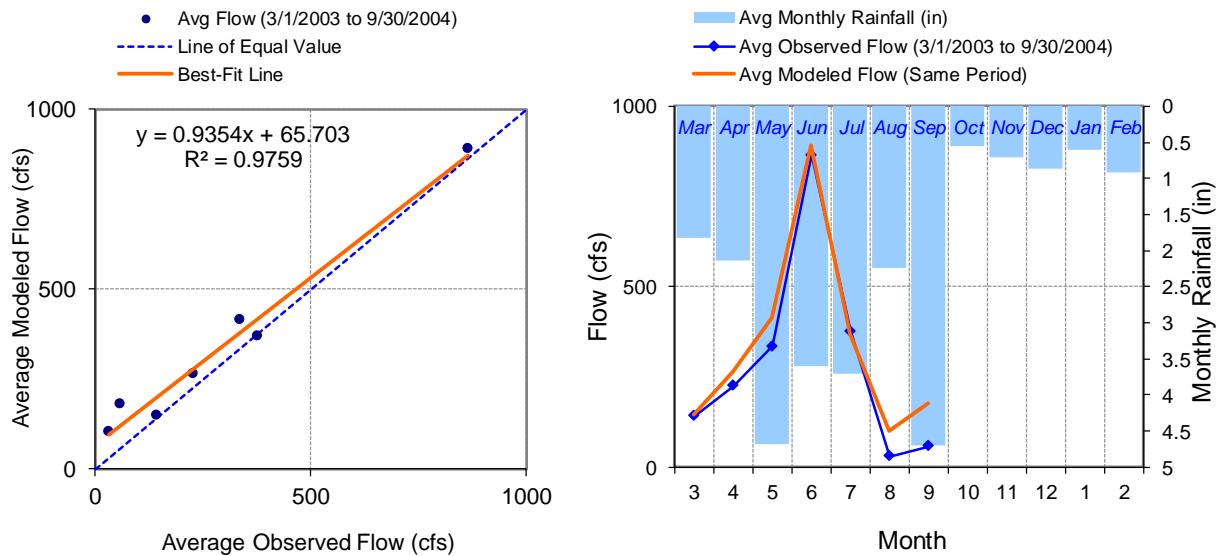


Figure 90. Mean monthly flow at West Fork Des Moines River near Heron Lake



**Figure 91. Monthly flow regression and temporal variation at West Fork Des Moines River near Heron Lake**



**Figure 92. Seasonal regression and temporal aggregate at West Fork Des Moines River near Heron Lake**

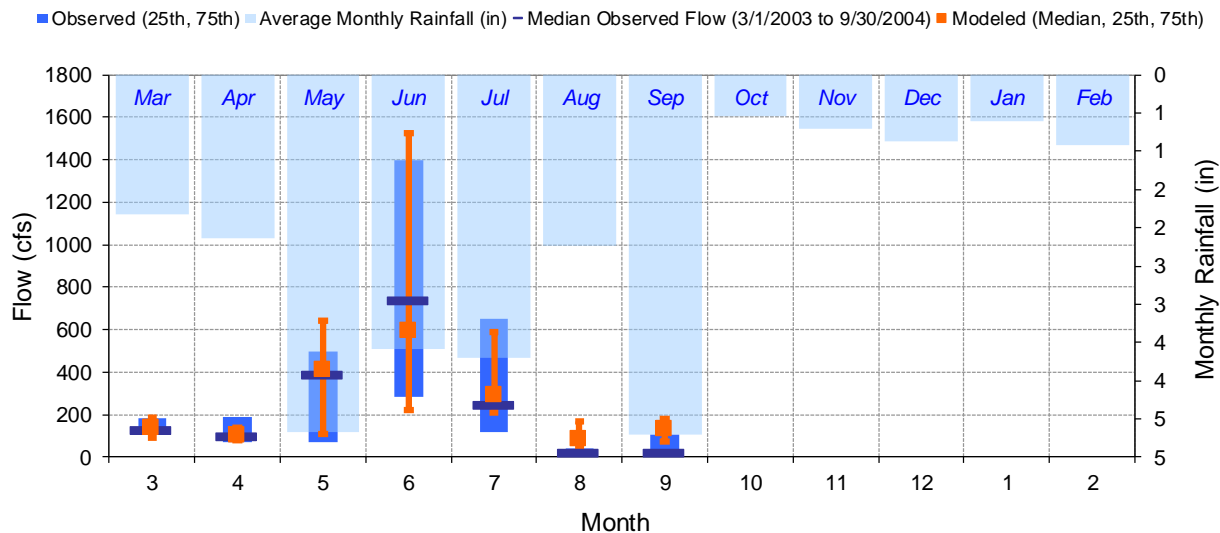


Figure 93. Seasonal medians and ranges at West Fork Des Moines River near Heron Lake

Table 10. Seasonal summary at West Fork Des Moines River near Heron Lake

MONTH	OBSERVED FLOW (CFS)				MODELED FLOW (CFS)			
	MEAN	MEDIAN	25TH	75TH	MEAN	MEDIAN	25TH	75TH
Mar	141.58	126.90	111.50	181.55	145.83	139.28	89.73	184.22
Apr	225.75	98.84	68.93	188.84	263.17	101.07	78.76	140.56
May	334.46	387.50	72.67	498.84	413.97	412.53	106.72	640.81
Jun	863.85	735.62	285.75	1396.05	890.35	598.02	221.65	1524.16
Jul	376.96	245.52	120.72	654.06	367.18	295.34	207.30	586.37
Aug	30.32	21.62	5.45	42.97	100.87	84.57	36.59	167.74
Sep	58.54	21.19	9.00	106.78	178.84	135.14	72.24	178.51
Oct	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nov	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dec	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00



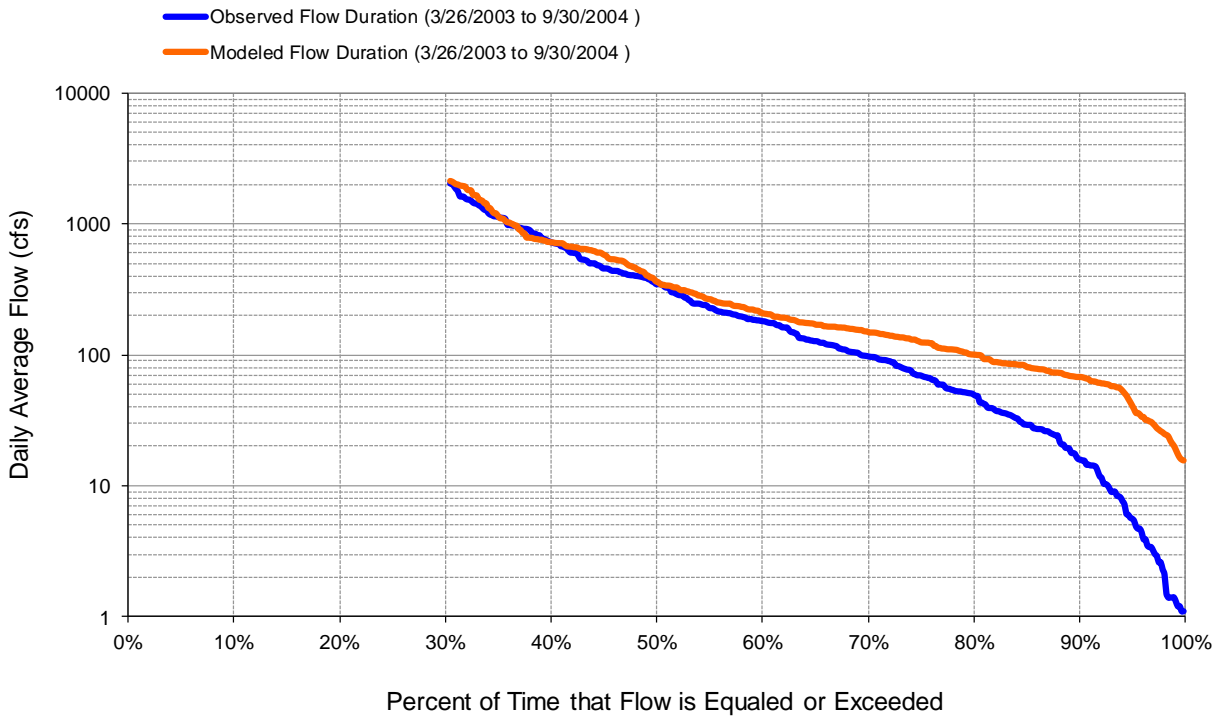


Figure 94. Flow exceedence at West Fork Des Moines River near Heron Lake

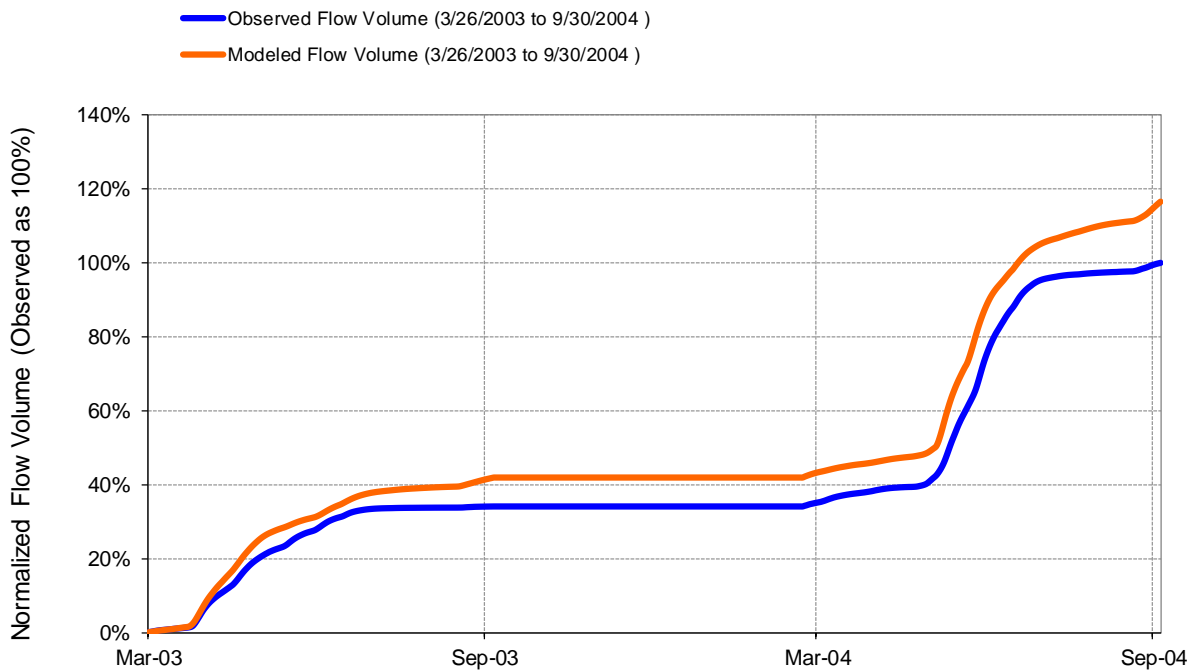


Figure 95. Flow accumulation at West Fork Des Moines River near Heron Lake

## JACK CREEK NEAR HERON LAKE (HYDSTRA 51092001)

Table 11. Summary statistics at Jack Creek near Heron Lake

HSPF Simulated Flow		Observed Flow Gage	
<b>REACH OUTFLOW FROM DSN 8</b>  10-Year Analysis Period: 10/1/2004 - 9/30/2014 Flow volumes are (inches/year) for upstream drainage area		<b>Jack Creek near Heron Lake</b>  Manually Entered Data  Drainage Area (sq-mi): 204.3	
Total Simulated In-stream Flow:	<b>5.53</b>	Total Observed In-stream Flow:	<b>5.64</b>
Total of simulated highest 10% flows:	<b>2.49</b>	Total of Observed highest 10% flows:	<b>2.56</b>
Total of Simulated lowest 50% flows:	<b>0.52</b>	Total of Observed Lowest 50% flows:	<b>0.35</b>
Simulated Summer Flow Volume (months 7-9):	<b>1.39</b>	Observed Summer Flow Volume (7-9):	<b>1.10</b>
Simulated Fall Flow Volume (months 10-12):	<b>0.51</b>	Observed Fall Flow Volume (10-12):	<b>0.53</b>
Simulated Winter Flow Volume (months 1-3):	<b>0.44</b>	Observed Winter Flow Volume (1-3):	<b>0.54</b>
Simulated Spring Flow Volume (months 4-6):	<b>3.19</b>	Observed Spring Flow Volume (4-6):	<b>3.48</b>
Total Simulated Storm Volume:	<b>1.51</b>	Total Observed Storm Volume:	<b>1.22</b>
Simulated Summer Storm Volume (7-9):	<b>0.42</b>	Observed Summer Storm Volume (7-9):	<b>0.29</b>
<i>Errors (Simulated-Observed)</i>	<i>Error Statistics</i>	<i>Recommended Criteria</i>	
Error in total volume:	-2.00	10	
Error in 50% lowest flows:	48.67	10	
Error in 10% highest flows:	-2.61	15	
Seasonal volume error - Summer:	26.87	30	
Seasonal volume error - Fall:	-3.79	30	Clear
Seasonal volume error - Winter:	-18.08	30	
Seasonal volume error - Spring:	-8.36	30	
Error in storm volumes:	23.89	20	
Error in summer storm volumes:	47.80	50	
Nash-Sutcliffe Coefficient of Efficiency, E:	0.673	Model accuracy increases	
Baseline adjusted coefficient (Garrick), E':	0.573		
Monthly NSE	0.799		

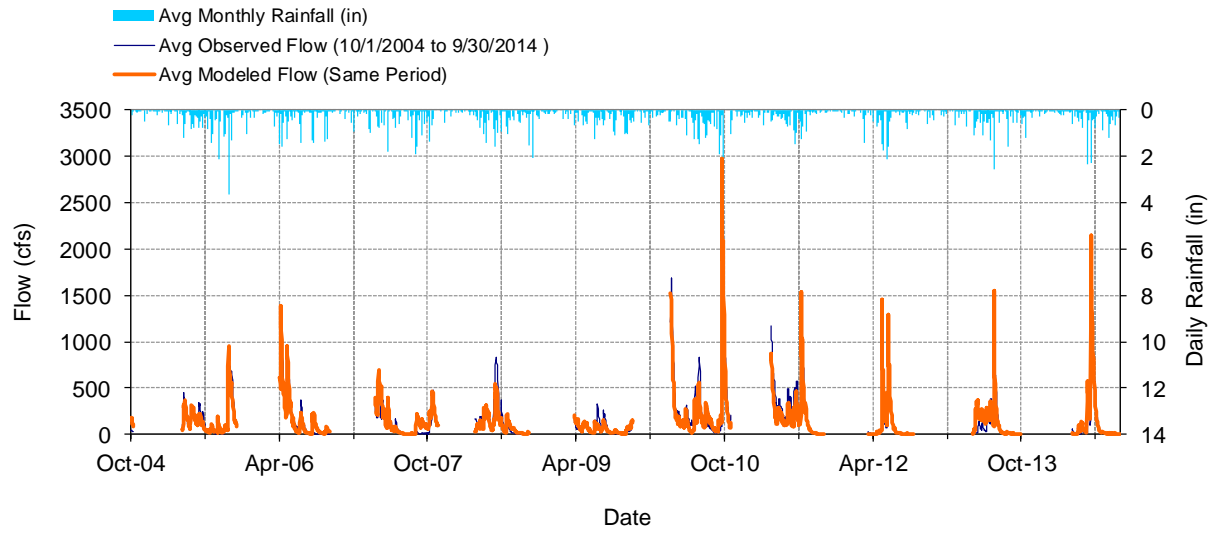


Figure 96. Mean daily flow at Jack Creek near Heron Lake

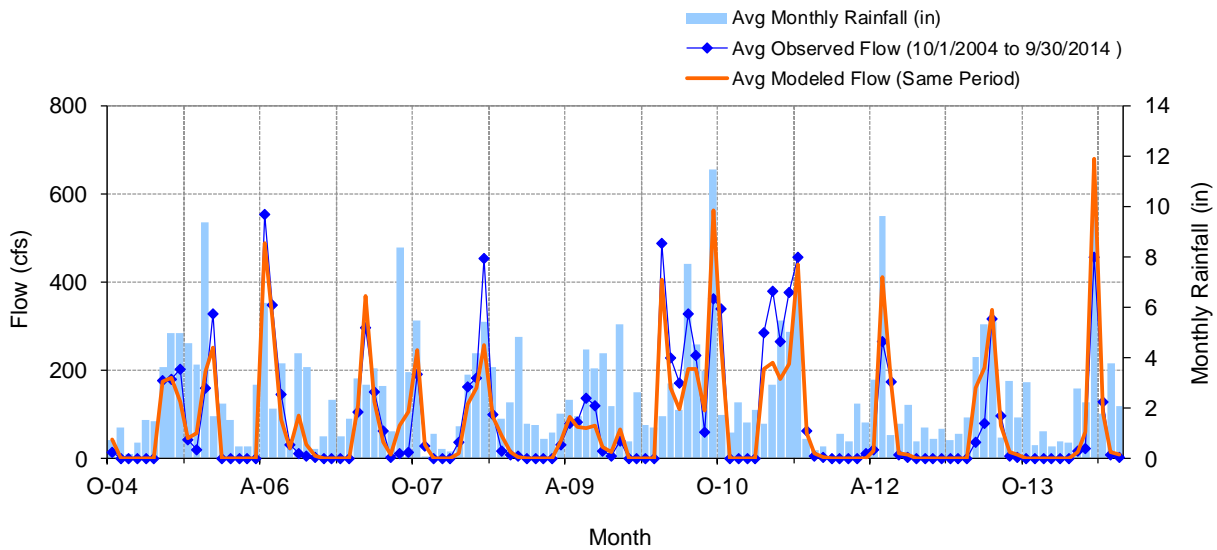


Figure 97. Mean monthly flow at Jack Creek near Heron Lake

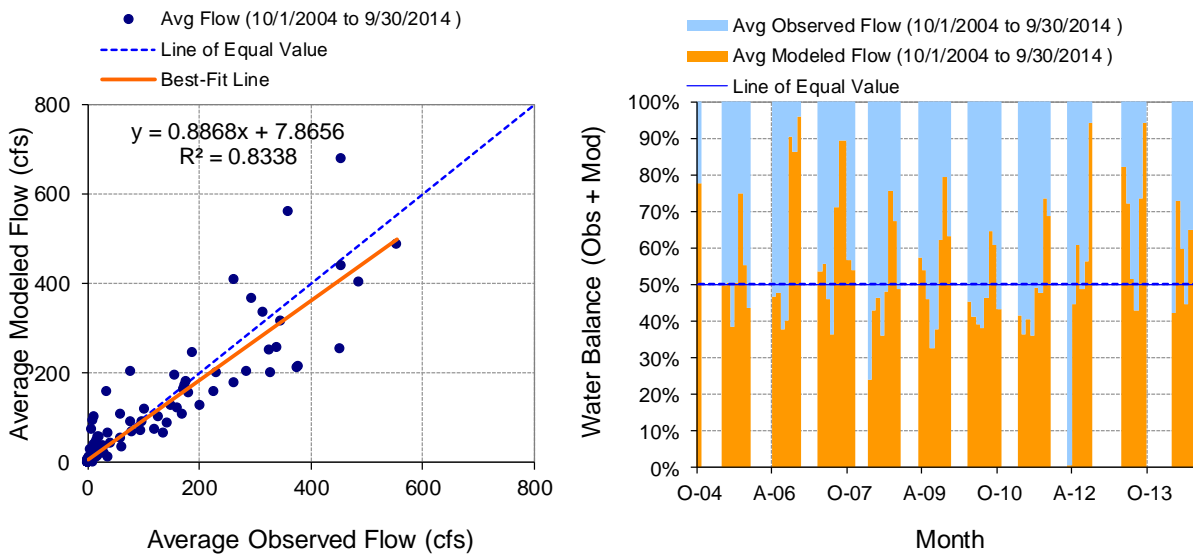


Figure 98. Monthly flow regression and temporal variation at Jack Creek near Heron Lake

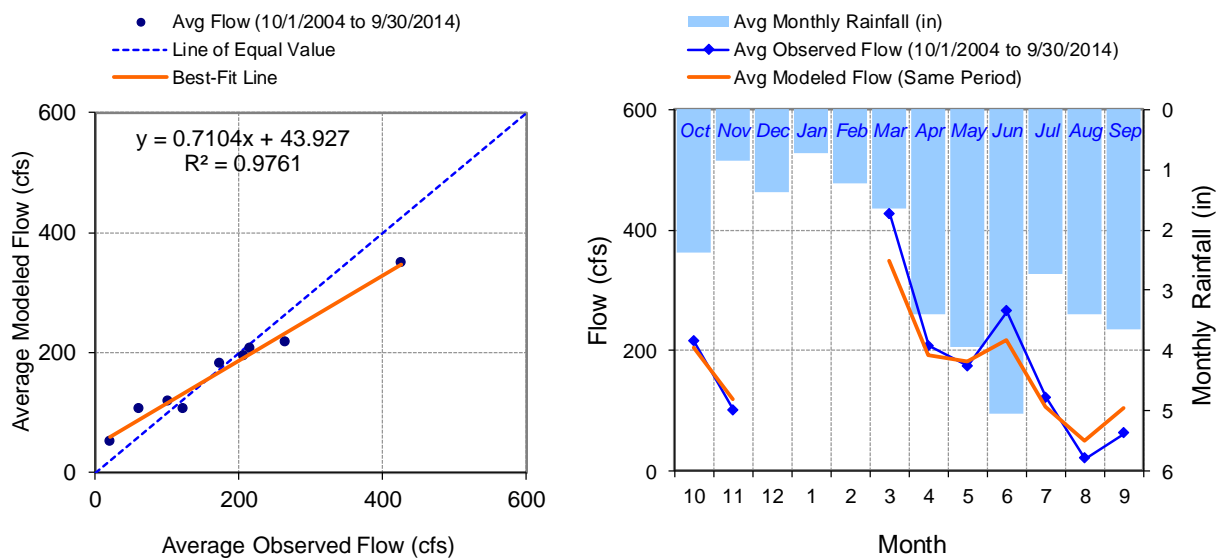


Figure 99. Seasonal regression and temporal aggregate at Jack Creek near Heron Lake

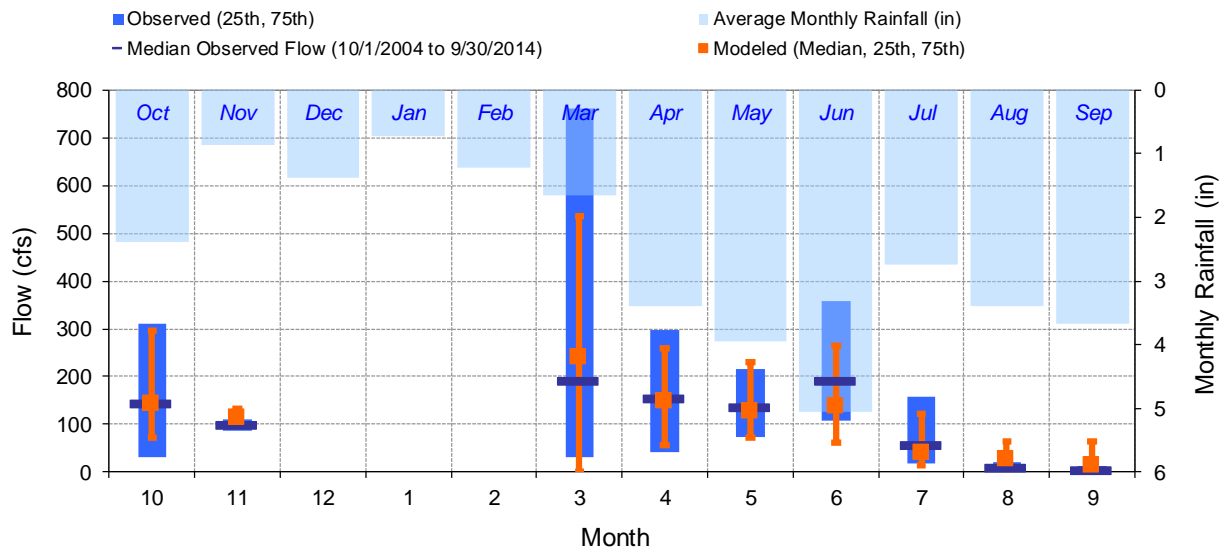


Figure 100. Seasonal medians and ranges at Jack Creek near Heron Lake

Table 12. Seasonal summary at Jack Creek near Heron Lake

MONTH	OBSERVED FLOW (CFS)				MODELED FLOW (CFS)			
	MEAN	MEDIAN	25TH	75TH	MEAN	MEDIAN	25TH	75TH
Oct	214.86	143.35	30.11	310.06	205.41	144.49	72.60	296.76
Nov	100.32	98.89	87.44	109.64	118.09	114.65	104.11	131.68
Dec	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	426.38	191.00	31.00	760.00	349.29	240.45	1.01	534.95
Apr	206.70	154.00	41.00	297.72	192.49	149.51	55.23	259.67
May	173.33	134.64	73.58	214.75	181.10	128.69	70.94	229.43
Jun	264.62	189.50	108.47	357.78	216.60	137.37	60.43	265.03
Jul	121.34	56.90	17.00	156.92	106.23	41.42	15.23	121.28
Aug	20.28	10.00	4.51	21.00	50.05	27.60	11.57	64.81
Sep	61.35	4.27	1.90	12.00	104.97	14.09	8.77	64.76

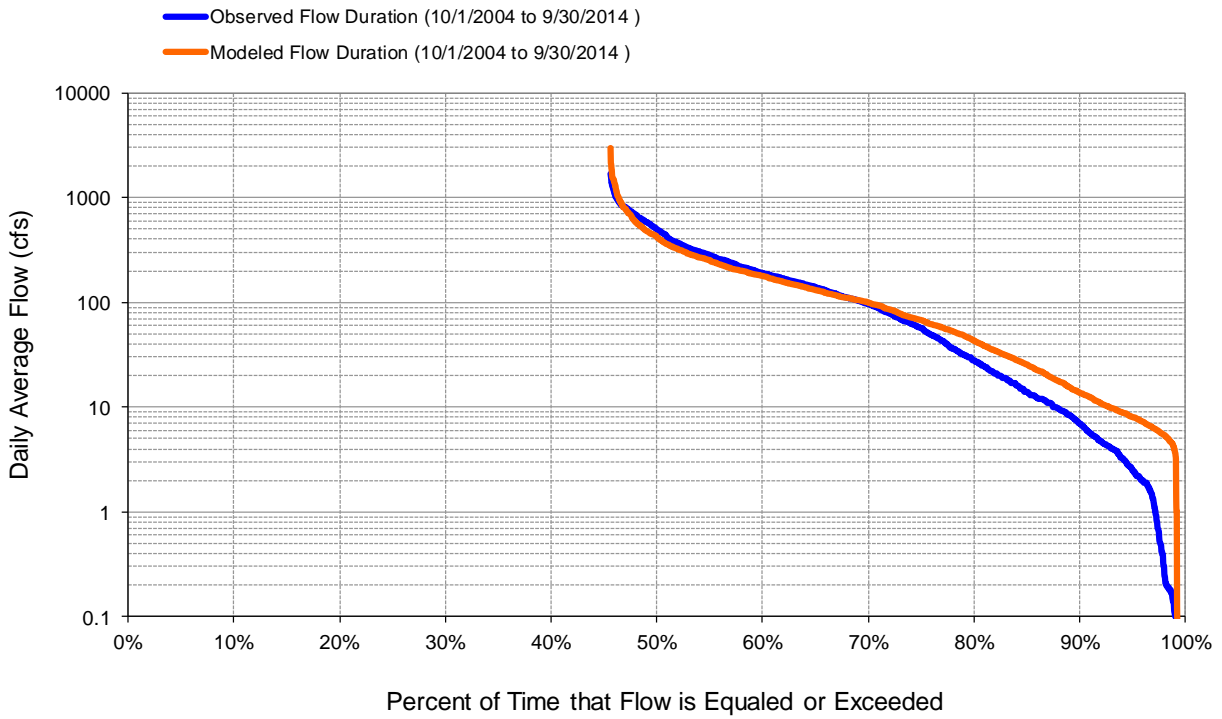


Figure 101. Flow exceedence at Jack Creek near Heron Lake

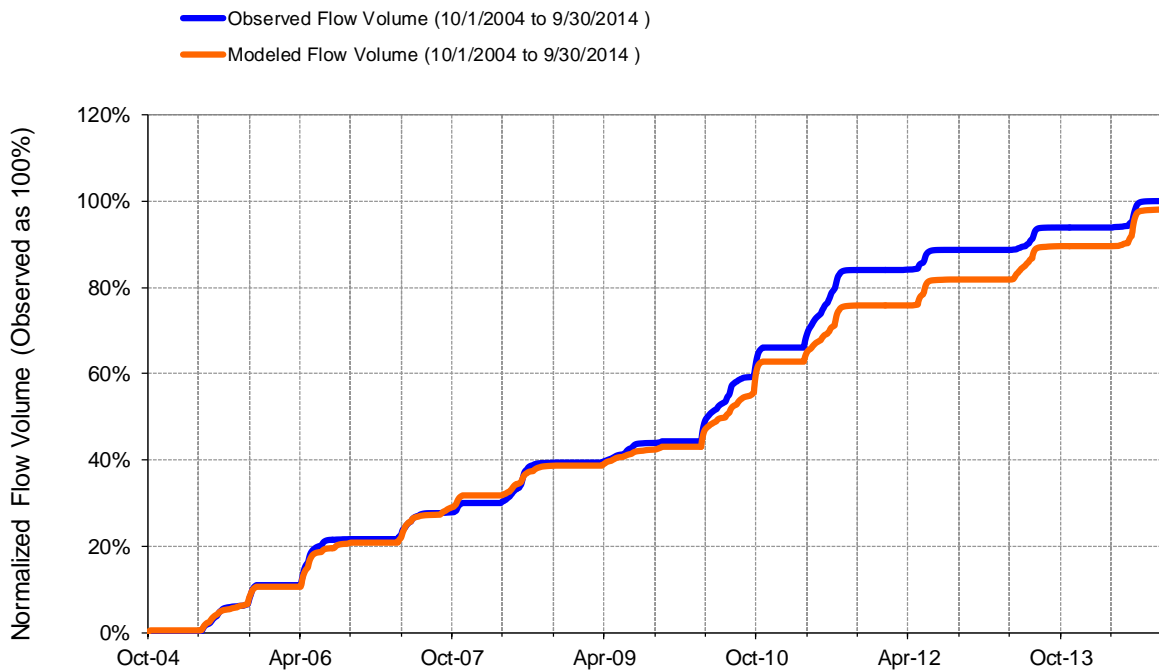


Figure 102. Flow accumulation at Jack Creek near Heron Lake

## OKABENA CREEK NEAR OKABENA (HYDSTRA 51093001)

Table 13. Summary statistics at Okabena Creek near Okabena

HSPF Simulated Flow		Observed Flow Gage	
<b>REACH OUTFLOW FROM DSN 7</b>  10-Year Analysis Period: 10/1/2004 - 9/30/2014 Flow volumes are (inches/year) for upstream drainage area		<b>Okabena Creek near Okabena</b>  Manually Entered Data  Drainage Area (sq-mi): 133.1	
Total Simulated In-stream Flow:	<b>8.26</b>	Total Observed In-stream Flow:	<b>8.37</b>
Total of simulated highest 10% flows:	<b>3.89</b>	Total of Observed highest 10% flows:	<b>4.59</b>
Total of Simulated lowest 50% flows:	<b>0.77</b>	Total of Observed Lowest 50% flows:	<b>0.51</b>
Simulated Summer Flow Volume (months 7-9):	<b>2.59</b>	Observed Summer Flow Volume (7-9):	<b>2.08</b>
Simulated Fall Flow Volume (months 10-12):	<b>0.58</b>	Observed Fall Flow Volume (10-12):	<b>0.78</b>
Simulated Winter Flow Volume (months 1-3):	<b>0.37</b>	Observed Winter Flow Volume (1-3):	<b>0.54</b>
Simulated Spring Flow Volume (months 4-6):	<b>4.73</b>	Observed Spring Flow Volume (4-6):	<b>4.97</b>
Total Simulated Storm Volume:	<b>3.35</b>	Total Observed Storm Volume:	<b>3.23</b>
Simulated Summer Storm Volume (7-9):	<b>1.12</b>	Observed Summer Storm Volume (7-9):	<b>0.93</b>
<i>Errors (Simulated-Observed)</i>	<i>Error Statistics</i>	<i>Recommended Criteria</i>	
Error in total volume:	-1.29	10	
Error in 50% lowest flows:	50.41	10	
Error in 10% highest flows:	-15.40	15	
Seasonal volume error - Summer:	24.22	30	
Seasonal volume error - Fall:	-25.79	30	Clear
Seasonal volume error - Winter:	-31.98	30	
Seasonal volume error - Spring:	-4.82	30	
Error in storm volumes:	3.72	20	
Error in summer storm volumes:	21.03	50	
Nash-Sutcliffe Coefficient of Efficiency, E:	0.712	Model accuracy increases	
Baseline adjusted coefficient (Garrick), E':	0.505		
Monthly NSE	0.812		

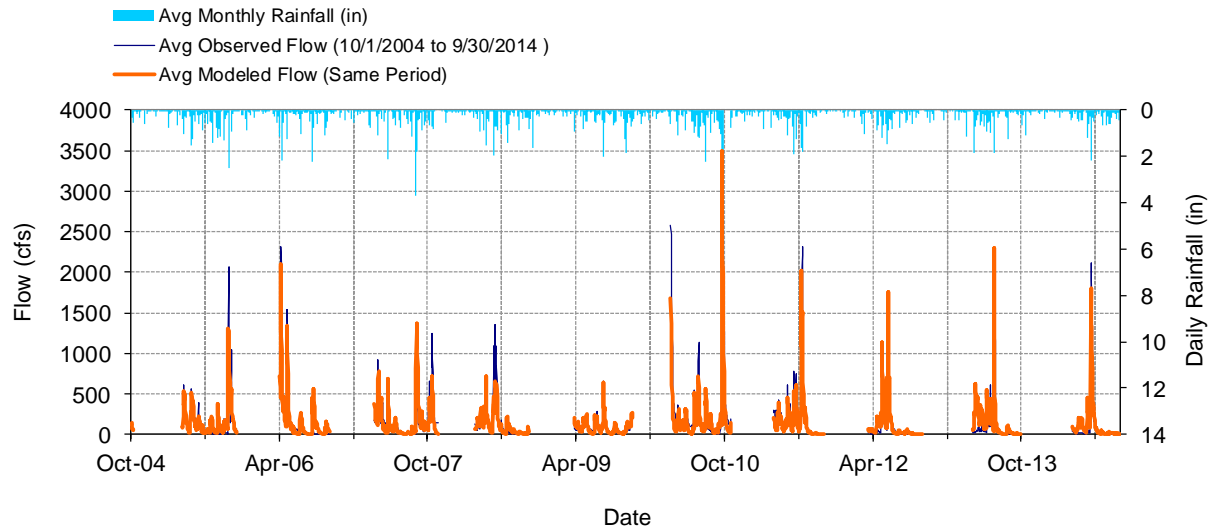


Figure 103. Mean daily flow at Okabena Creek near Okabena

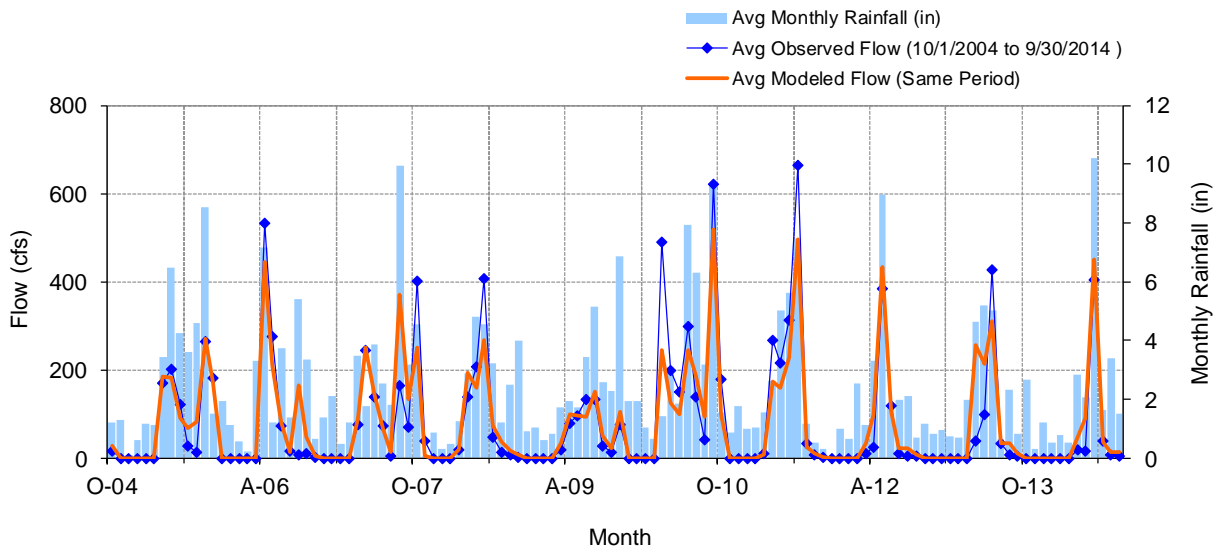


Figure 104. Mean monthly flow at Okabena Creek near Okabena



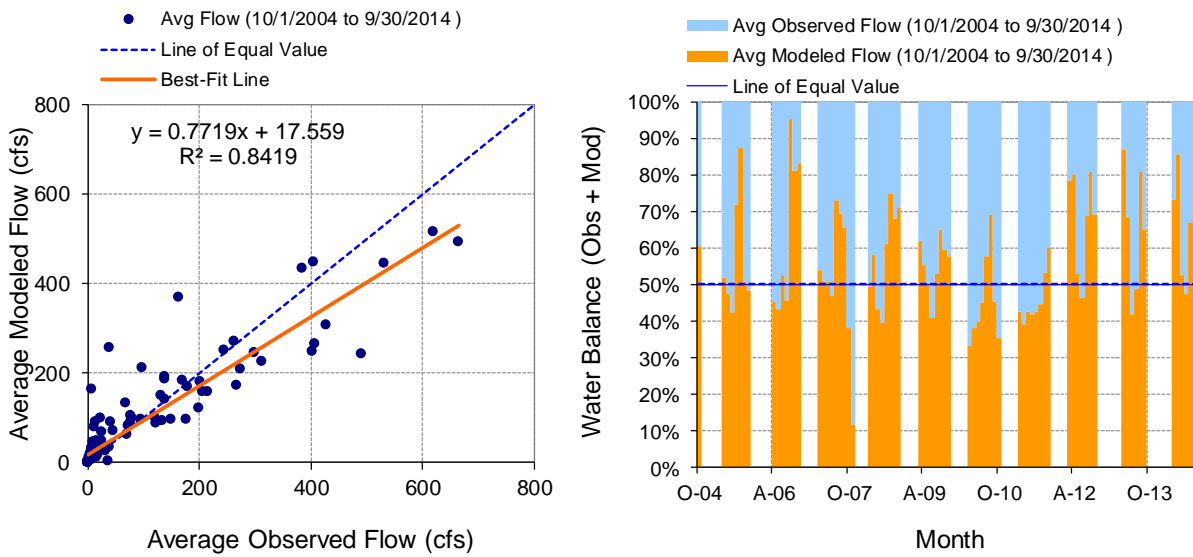


Figure 105. Monthly flow regression and temporal variation at Okabena Creek near Okabena

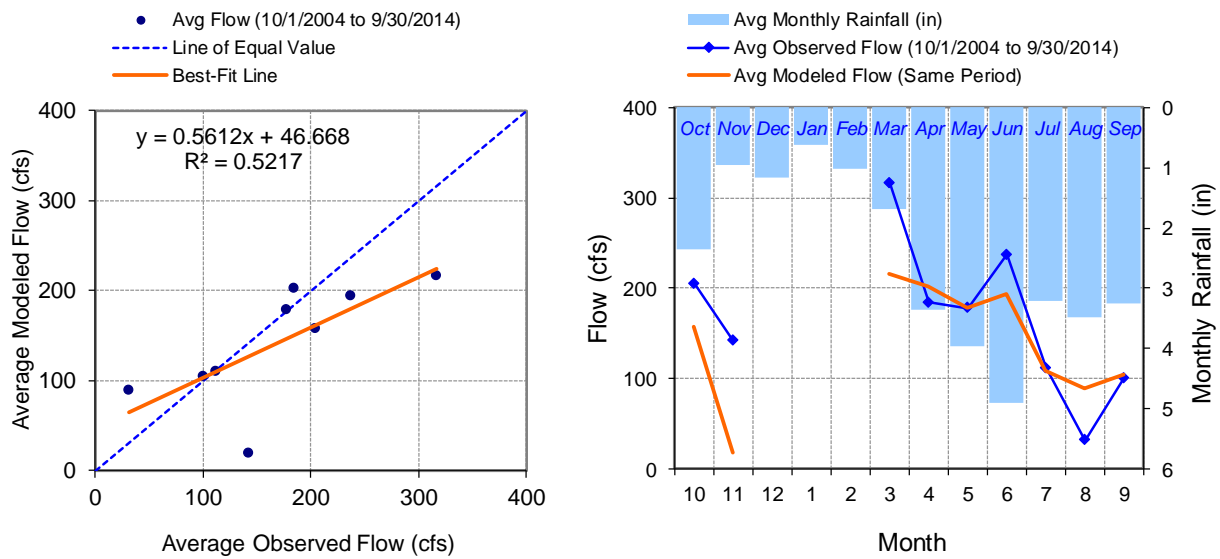


Figure 106. Seasonal regression and temporal aggregate at Okabena Creek near Okabena

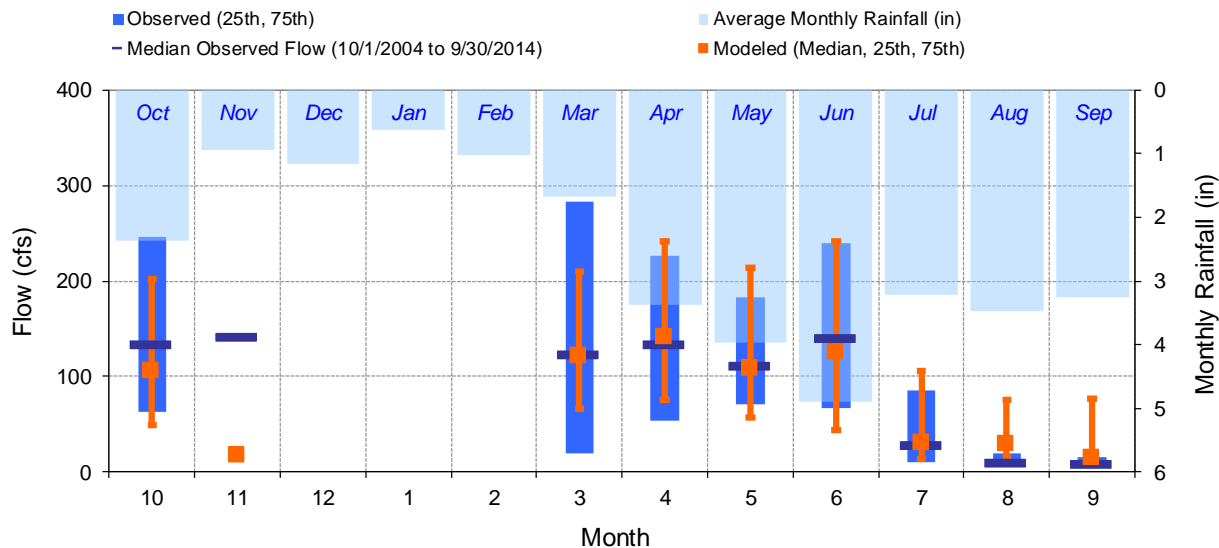


Figure 107. Seasonal medians and ranges at Okabena Creek near Okabena

Table 14. Seasonal summary at Okabena Creek near Okabena

MONTH	OBSERVED FLOW (CFS)				MODELED FLOW (CFS)			
	MEAN	MEDIAN	25TH	75TH	MEAN	MEDIAN	25TH	75TH
Oct	204.86	133.00	63.40	245.77	157.35	105.65	49.72	202.01
Nov	141.81	141.83	140.58	143.01	18.54	17.06	14.95	21.70
Dec	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	316.61	123.34	19.00	283.00	215.35	121.18	66.72	209.48
Apr	184.21	133.81	54.50	226.40	201.20	141.94	75.62	241.30
May	177.99	111.00	71.00	182.94	178.11	108.36	56.83	213.38
Jun	237.43	139.67	67.09	239.96	192.95	125.32	44.43	241.78
Jul	111.39	28.42	9.93	85.00	108.99	30.89	14.37	105.82
Aug	31.53	10.42	5.82	20.00	88.55	29.23	15.47	75.43
Sep	100.73	8.85	4.55	16.00	104.44	15.08	9.14	76.38

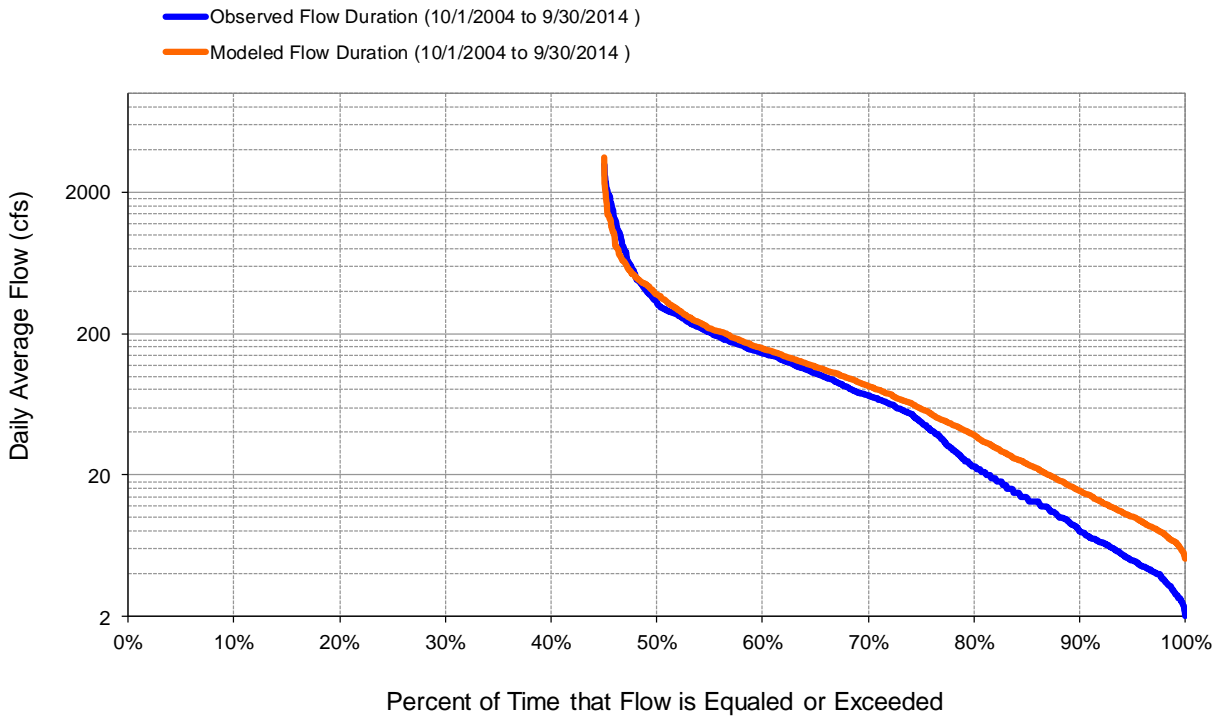


Figure 108. Flow exceedence at Okabena Creek near Okabena

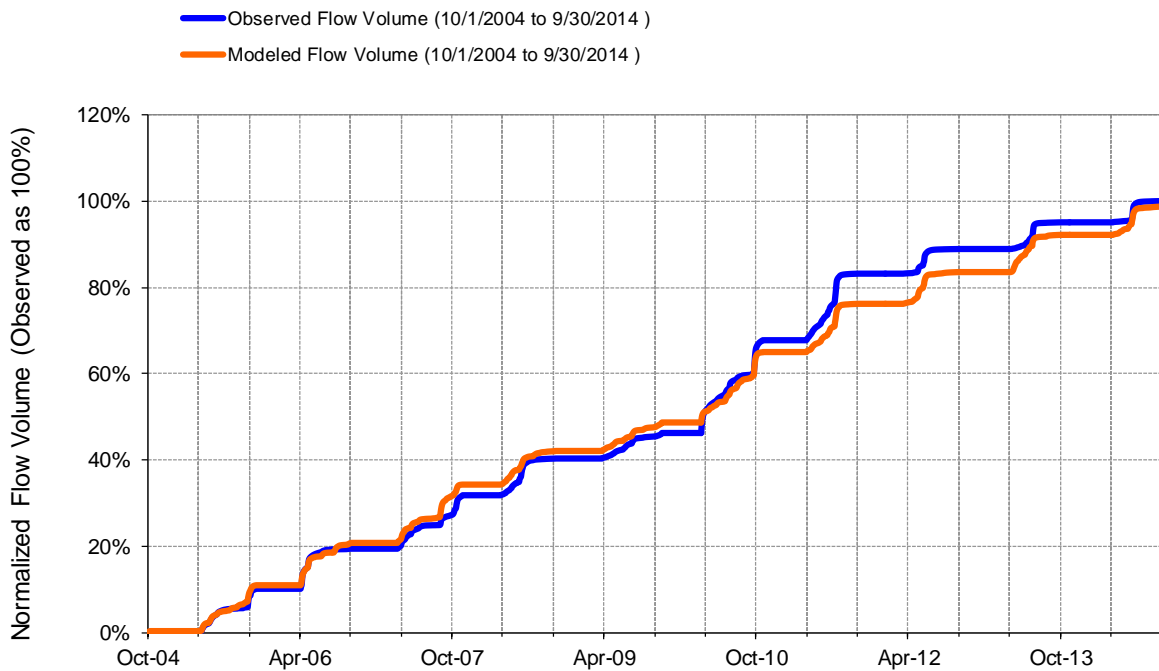


Figure 109. Flow accumulation at Okabena Creek near Okabena

## HERON LAKE OUTLET NEAR HERON LAKE (HYDSTRA 51017001)

Table 15. Summary statistics at Heron Lake Outlet near Heron Lake

HSPF Simulated Flow		Observed Flow Gage	
<b>REACH OUTFLOW FROM DSN 9</b>  10-Year Analysis Period: 10/1/2004 - 9/30/2014 Flow volumes are (inches/year) for upstream drainage area		<b>Heron Lake outlet near Heron Lake</b>  Manually Entered Data  Drainage Area (sq-mi): 1250	
Total Simulated In-stream Flow:	<b>2.39</b>	Total Observed In-stream Flow:	<b>2.46</b>
Total of simulated highest 10% flows:	<b>0.92</b>	Total of Observed highest 10% flows:	<b>0.88</b>
Total of Simulated lowest 50% flows:	<b>0.29</b>	Total of Observed Lowest 50% flows:	<b>0.24</b>
Simulated Summer Flow Volume (months 7-9):	<b>0.64</b>	Observed Summer Flow Volume (7-9):	<b>0.58</b>
Simulated Fall Flow Volume (months 10-12):	<b>0.26</b>	Observed Fall Flow Volume (10-12):	<b>0.26</b>
Simulated Winter Flow Volume (months 1-3):	<b>0.19</b>	Observed Winter Flow Volume (1-3):	<b>0.21</b>
Simulated Spring Flow Volume (months 4-6):	<b>1.29</b>	Observed Spring Flow Volume (4-6):	<b>1.41</b>
Total Simulated Storm Volume:	<b>0.71</b>	Total Observed Storm Volume:	<b>0.46</b>
Simulated Summer Storm Volume (7-9):	<b>0.23</b>	Observed Summer Storm Volume (7-9):	<b>0.15</b>
<i>Errors (Simulated-Observed)</i>	<i>Error Statistics</i>	<i>Recommended Criteria</i>	
Error in total volume:	-2.88	10	
Error in 50% lowest flows:	23.31	10	
Error in 10% highest flows:	4.79	15	
Seasonal volume error - Summer:	11.02	30	
Seasonal volume error - Fall:	-0.26	30	Clear
Seasonal volume error - Winter:	-7.32	30	
Seasonal volume error - Spring:	-8.41	30	
Error in storm volumes:	54.83	20	
Error in summer storm volumes:	53.72	50	
Nash-Sutcliffe Coefficient of Efficiency, E:	0.560	Model accuracy increases	
Baseline adjusted coefficient (Garrick), E':	0.438		
Monthly NSE	0.718		

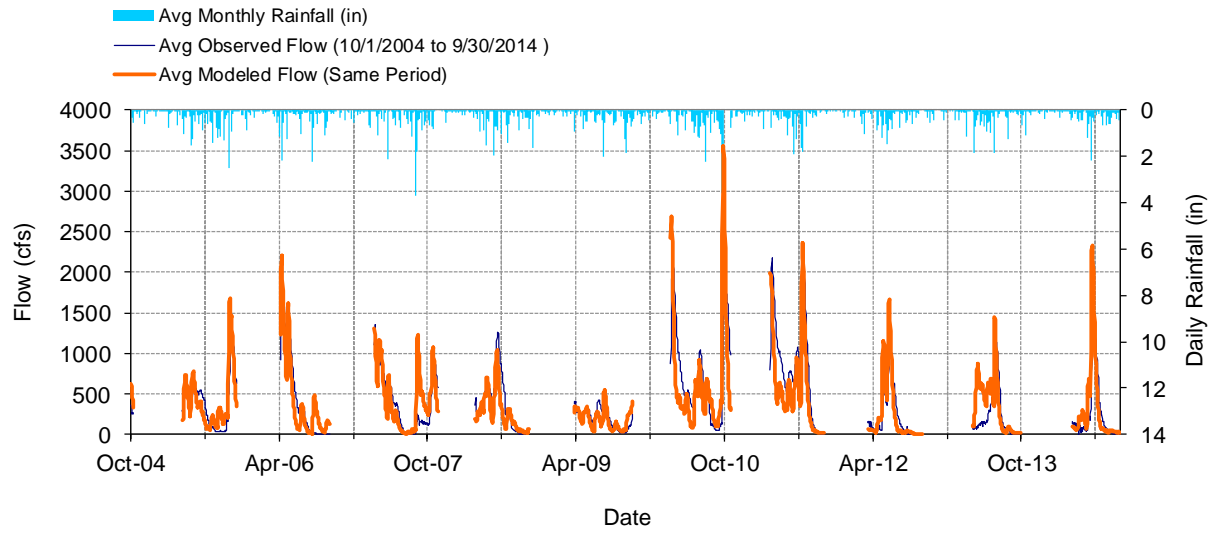


Figure 110. Mean daily flow at Heron Lake Outlet near Heron Lake

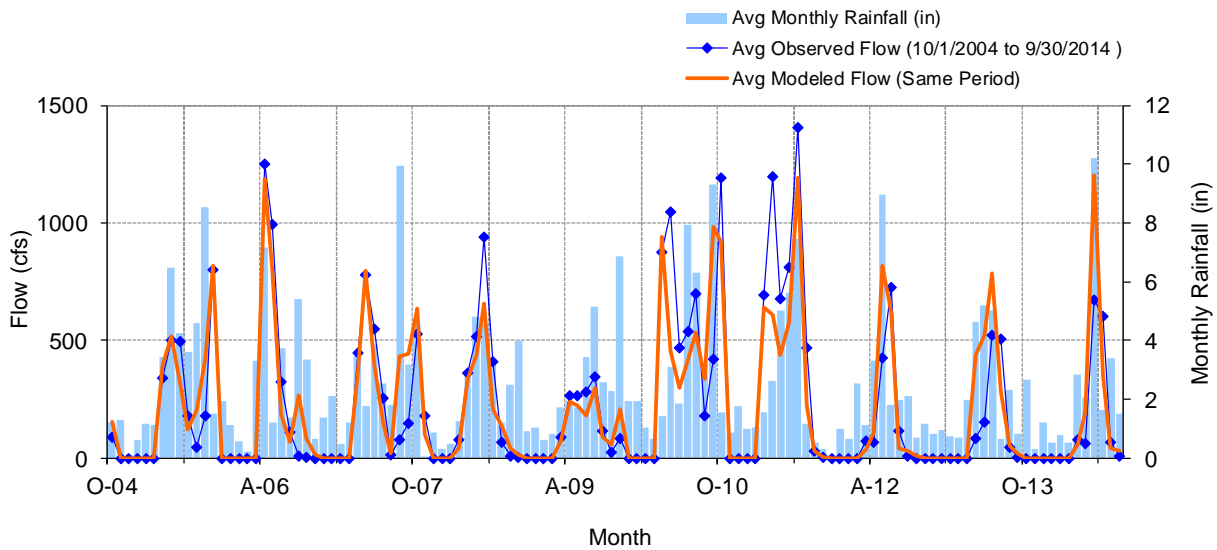


Figure 111. Mean monthly flow at Heron Lake Outlet near Heron Lake

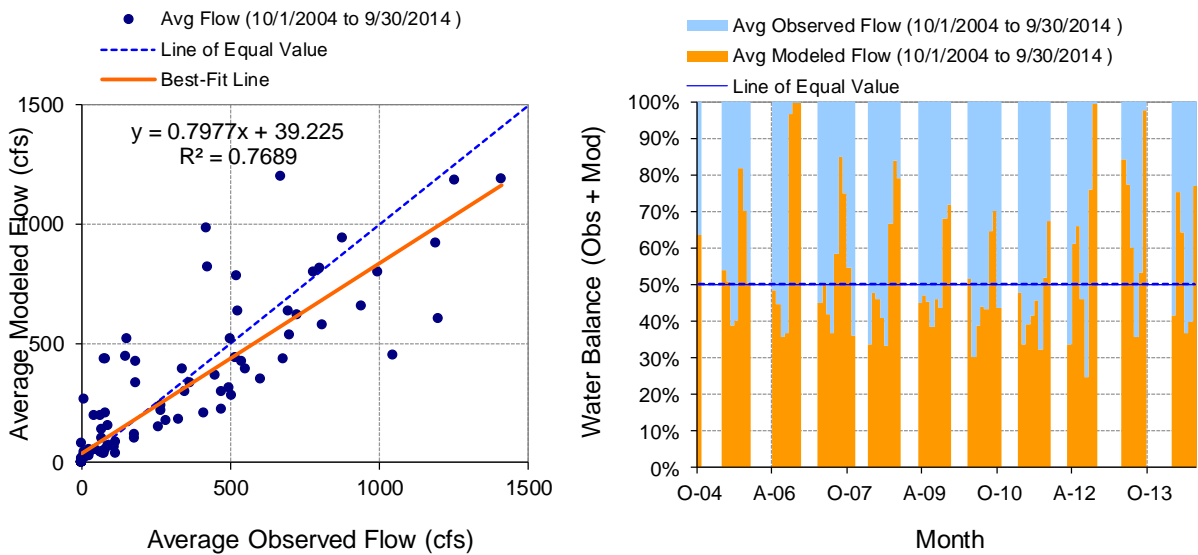


Figure 112. Monthly flow regression and temporal variation at Heron Lake Outlet near Heron Lake

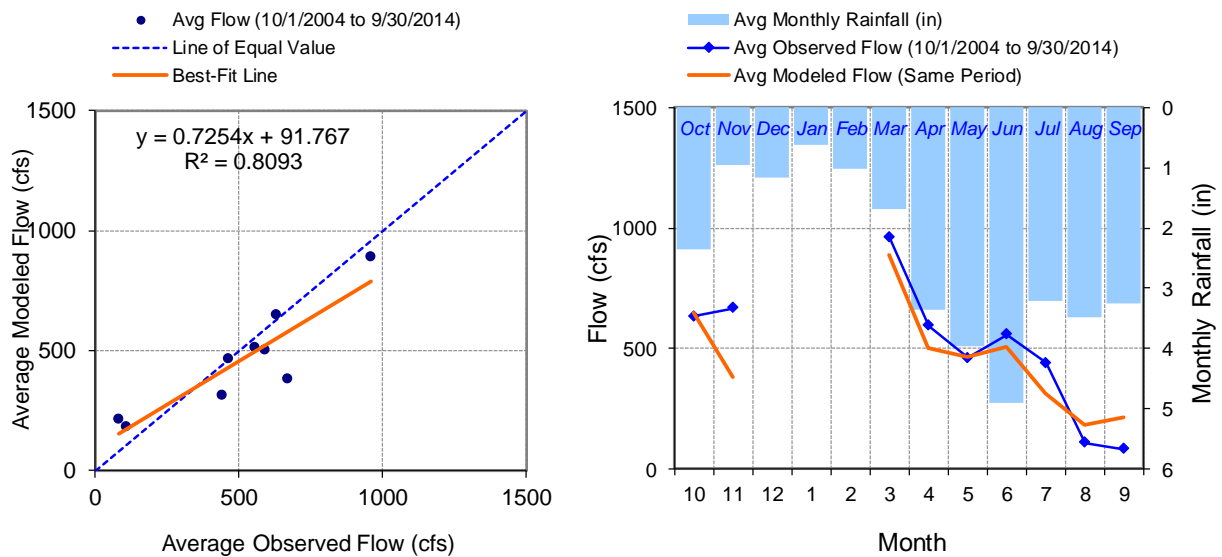


Figure 113. Seasonal regression and temporal aggregate at Heron Lake Outlet near Heron Lake

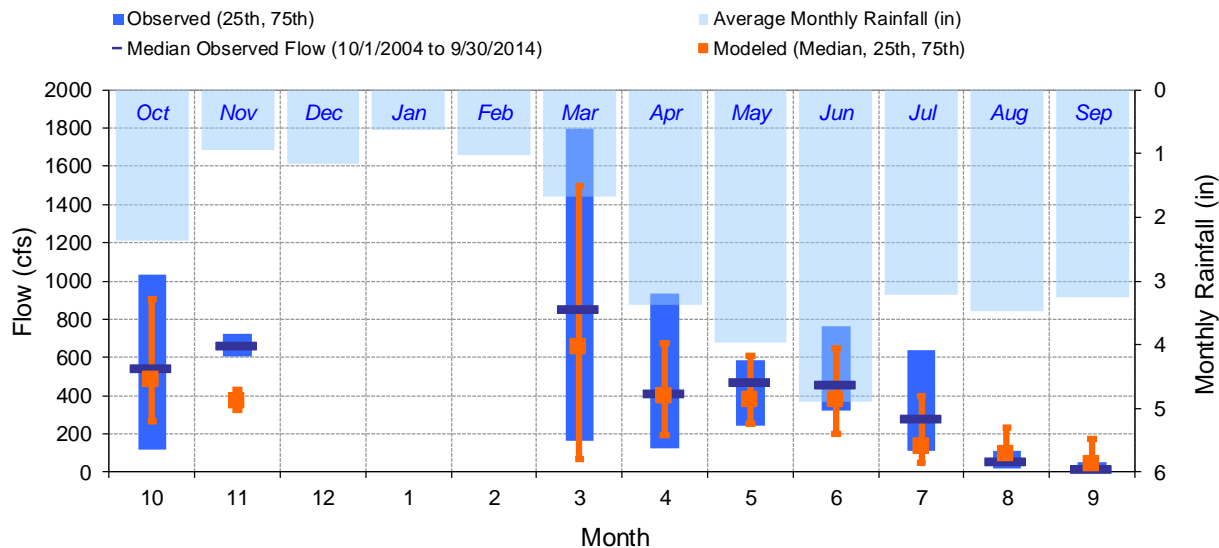


Figure 114. Seasonal medians and ranges at Heron Lake Outlet near Heron Lake

Table 16. Seasonal summary at Heron Lake Outlet near Heron Lake

MONTH	OBSERVED FLOW (CFS)				MODELED FLOW (CFS)			
	MEAN	MEDIAN	25TH	75TH	MEAN	MEDIAN	25TH	75TH
Oct	631.94	540.26	116.17	1031.45	647.69	481.86	268.38	906.90
Nov	667.84	663.16	607.88	721.27	379.39	369.22	322.83	428.47
Dec	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	958.68	854.44	165.00	1800.00	888.54	653.49	70.52	1496.70
Apr	592.87	409.00	127.00	936.35	498.35	399.26	190.78	671.57
May	461.58	472.07	243.50	588.75	464.14	376.29	254.77	610.43
Jun	556.81	460.00	321.46	762.50	508.51	378.50	198.34	647.38
Jul	439.50	276.61	109.79	637.50	310.48	133.18	49.51	399.38
Aug	108.57	56.00	17.41	113.25	180.67	96.98	46.63	233.42
Sep	82.07	13.00	0.63	54.00	212.33	44.98	25.37	176.55

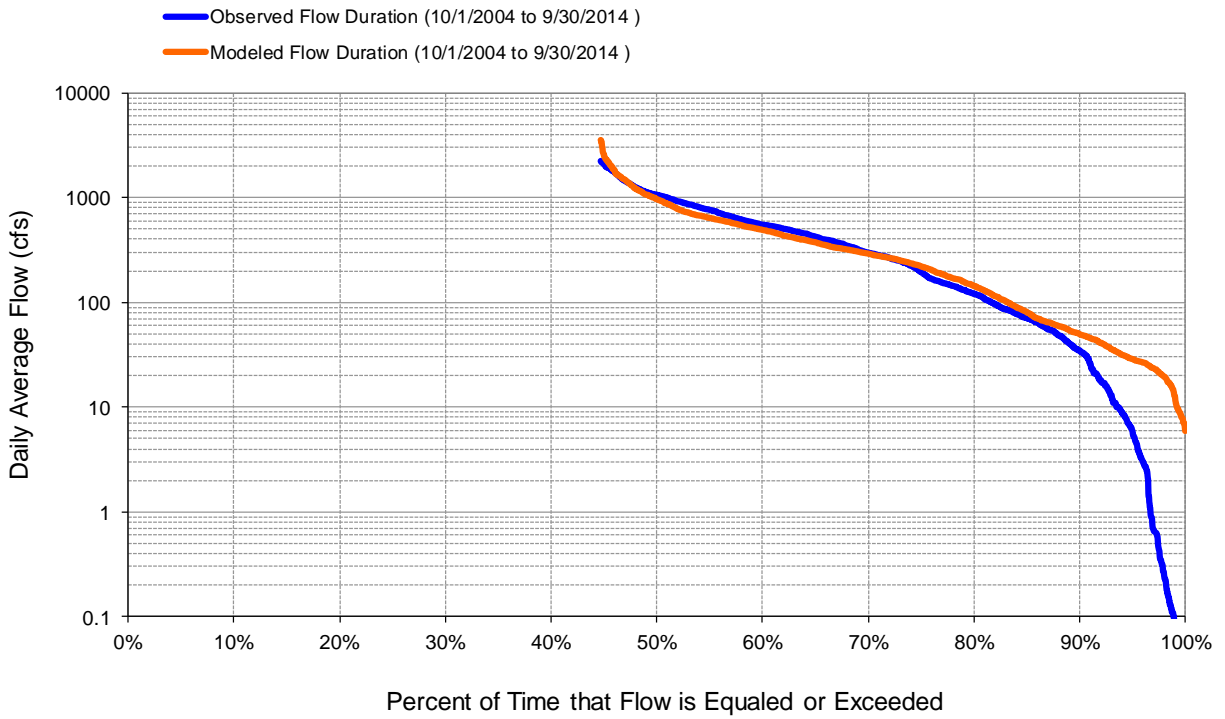


Figure 115. Flow exceedence at Heron Lake Outlet near Heron Lake

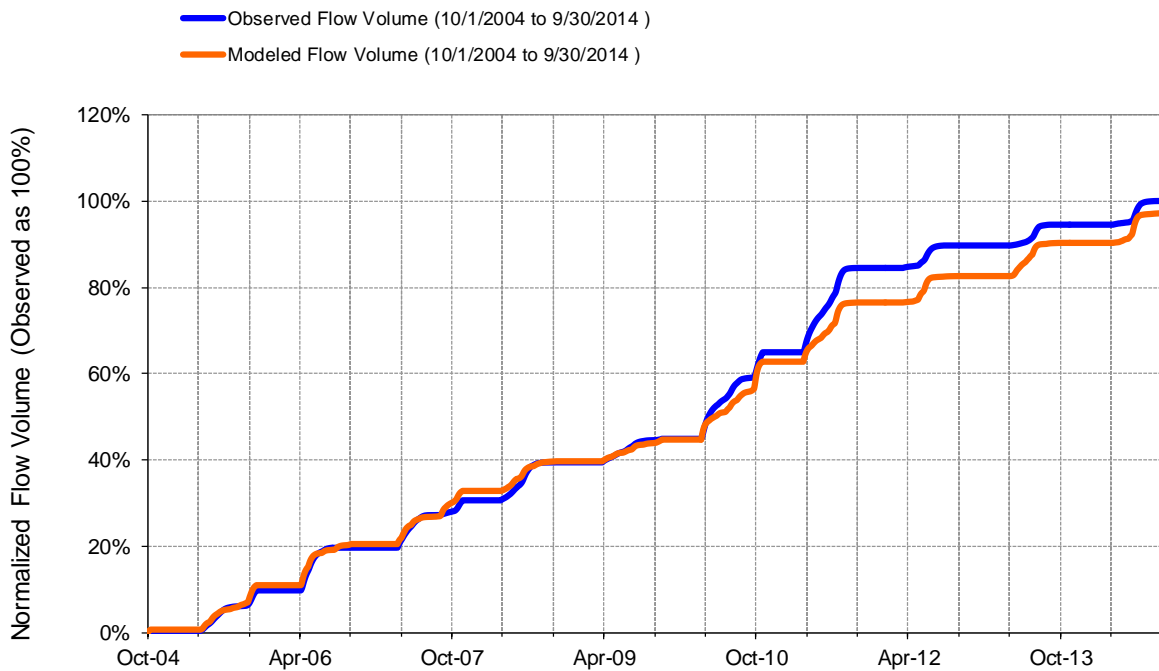


Figure 116. Flow accumulation at Heron Lake Outlet near Heron Lake



## WEST FORK DES MOINES RIVER NEAR WINDOM (HYDSTRA 51011001)

Table 17. Summary statistics at West Fork Des Moines River near Windom

HSPF Simulated Flow		Observed Flow Gage	
<b>REACH OUTFLOW FROM DSN 10</b>  1.5-Year Analysis Period: 4/1/2003 - 9/30/2004 Flow volumes are (inches/year) for upstream drainage area		<b>West Fork Des Moines River near Windom</b>  Manually Entered Data  Drainage Area (sq-mi): 1200	
Total Simulated In-stream Flow:	<b>5.20</b>	Total Observed In-stream Flow:	<b>4.61</b>
Total of simulated highest 10% flows:	<b>1.79</b>	Total of Observed highest 10% flows:	<b>1.57</b>
Total of Simulated lowest 50% flows:	<b>0.65</b>	Total of Observed Lowest 50% flows:	<b>0.56</b>
Simulated Summer Flow Volume (months 7-9):	<b>2.23</b>	Observed Summer Flow Volume (7-9):	<b>1.59</b>
Simulated Fall Flow Volume (months 10-12):	<b>0.00</b>	Observed Fall Flow Volume (10-12):	<b>0.00</b>
Simulated Winter Flow Volume (months 1-3):	<b>0.07</b>	Observed Winter Flow Volume (1-3):	<b>0.10</b>
Simulated Spring Flow Volume (months 4-6):	<b>2.89</b>	Observed Spring Flow Volume (4-6):	<b>2.92</b>
Total Simulated Storm Volume:	<b>1.58</b>	Total Observed Storm Volume:	<b>1.08</b>
Simulated Summer Storm Volume (7-9):	<b>0.70</b>	Observed Summer Storm Volume (7-9):	<b>0.37</b>
<i>Errors (Simulated-Observed)</i>	<i>Error Statistics</i>	<i>Recommended Criteria</i>	
Error in total volume:	12.80	10	
Error in 50% lowest flows:	16.54	10	
Error in 10% highest flows:	14.37	15	
Seasonal volume error - Summer:	40.39	30	
Seasonal volume error - Fall:	0.00	30	Clear
Seasonal volume error - Winter:	-30.13	30	
Seasonal volume error - Spring:	-0.79	30	
Error in storm volumes:	46.92	20	
Error in summer storm volumes:	90.95	50	
Nash-Sutcliffe Coefficient of Efficiency, E:	0.674	Model accuracy increases	
Baseline adjusted coefficient (Garrick), E':	0.565		
Monthly NSE	0.912		

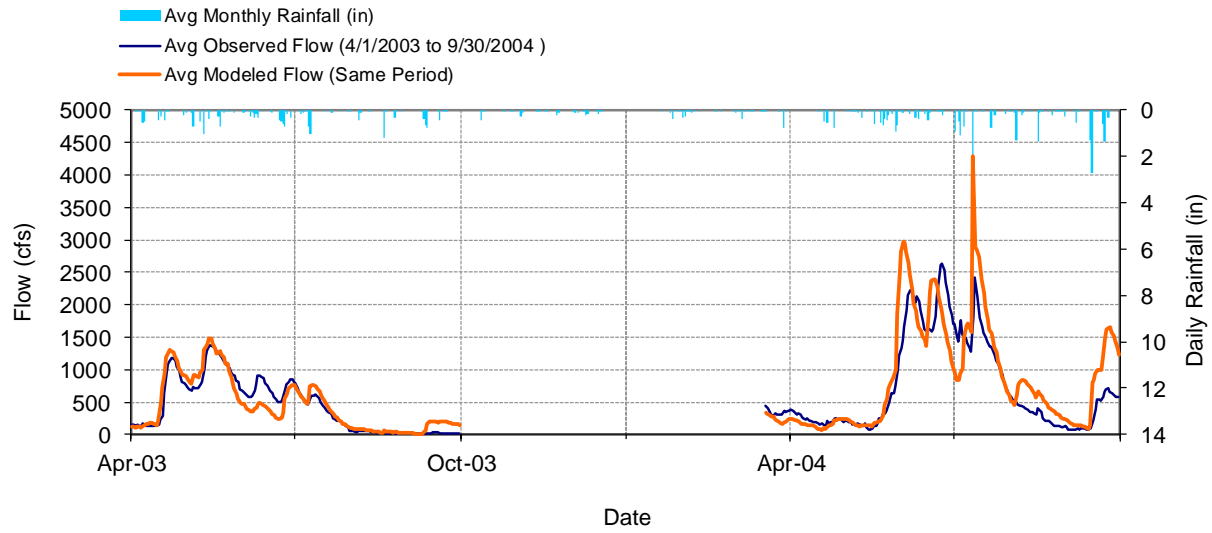


Figure 117. Mean daily flow at West Fork Des Moines River near Windom

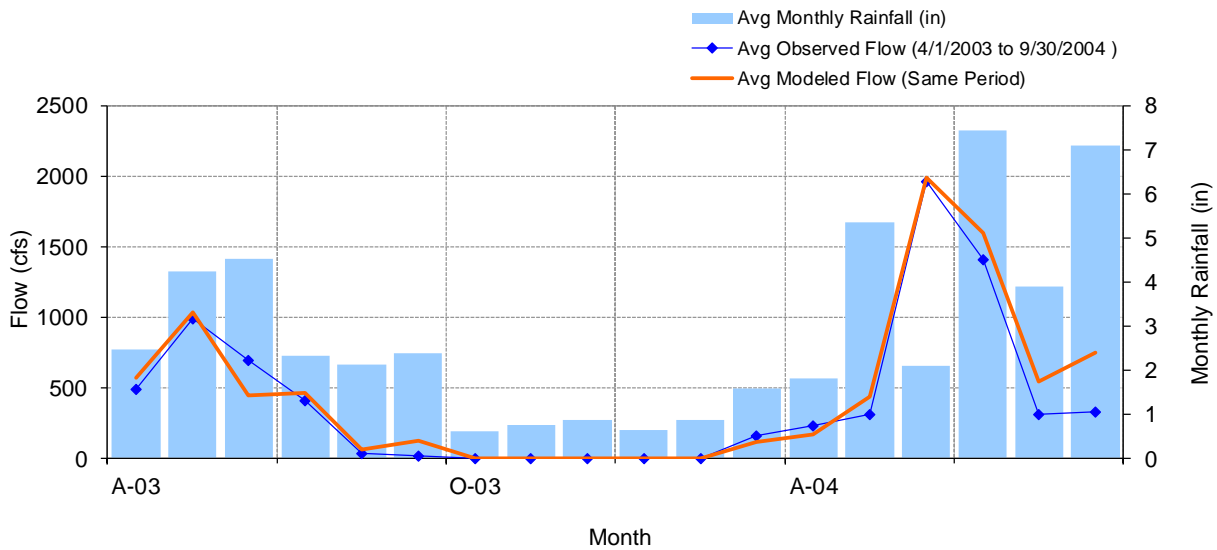


Figure 118. Mean monthly flow at West Fork Des Moines River near Windom

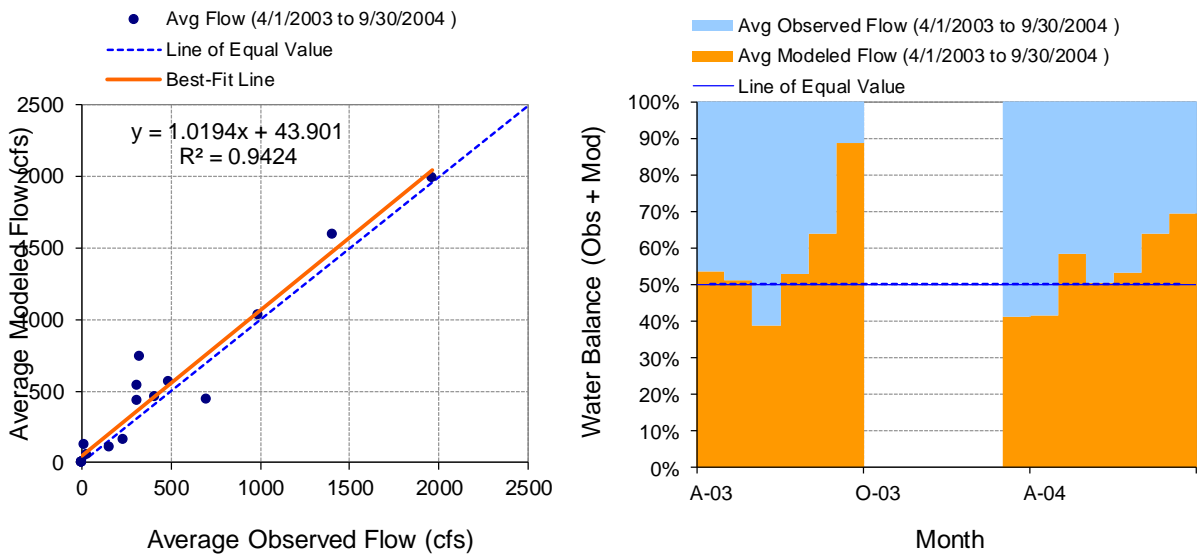


Figure 119. Monthly flow regression and temporal variation at West Fork Des Moines River near Windom

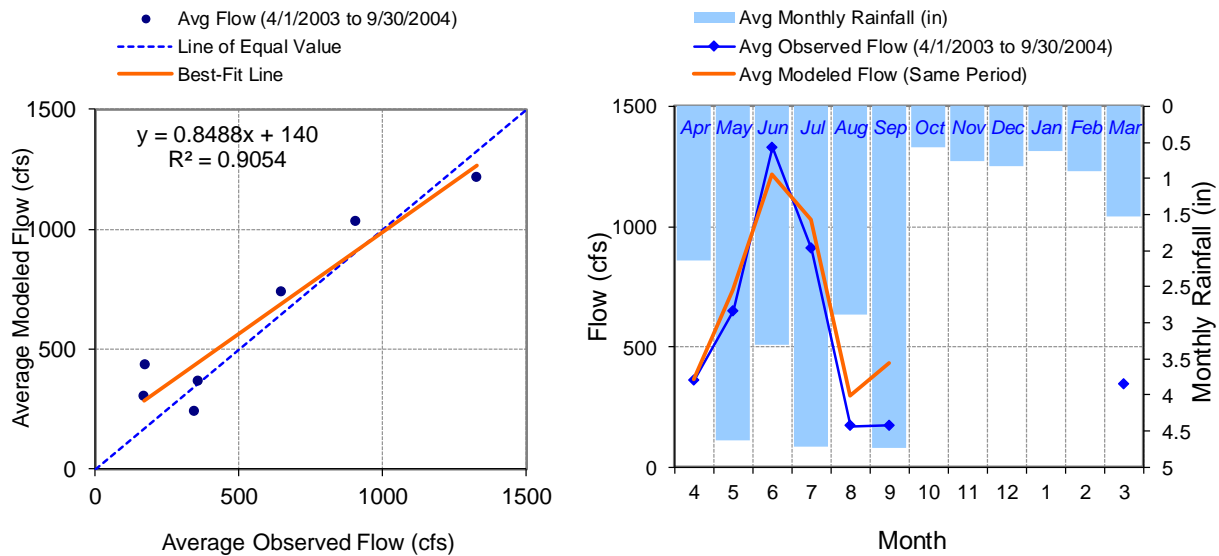


Figure 120. Seasonal regression and temporal aggregate at West Fork Des Moines River near Windom

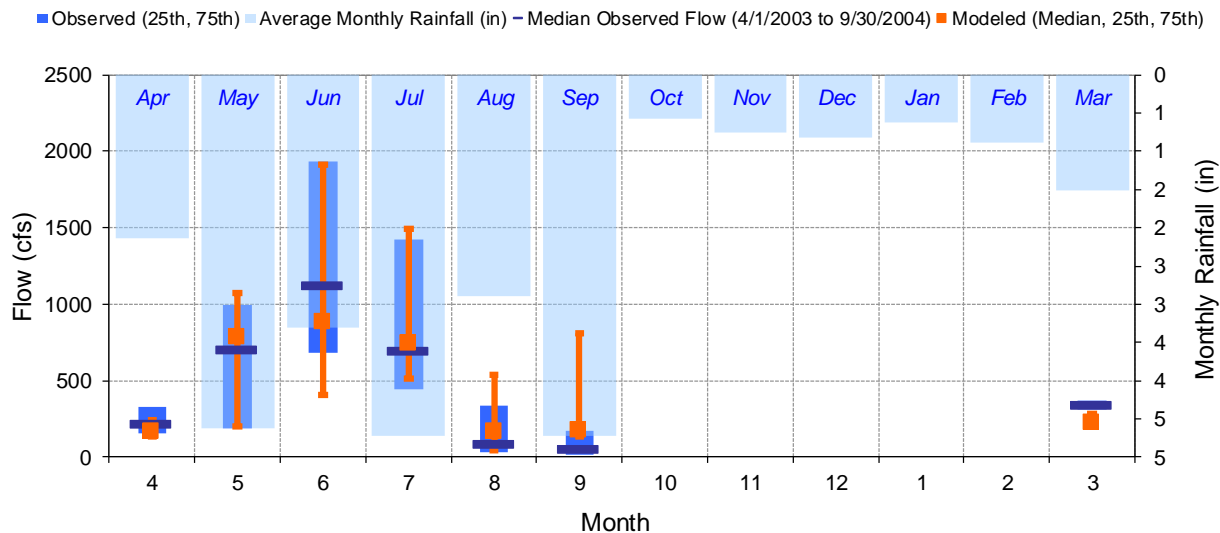


Figure 121. Seasonal medians and ranges at West Fork Des Moines River near Windom

Table 18. Seasonal summary at West Fork Des Moines River near Windom

MONTH	OBSERVED FLOW (CFS)				MODELED FLOW (CFS)			
	MEAN	MEDIAN	25TH	75TH	MEAN	MEDIAN	25TH	75TH
Apr	359.83	214.53	153.20	326.94	365.14	167.31	131.38	238.06
May	647.92	704.50	190.91	998.83	733.79	789.18	200.32	1070.88
Jun	1327.69	1120.21	682.00	1937.12	1215.11	883.85	407.44	1917.20
Jul	908.17	694.93	444.00	1423.70	1028.97	745.97	514.30	1495.02
Aug	169.56	88.65	29.30	333.26	298.80	164.70	47.92	539.10
Sep	172.10	52.04	12.90	170.43	432.98	179.00	132.78	809.04
Oct	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nov	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dec	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	342.84	338.24	308.16	371.90	239.54	227.34	198.27	282.53

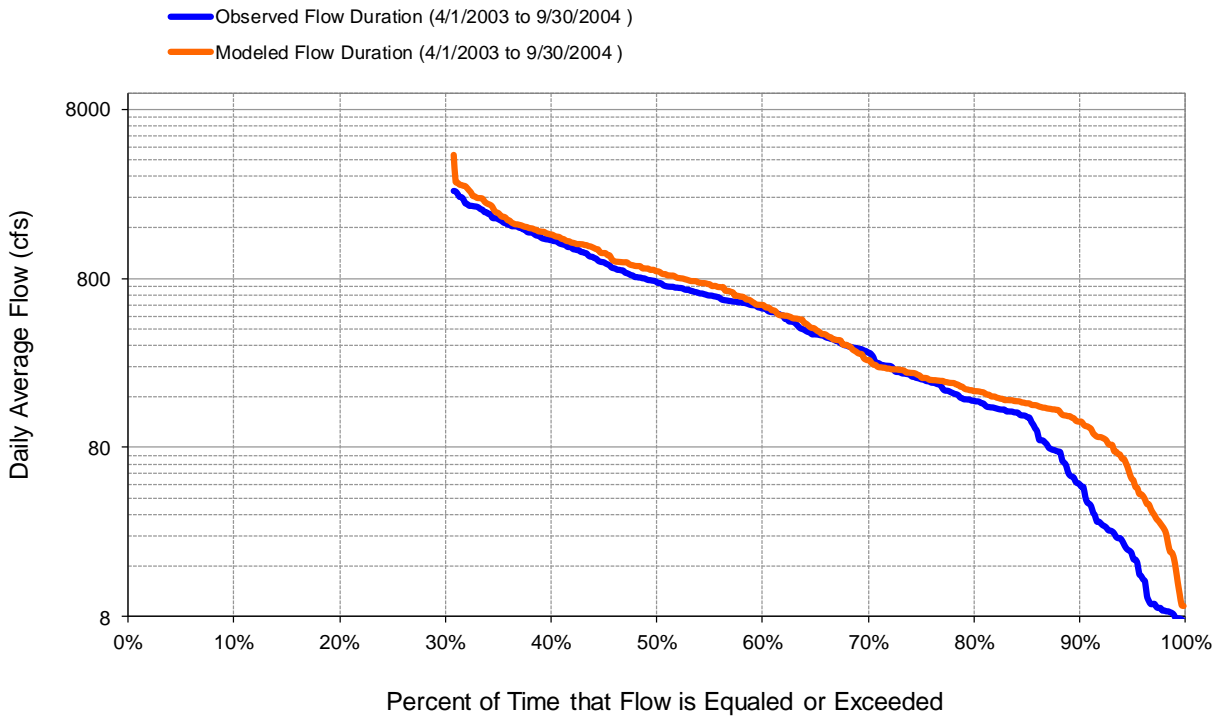


Figure 122. Flow exceedance at West Fork Des Moines River near Windom

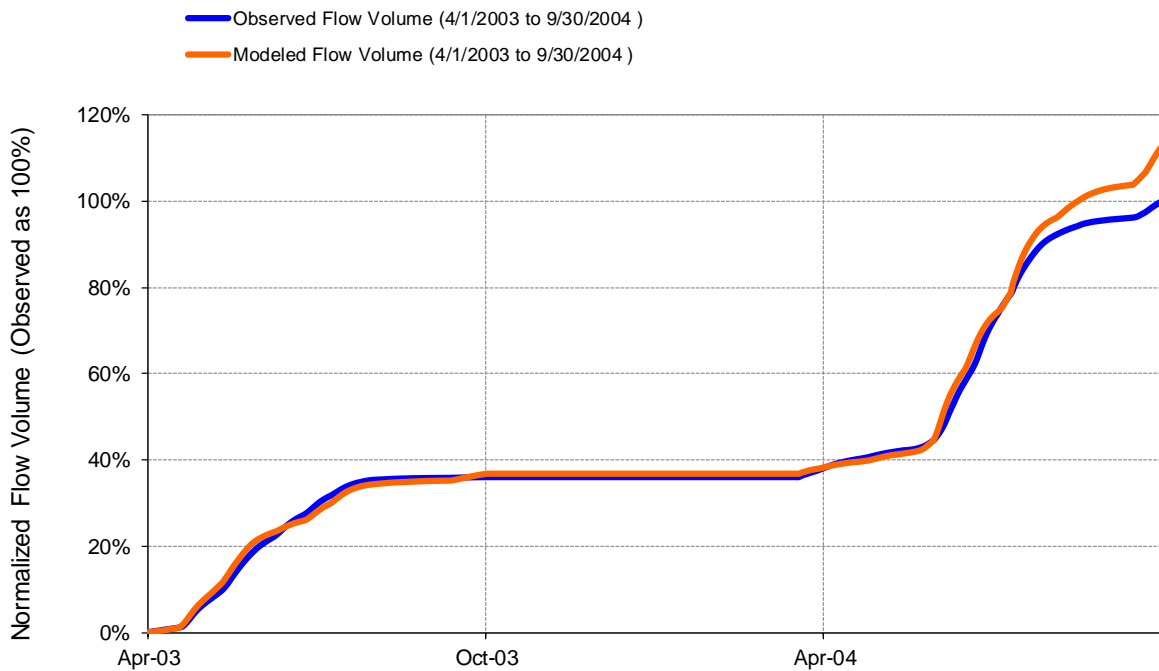


Figure 123. Flow accumulation at West Fork Des Moines River near Windom

## DES MOINES RIVER AT JACKSON (USGS 05476000)

Table 19. Summary statistics at Des Moines River at Jackson

HSPF Simulated Flow		Observed Flow Gage	
<b>REACH OUTFLOW FROM DSN 12</b>  10-Year Analysis Period: 10/1/2004 - 9/30/2014 Flow volumes are (inches/year) for upstream drainage area		<b>Des Moines River at Jackson</b>  Manually Entered Data  Drainage Area (sq-mi): 1250	
Total Simulated In-stream Flow:	<b>7.22</b>	Total Observed In-stream Flow:	<b>7.39</b>
Total of simulated highest 10% flows:	<b>3.53</b>	Total of Observed highest 10% flows:	<b>3.54</b>
Total of Simulated lowest 50% flows:	<b>0.52</b>	Total of Observed Lowest 50% flows:	<b>0.47</b>
Simulated Summer Flow Volume (months 7-9):	<b>1.52</b>	Observed Summer Flow Volume (7-9):	<b>1.43</b>
Simulated Fall Flow Volume (months 10-12):	<b>1.07</b>	Observed Fall Flow Volume (10-12):	<b>1.14</b>
Simulated Winter Flow Volume (months 1-3):	<b>1.20</b>	Observed Winter Flow Volume (1-3):	<b>1.09</b>
Simulated Spring Flow Volume (months 4-6):	<b>3.43</b>	Observed Spring Flow Volume (4-6):	<b>3.73</b>
Total Simulated Storm Volume:	<b>2.34</b>	Total Observed Storm Volume:	<b>1.67</b>
Simulated Summer Storm Volume (7-9):	<b>0.58</b>	Observed Summer Storm Volume (7-9):	<b>0.39</b>
<i>Errors (Simulated-Observed)</i>	<i>Error Statistics</i>	<i>Recommended Criteria</i>	
Error in total volume:	-2.26	10	
Error in 50% lowest flows:	9.76	10	
Error in 10% highest flows:	-0.41	15	
Seasonal volume error - Summer:	5.83	30	
Seasonal volume error - Fall:	-5.97	30	Clear
Seasonal volume error - Winter:	10.59	30	
Seasonal volume error - Spring:	-7.98	30	
Error in storm volumes:	40.42	20	
Error in summer storm volumes:	47.74	50	
Nash-Sutcliffe Coefficient of Efficiency, E:	0.700	Model accuracy increases	
Baseline adjusted coefficient (Garrick), E':	0.566		
Monthly NSE	0.775		

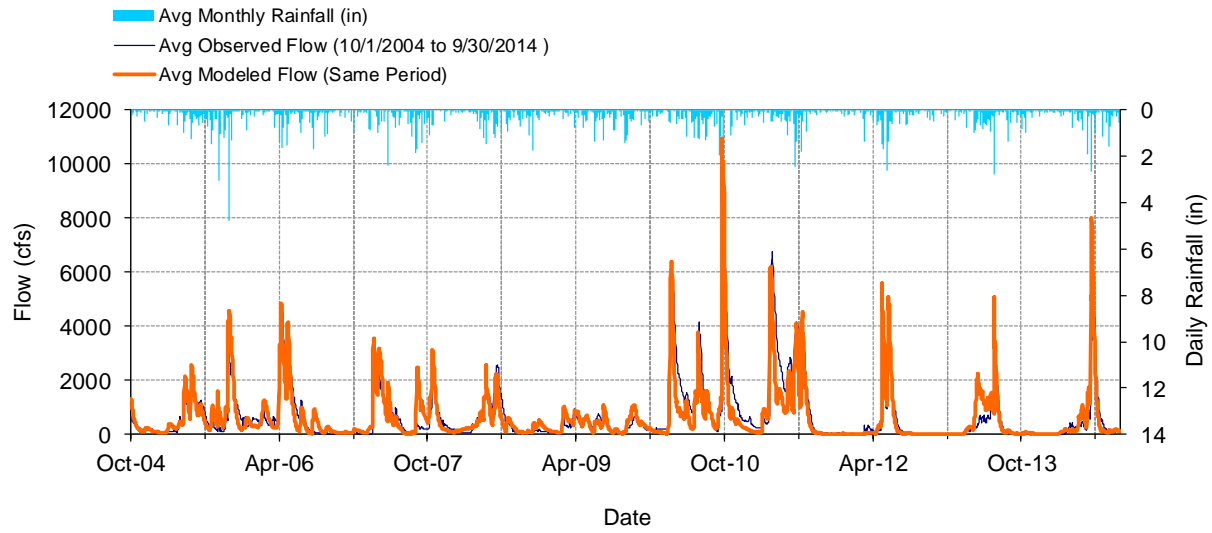


Figure 124. Mean daily flow at Des Moines River at Jackson

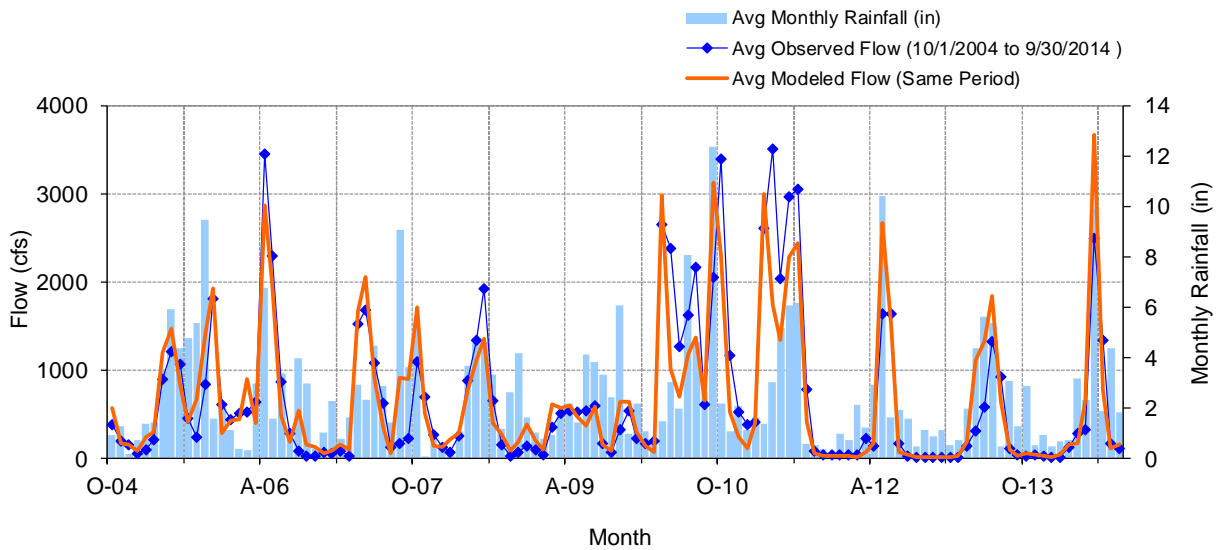


Figure 125. Mean monthly flow at Des Moines River at Jackson

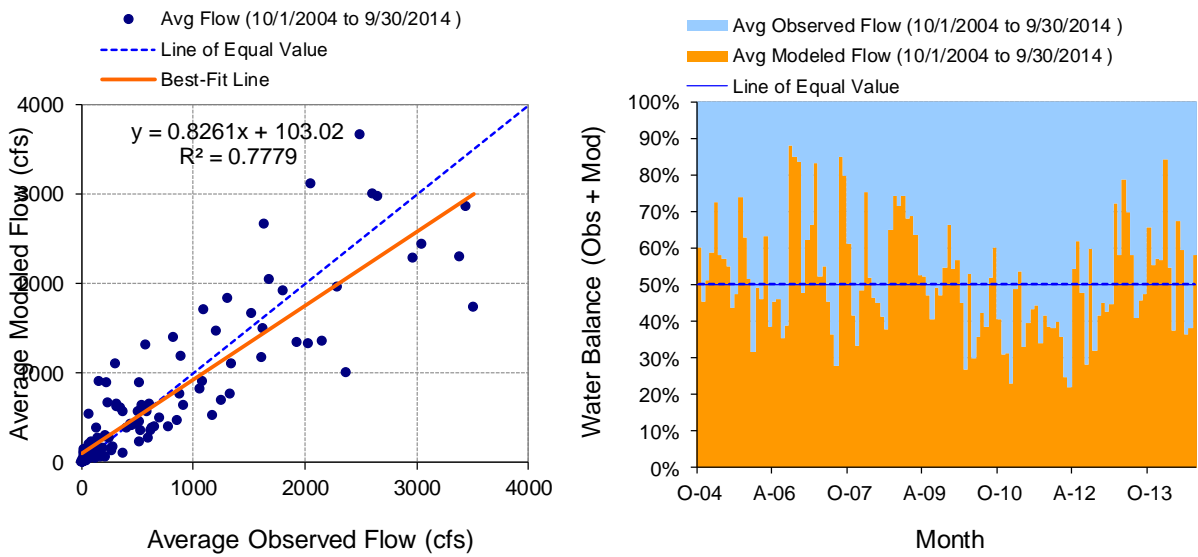


Figure 126. Monthly flow regression and temporal variation at Des Moines River at Jackson

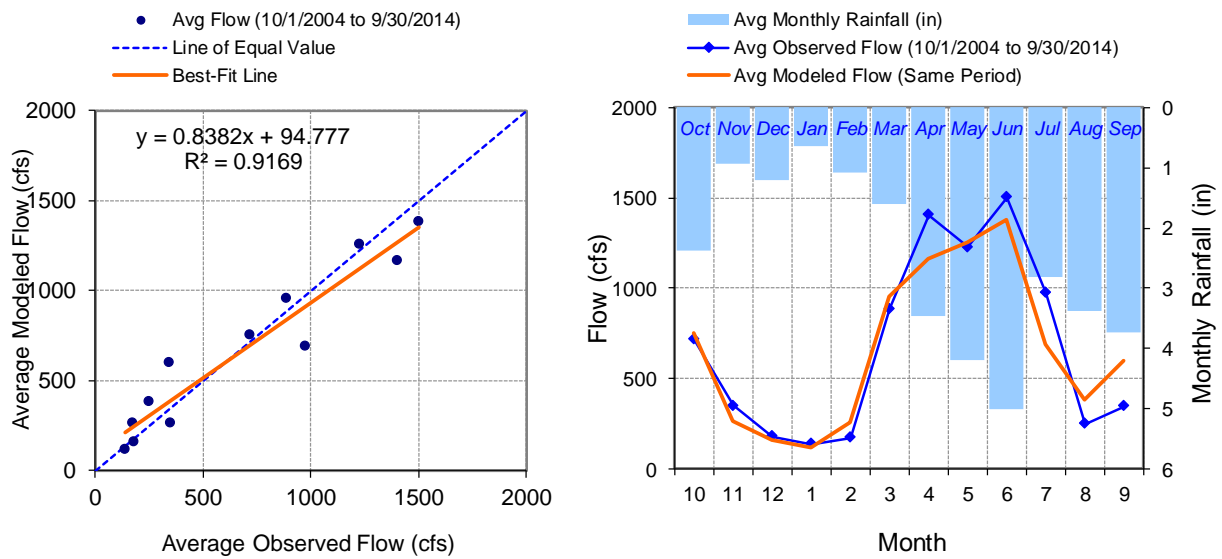


Figure 127. Seasonal regression and temporal aggregate at Des Moines River at Jackson



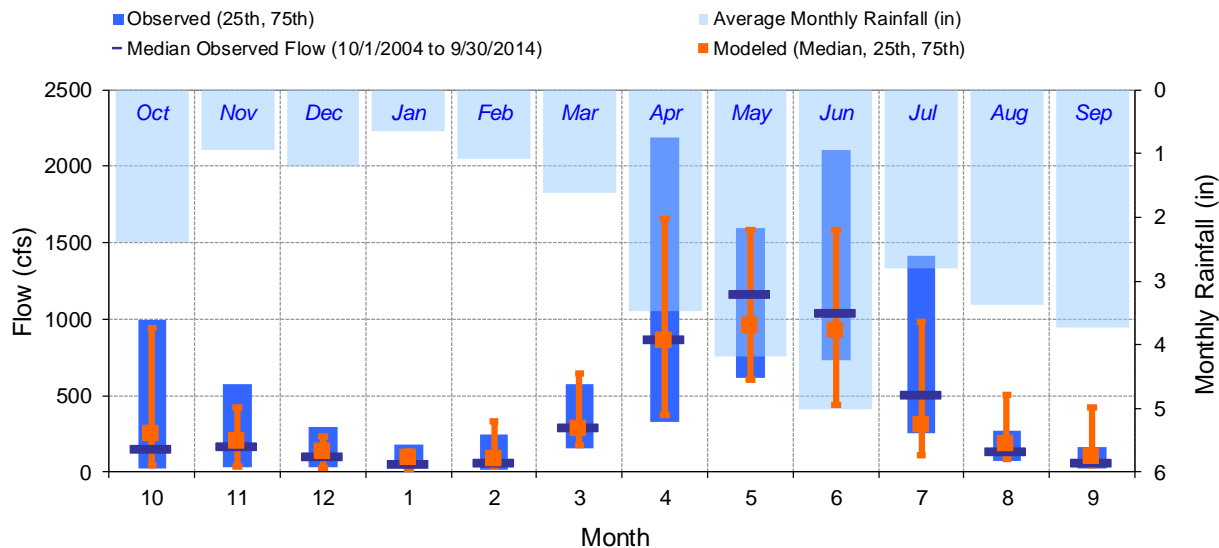


Figure 128. Seasonal medians and ranges at Des Moines River at Jackson

Table 20. Seasonal summary at Des Moines River at Jackson

MONTH	OBSERVED FLOW (CFS)				MODELED FLOW (CFS)			
	MEAN	MEDIAN	25TH	75TH	MEAN	MEDIAN	25TH	75TH
Oct	715.92	155.50	26.25	998.25	750.30	254.04	46.22	941.02
Nov	348.36	171.00	35.00	573.25	261.01	203.70	38.63	419.24
Dec	179.54	104.50	32.00	295.75	156.10	131.46	28.01	233.71
Jan	137.95	52.50	29.00	180.00	114.10	94.03	17.20	137.14
Feb	170.34	65.00	18.25	247.50	257.24	86.64	33.11	336.10
Mar	885.54	290.50	152.00	574.50	955.16	283.40	178.76	645.04
Apr	1405.19	871.50	332.25	2185.00	1163.99	862.12	373.98	1653.94
May	1227.08	1165.00	613.50	1597.50	1256.45	958.62	607.42	1584.80
Jun	1503.06	1040.00	729.50	2110.00	1380.48	927.37	443.06	1587.75
Jul	972.28	509.50	255.50	1415.00	686.82	306.75	110.13	980.30
Aug	247.84	134.50	74.00	268.75	382.07	186.98	87.12	509.18
Sep	345.68	61.50	28.00	160.50	595.58	103.16	45.70	425.54

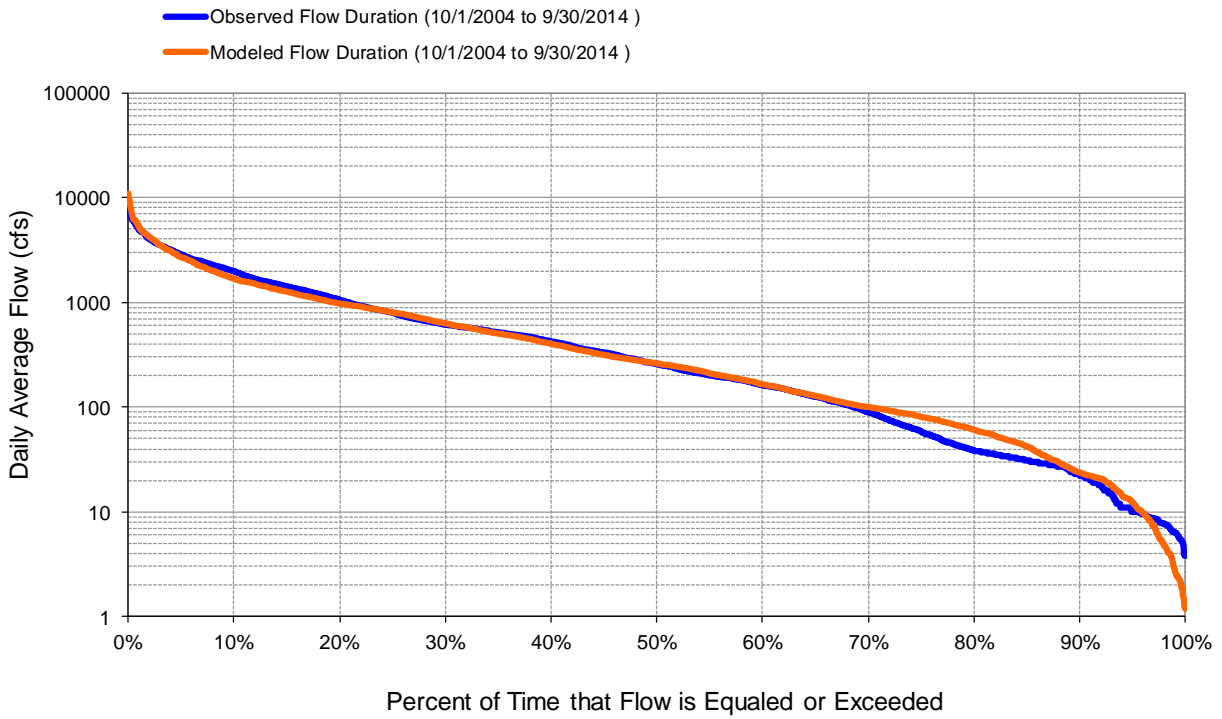


Figure 129. Flow exceedance at Des Moines River at Jackson

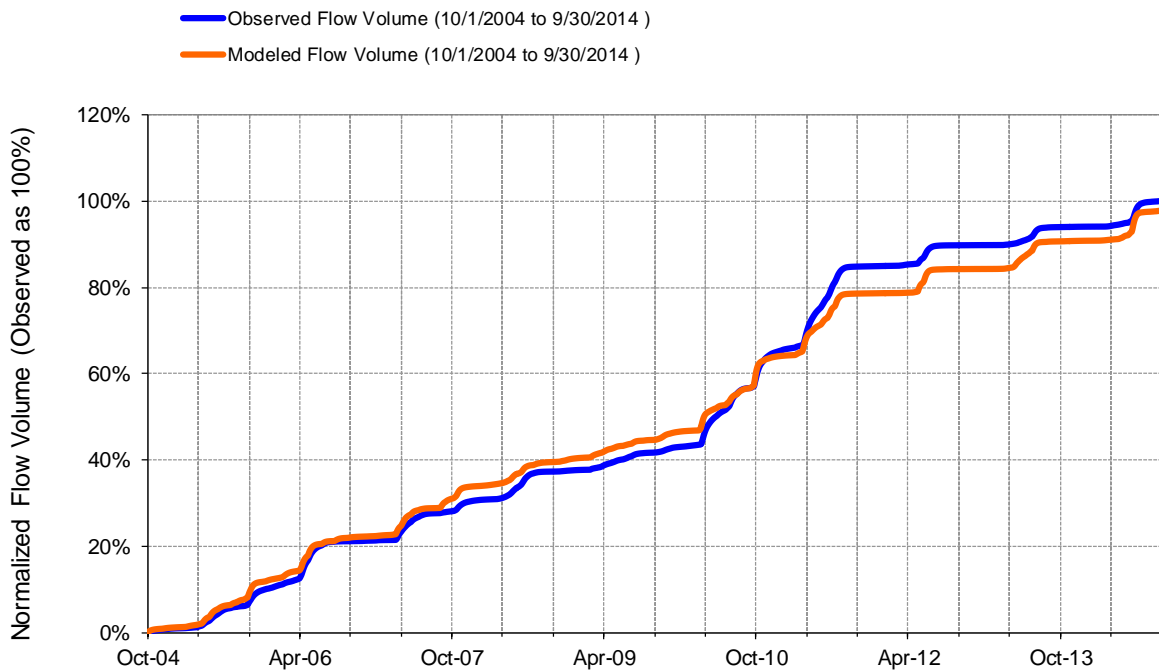


Figure 130. Flow accumulation at Des Moines River at Jackson

## DES MOINES RIVER AT ESTHERVILLE (USACE)

Table 21. Summary statistics at Des Moines River at Estherville

HSPF Simulated Flow		Observed Flow Gage	
<b>REACH OUTFLOW FROM DSN 13</b>  10.75-Year Analysis Period: 1/1/2004 - 9/30/2014 Flow volumes are (inches/year) for upstream drainage area		<b>USACE Des Moines River at Eserville</b>  Manually Entered Data  Drainage Area (sq-mi): 1372	
Total Simulated In-stream Flow:	<b>7.41</b>	Total Observed In-stream Flow:	<b>6.93</b>
Total of simulated highest 10% flows:	<b>3.44</b>	Total of Observed highest 10% flows:	<b>3.21</b>
Total of Simulated lowest 50% flows:	<b>0.60</b>	Total of Observed Lowest 50% flows:	<b>0.55</b>
Simulated Summer Flow Volume (months 7-9):	<b>1.73</b>	Observed Summer Flow Volume (7-9):	<b>1.36</b>
Simulated Fall Flow Volume (months 10-12):	<b>0.98</b>	Observed Fall Flow Volume (10-12):	<b>1.02</b>
Simulated Winter Flow Volume (months 1-3):	<b>1.17</b>	Observed Winter Flow Volume (1-3):	<b>1.10</b>
Simulated Spring Flow Volume (months 4-6):	<b>3.54</b>	Observed Spring Flow Volume (4-6):	<b>3.45</b>
Total Simulated Storm Volume:	<b>2.43</b>	Total Observed Storm Volume:	<b>1.69</b>
Simulated Summer Storm Volume (7-9):	<b>0.59</b>	Observed Summer Storm Volume (7-9):	<b>0.36</b>
<i>Errors (Simulated-Observed)</i>	<i>Error Statistics</i>	<i>Recommended Criteria</i>	
Error in total volume:	7.02	10	
Error in 50% lowest flows:	9.25	10	
Error in 10% highest flows:	7.25	15	
Seasonal volume error - Summer:	27.44	30	
Seasonal volume error - Fall:	-3.18	30	Clear
Seasonal volume error - Winter:	5.61	30	
Seasonal volume error - Spring:	2.45	30	
Error in storm volumes:	43.94	20	
Error in summer storm volumes:	62.97	50	
Nash-Sutcliffe Coefficient of Efficiency, E:	0.580	Model accuracy increases	
Baseline adjusted coefficient (Garrick), E':	0.503		
Monthly NSE	0.729		

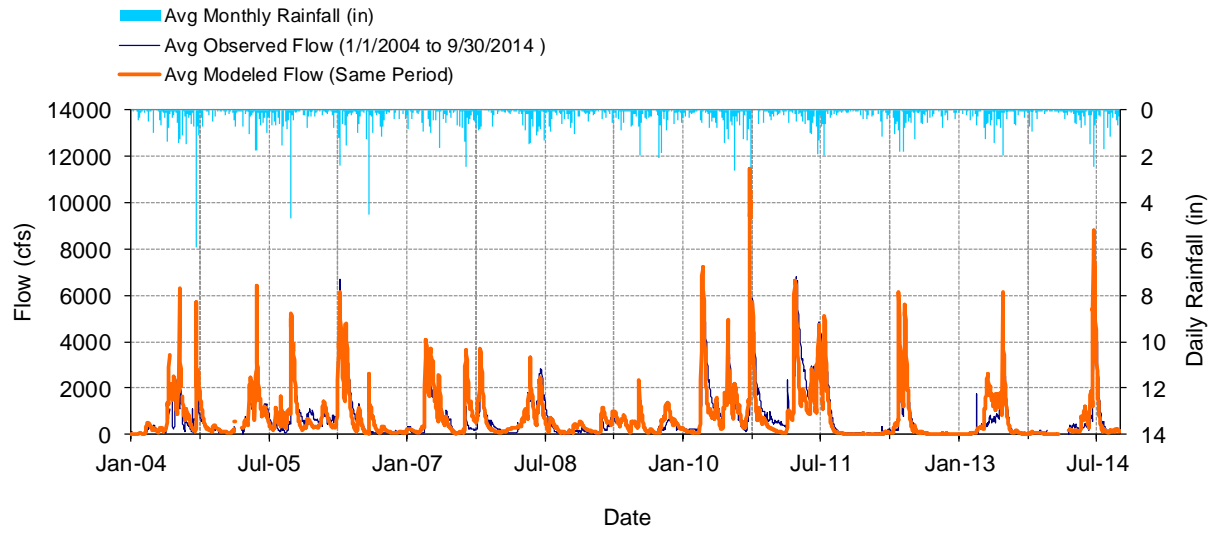


Figure 131. Mean daily flow at Des Moines River at Estherville

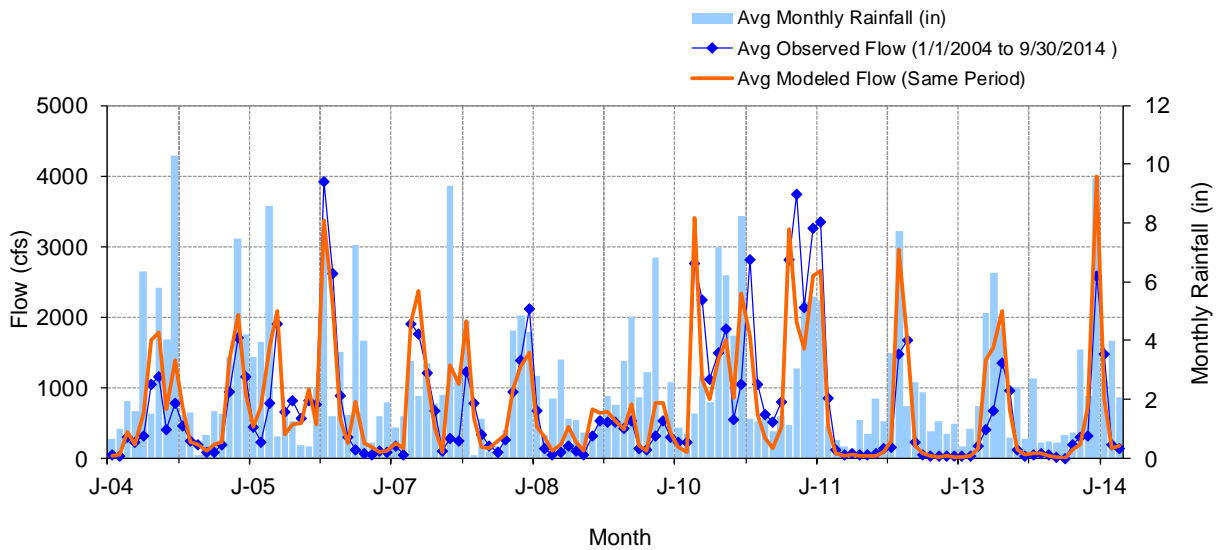


Figure 132. Mean monthly flow at Des Moines River at Estherville

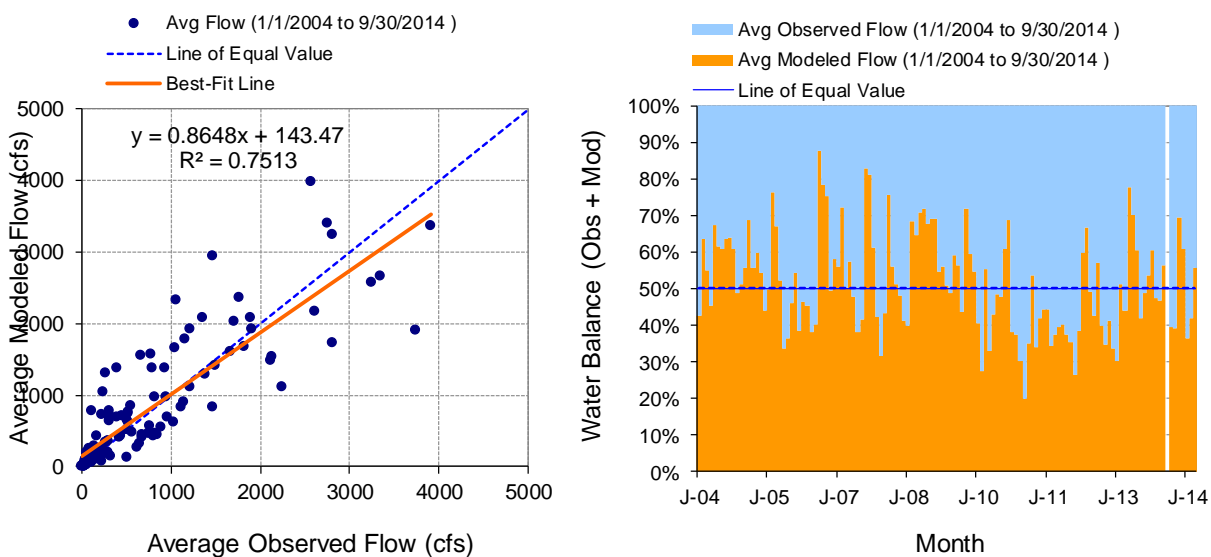


Figure 133. Monthly flow regression and temporal variation at Des Moines River at Estherville

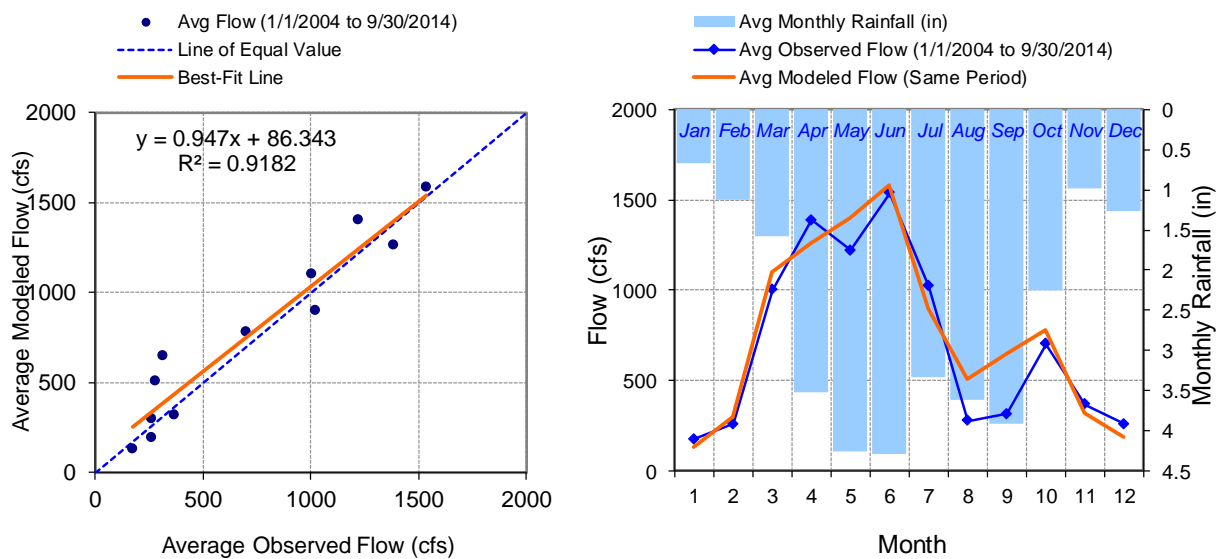


Figure 134. Seasonal regression and temporal aggregate at Des Moines River at Estherville

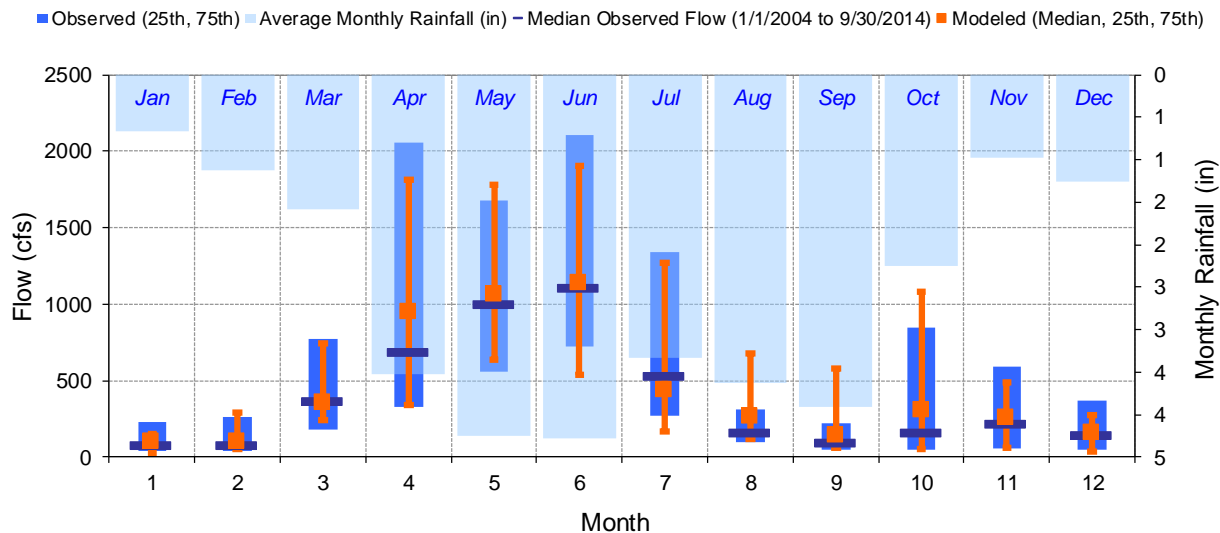


Figure 135. Seasonal medians and ranges at Des Moines River at Estherville

Table 22. Seasonal summary at Des Moines River at Estherville

MONTH	OBSERVED FLOW (CFS)				MODELED FLOW (CFS)			
	MEAN	MEDIAN	25TH	75TH	MEAN	MEDIAN	25TH	75TH
Jan	175.32	80.00	37.00	230.50	129.19	106.09	25.24	150.72
Feb	258.24	79.50	43.00	266.75	296.41	98.71	50.17	292.92
Mar	1002.40	367.00	180.00	777.00	1097.91	360.38	244.43	743.96
Apr	1386.89	683.00	332.00	2054.00	1261.71	950.62	341.14	1816.65
May	1221.48	998.00	557.00	1682.00	1398.73	1066.88	639.46	1781.69
Jun	1536.46	1103.00	726.00	2110.00	1579.86	1140.55	536.92	1907.05
Jul	1020.14	530.00	274.00	1342.50	899.63	441.78	166.39	1270.01
Aug	275.86	157.00	94.00	309.00	508.42	267.02	122.09	678.36
Sep	312.88	94.00	47.00	222.00	646.89	139.55	59.82	577.91
Oct	700.58	161.00	48.00	848.50	777.13	306.05	56.45	1085.36
Nov	365.66	216.00	60.50	589.50	316.64	257.03	57.75	490.57
Dec	259.29	145.00	52.00	369.00	187.84	159.71	37.93	277.65

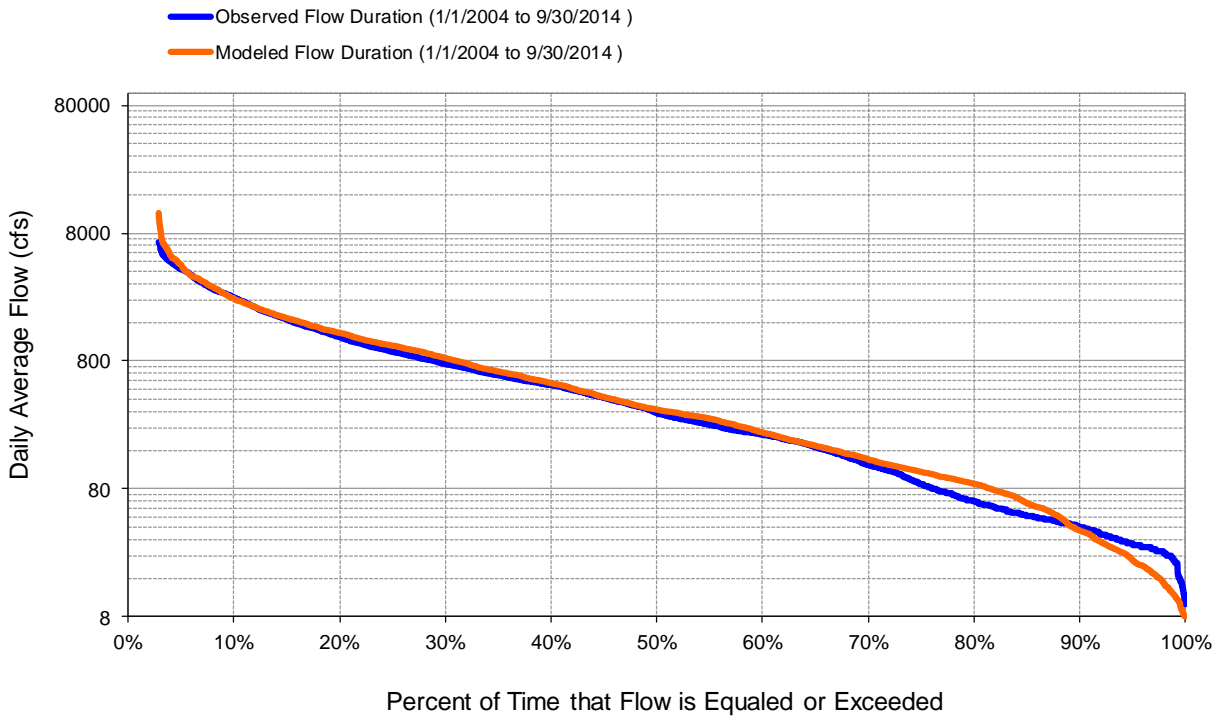


Figure 136. Flow exceedence at Des Moines River at Estherville

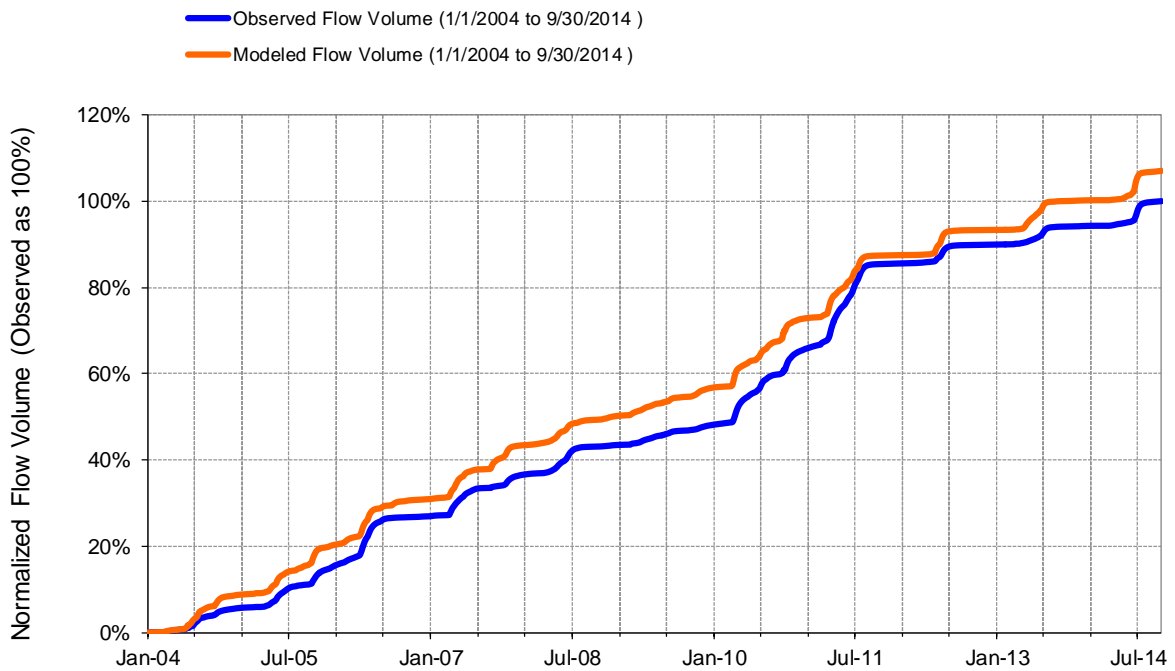


Figure 137. Flow accumulation at Des Moines River at Estherville

## MARTIN COUNTY DITCH NEAR DUNNELL (HYDSTRA 53008001)

**Table 23. Summary statistics at Martin County Ditch near Dunnell**

HSPF Simulated Flow		Observed Flow Gage	
<b>REACH OUTFLOW FROM DSN 14</b>  1.6-Year Analysis Period: 3/1/2009 - 10/31/2010 Flow volumes are (inches/year) for upstream drainage area		<b>Martin County Ditch nr Dunnell</b>  Manually Entered Data  Drainage Area (sq-mi): 36.6	
Total Simulated In-stream Flow:	<b>9.84</b>	Total Observed In-stream Flow:	<b>12.63</b>
Total of simulated highest 10% flows:	<b>4.89</b>	Total of Observed highest 10% flows:	<b>8.25</b>
Total of Simulated lowest 50% flows:	<b>0.71</b>	Total of Observed Lowest 50% flows:	<b>0.60</b>
Simulated Summer Flow Volume (months 7-9):	<b>4.55</b>	Observed Summer Flow Volume (7-9):	<b>4.82</b>
Simulated Fall Flow Volume (months 10-12):	<b>1.41</b>	Observed Fall Flow Volume (10-12):	<b>1.40</b>
Simulated Winter Flow Volume (months 1-3):	<b>0.77</b>	Observed Winter Flow Volume (1-3):	<b>3.05</b>
Simulated Spring Flow Volume (months 4-6):	<b>3.11</b>	Observed Spring Flow Volume (4-6):	<b>3.36</b>
Total Simulated Storm Volume:	<b>5.38</b>	Total Observed Storm Volume:	<b>4.63</b>
Simulated Summer Storm Volume (7-9):	<b>2.62</b>	Observed Summer Storm Volume (7-9):	<b>2.35</b>
<i>Errors (Simulated-Observed)</i>	<i>Error Statistics</i>	<i>Recommended Criteria</i>	
Error in total volume:	-22.11	10	
Error in 50% lowest flows:	17.51	10	
Error in 10% highest flows:	-40.74	15	
Seasonal volume error - Summer:	-5.60	30	
Seasonal volume error - Fall:	0.89	30	Clear
Seasonal volume error - Winter:	-74.87	30	
Seasonal volume error - Spring:	-7.46	30	
Error in storm volumes:	16.21	20	
Error in summer storm volumes:	11.38	50	
Nash-Sutcliffe Coefficient of Efficiency, E:	0.348	Model accuracy increases	
Baseline adjusted coefficient (Garrick), E':	0.325		
Monthly NSE	0.324		



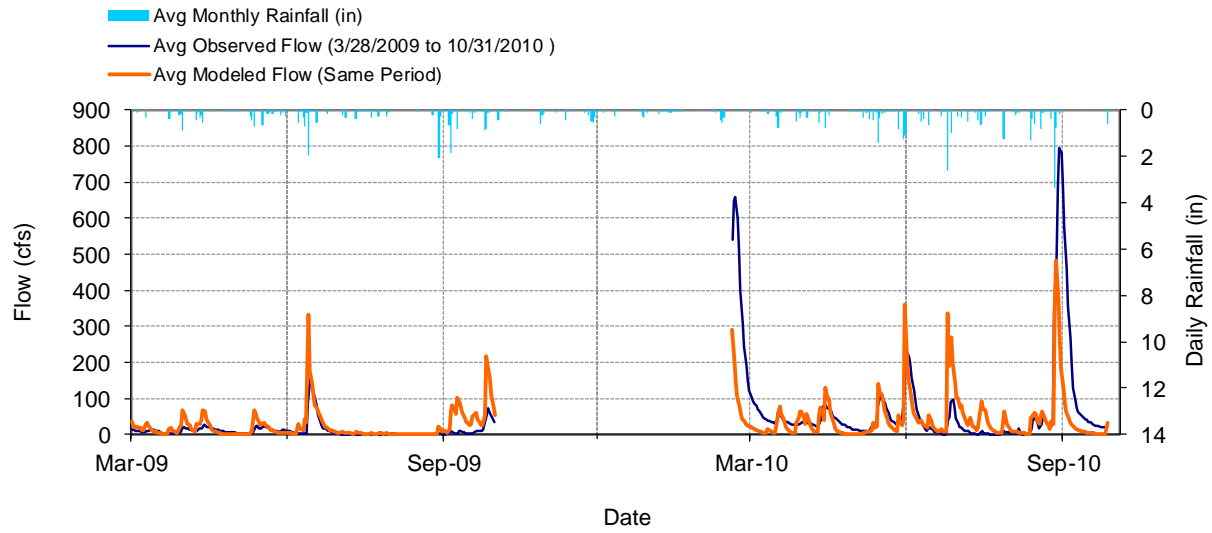


Figure 138. Mean daily flow at Martin County Ditch near Dunnell

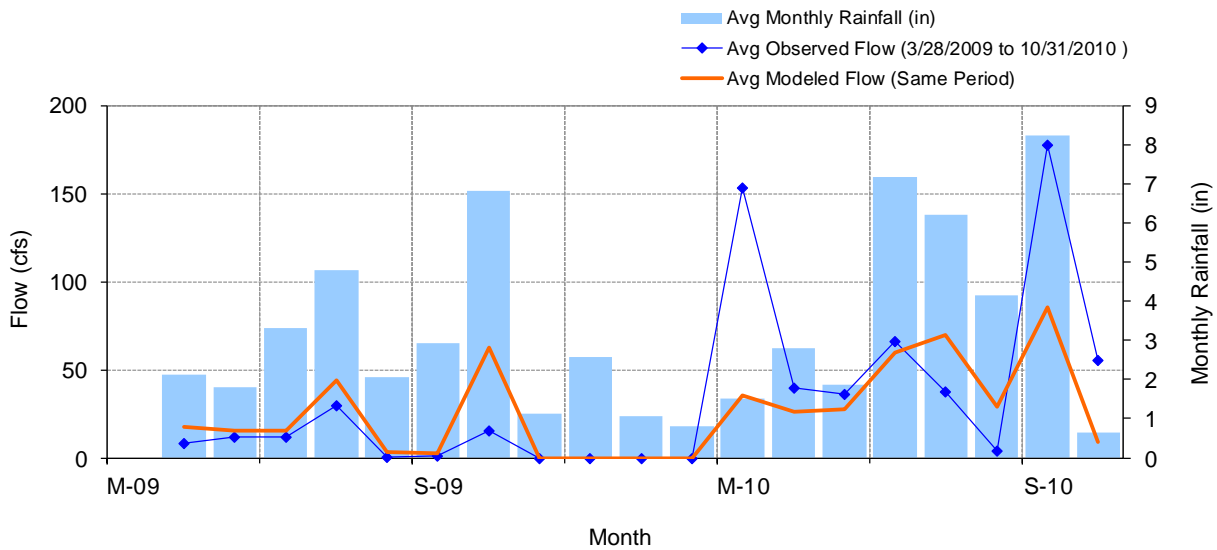


Figure 139. Mean monthly flow at Martin County Ditch near Dunnell

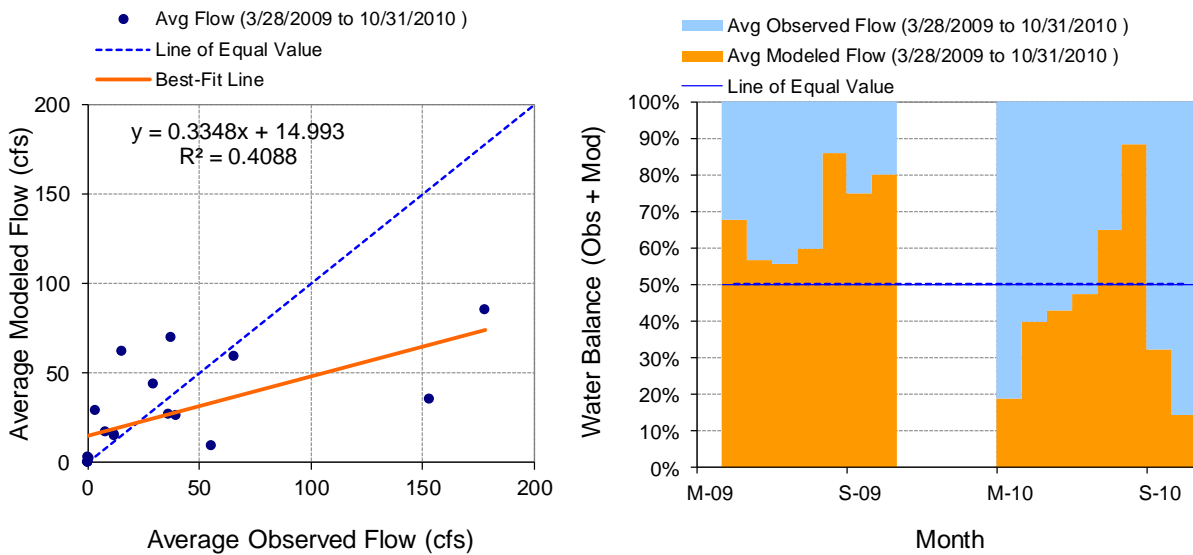


Figure 140. Monthly flow regression and temporal variation at Martin County Ditch near Dunnell

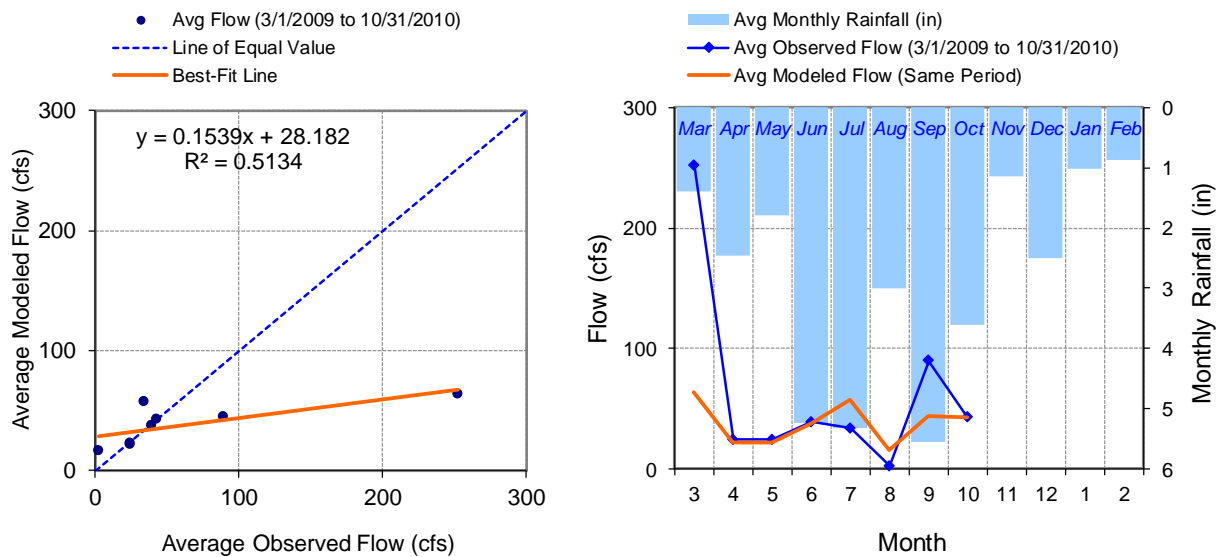


Figure 141. Seasonal regression and temporal aggregate at Martin County Ditch near Dunnell

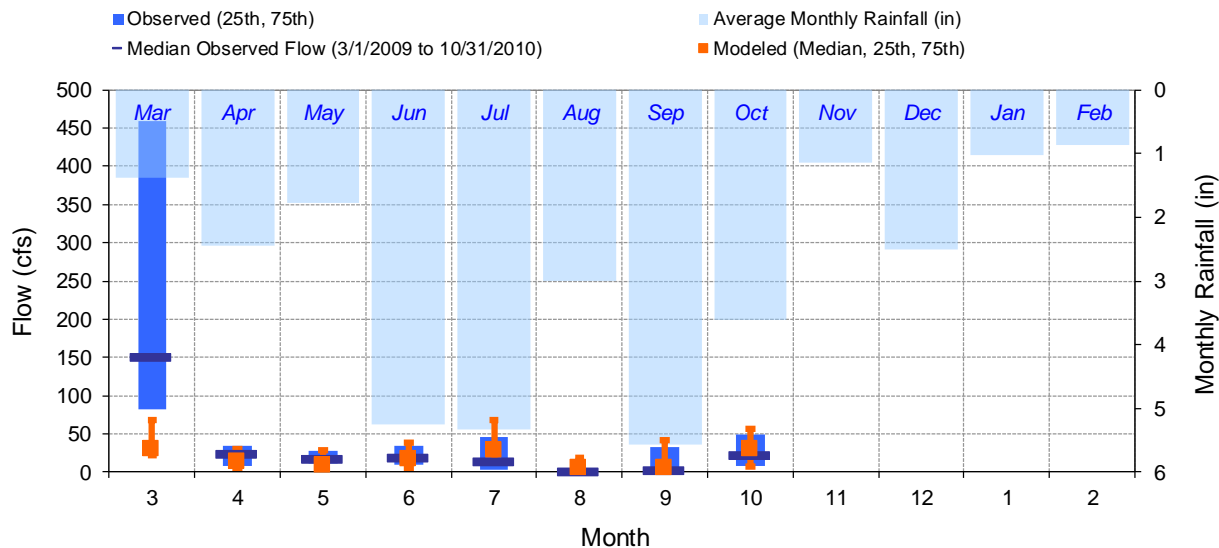


Figure 142. Seasonal medians and ranges at Martin County Ditch near Dunnell

Table 24. Seasonal summary at Martin County Ditch near Dunnell

MONTH	OBSERVED FLOW (CFS)				MODELED FLOW (CFS)			
	MEAN	MEDIAN	25TH	75TH	MEAN	MEDIAN	25TH	75TH
Mar	252.26	150.00	83.00	459.50	63.40	30.14	21.32	68.49
Apr	24.02	23.50	8.05	35.25	21.83	13.38	6.32	30.67
May	24.14	17.00	11.00	28.50	21.41	8.30	1.59	29.38
Jun	38.95	18.50	9.83	34.00	37.40	16.36	4.87	38.39
Jul	33.53	14.50	2.53	46.75	56.86	28.63	12.18	68.90
Aug	2.15	0.95	0.28	3.18	15.95	4.83	2.58	19.58
Sep	89.35	1.60	0.75	32.25	43.91	5.53	0.44	41.73
Oct	42.28	22.50	8.05	49.00	42.66	29.68	7.71	57.05
Nov	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dec	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

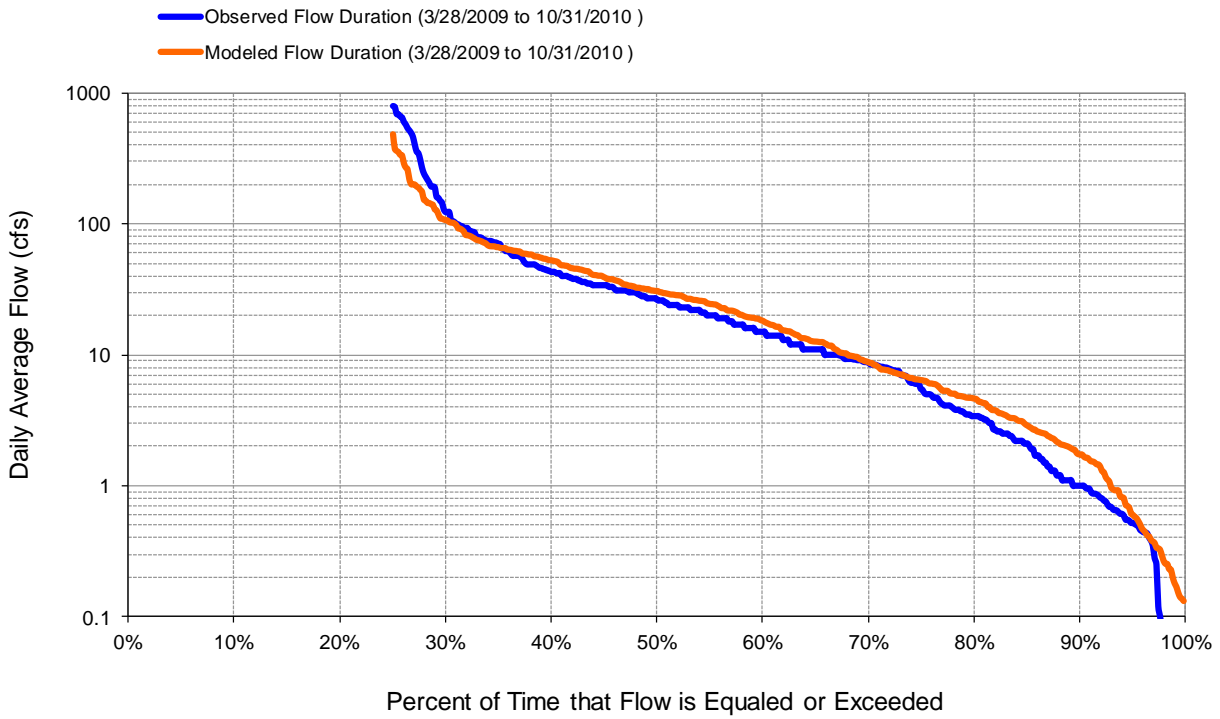


Figure 143. Flow exceedance at Martin County Ditch near Dunnell

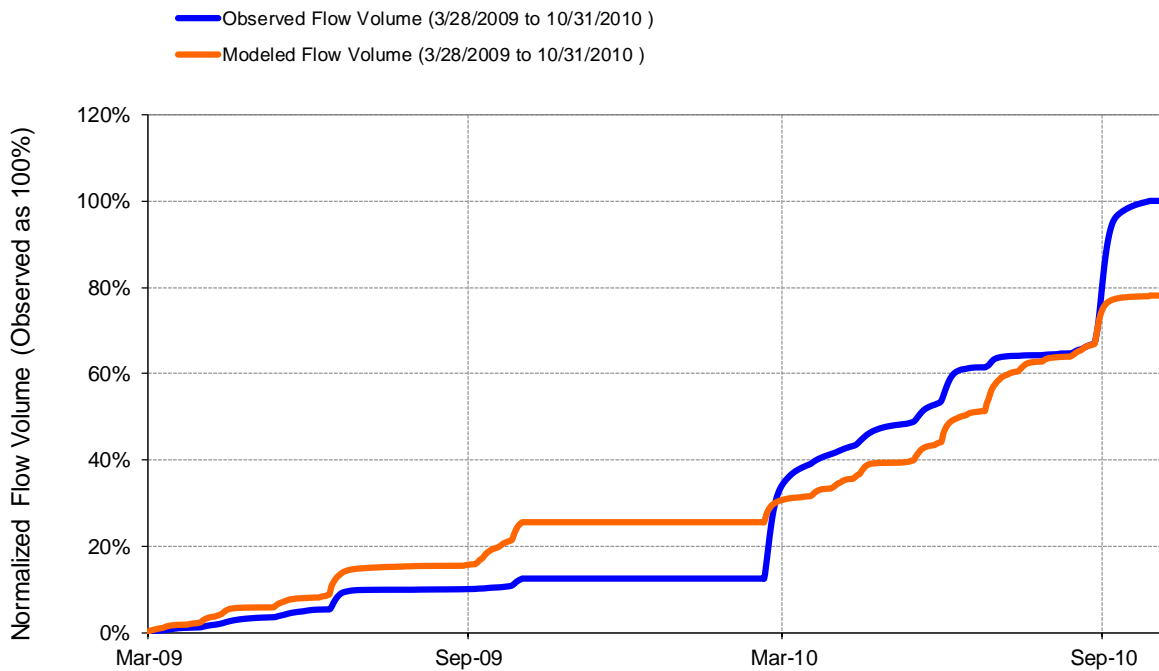


Figure 144. Flow accumulation at Martin County Ditch near Dunnell

## FOURMILE CREEK NEAR DUNNELL (HYDSTRA 53014001)

Table 25. Summary statistics at Fourmile Creek near Dunnell

HSPF Simulated Flow		Observed Flow Gage	
<b>REACH OUTFLOW FROM DSN 15</b>  1.6-Year Analysis Period: 3/1/2009 - 10/31/2010 Flow volumes are (inches/year) for upstream drainage area		<b>Fourmile Creek near Dunnell</b>  Manually Entered Data  Drainage Area (sq-mi): 15.4	
Total Simulated In-stream Flow:	<b>10.04</b>	Total Observed In-stream Flow:	<b>8.81</b>
Total of simulated highest 10% flows:	<b>4.87</b>	Total of Observed highest 10% flows:	<b>4.82</b>
Total of Simulated lowest 50% flows:	<b>0.81</b>	Total of Observed Lowest 50% flows:	<b>0.72</b>
Simulated Summer Flow Volume (months 7-9):	<b>4.62</b>	Observed Summer Flow Volume (7-9):	<b>2.72</b>
Simulated Fall Flow Volume (months 10-12):	<b>1.43</b>	Observed Fall Flow Volume (10-12):	<b>0.90</b>
Simulated Winter Flow Volume (months 1-3):	<b>0.76</b>	Observed Winter Flow Volume (1-3):	<b>1.82</b>
Simulated Spring Flow Volume (months 4-6):	<b>3.22</b>	Observed Spring Flow Volume (4-6):	<b>3.36</b>
Total Simulated Storm Volume:	<b>3.52</b>	Total Observed Storm Volume:	<b>2.13</b>
Simulated Summer Storm Volume (7-9):	<b>1.65</b>	Observed Summer Storm Volume (7-9):	<b>0.92</b>
<i>Errors (Simulated-Observed)</i>	<i>Error Statistics</i>	<i>Recommended Criteria</i>	
Error in total volume:	14.01	10	
Error in 50% lowest flows:	12.85	10	
Error in 10% highest flows:	1.09	15	
Seasonal volume error - Summer:	69.60	30	
Seasonal volume error - Fall:	58.69	30	Clear
Seasonal volume error - Winter:	-57.97	30	
Seasonal volume error - Spring:	-4.11	30	
Error in storm volumes:	65.57	20	
Error in summer storm volumes:	79.11	50	
Nash-Sutcliffe Coefficient of Efficiency, E:	0.541	Model accuracy increases	
Baseline adjusted coefficient (Garrick), E':	0.261		
Monthly NSE	0.353		

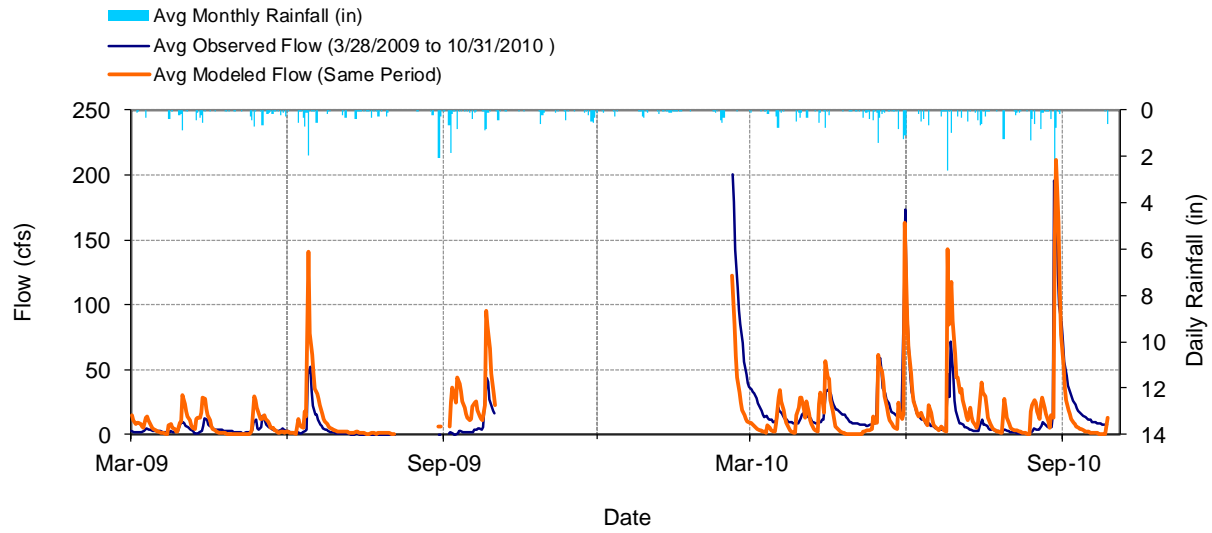


Figure 145. Mean daily flow at Fourmile Creek near Dunnell

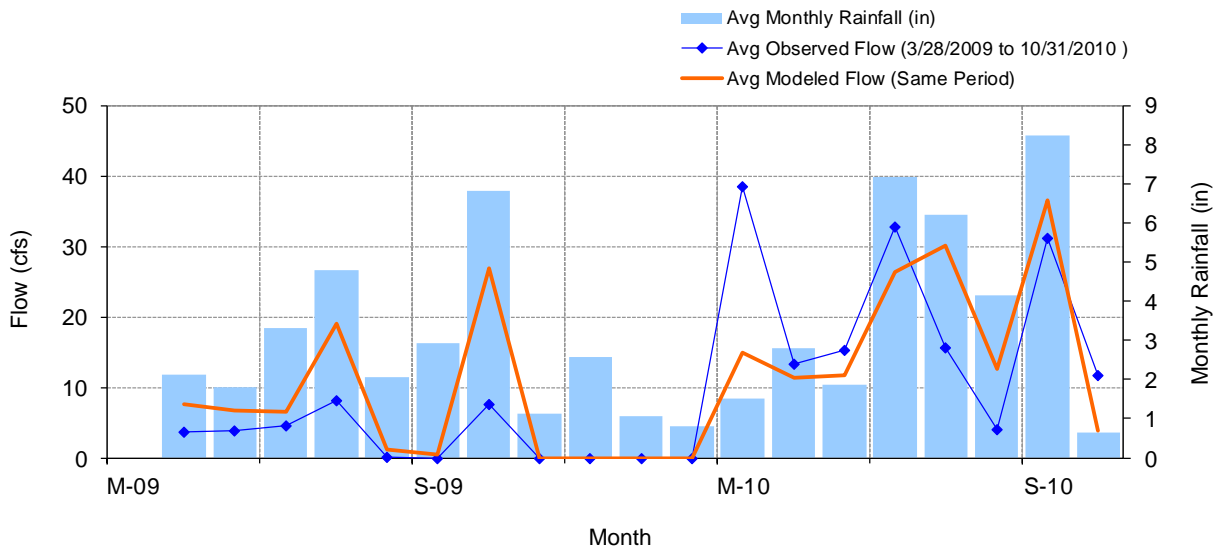


Figure 146. Mean monthly flow at Fourmile Creek near Dunnell

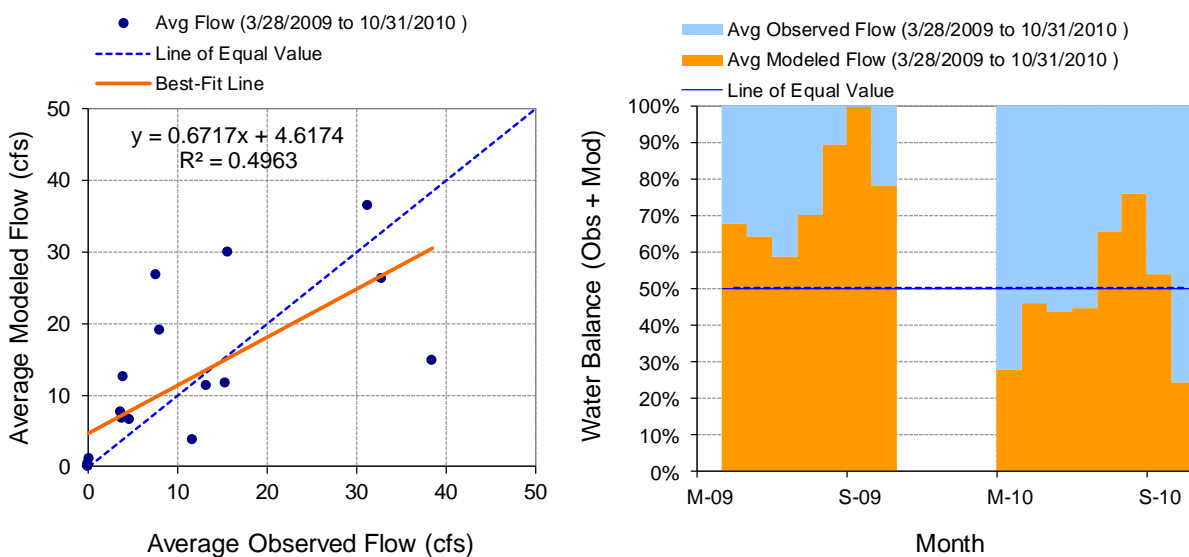


Figure 147. Monthly flow regression and temporal variation at Fourmile Creek near Dunnell

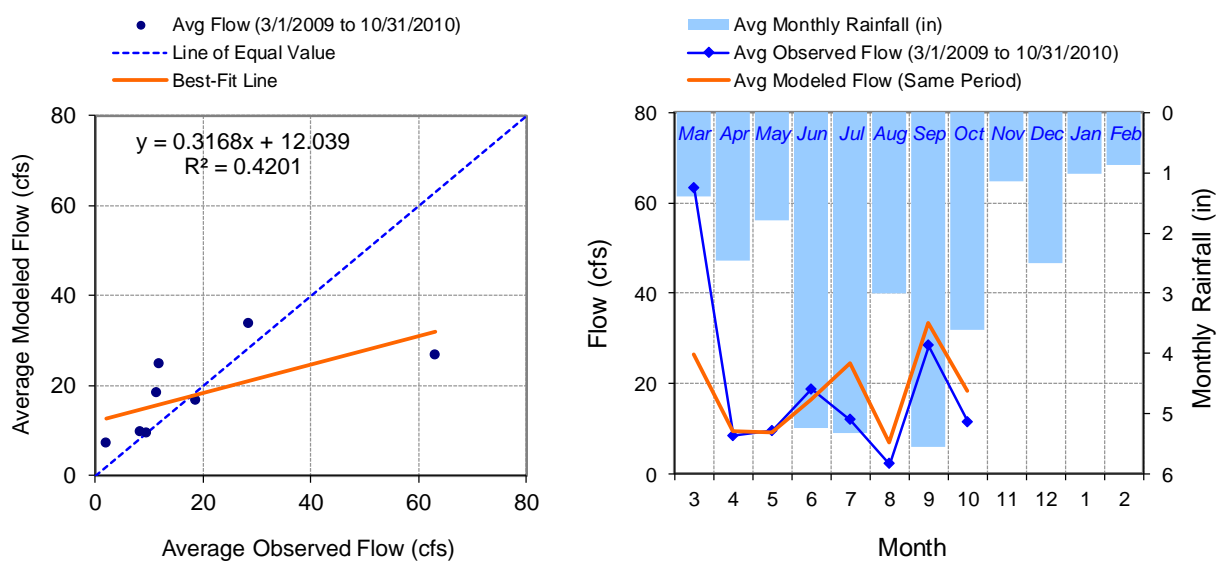


Figure 148. Seasonal regression and temporal aggregate at Fourmile Creek near Dunnell

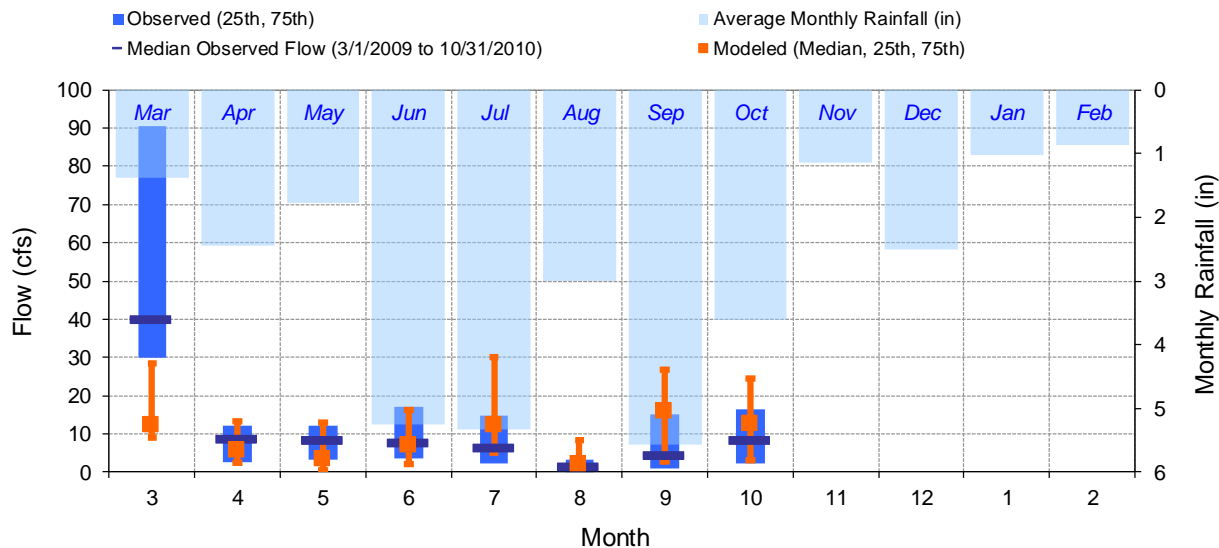


Figure 149. Seasonal medians and ranges at Fourmile Creek near Dunnell

Table 26. Seasonal summary at Fourmile Creek near Dunnell

MONTH	OBSERVED FLOW (CFS)				MODELED FLOW (CFS)			
	MEAN	MEDIAN	25TH	75TH	MEAN	MEDIAN	25TH	75TH
Mar	63.24	40.00	30.00	90.50	26.58	12.41	8.99	28.36
Apr	8.44	8.75	2.60	12.00	9.46	5.68	2.56	13.30
May	9.55	8.50	3.13	12.00	9.28	3.53	0.58	12.95
Jun	18.73	7.75	3.48	17.00	16.47	7.07	2.02	16.19
Jul	11.86	6.25	2.23	14.75	24.57	12.24	5.18	29.99
Aug	2.09	1.60	0.08	3.30	6.95	2.05	1.07	8.30
Sep	28.39	4.40	1.10	15.00	33.50	15.82	2.92	26.66
Oct	11.49	8.50	2.40	16.50	18.23	12.60	3.08	24.44
Nov	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dec	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00



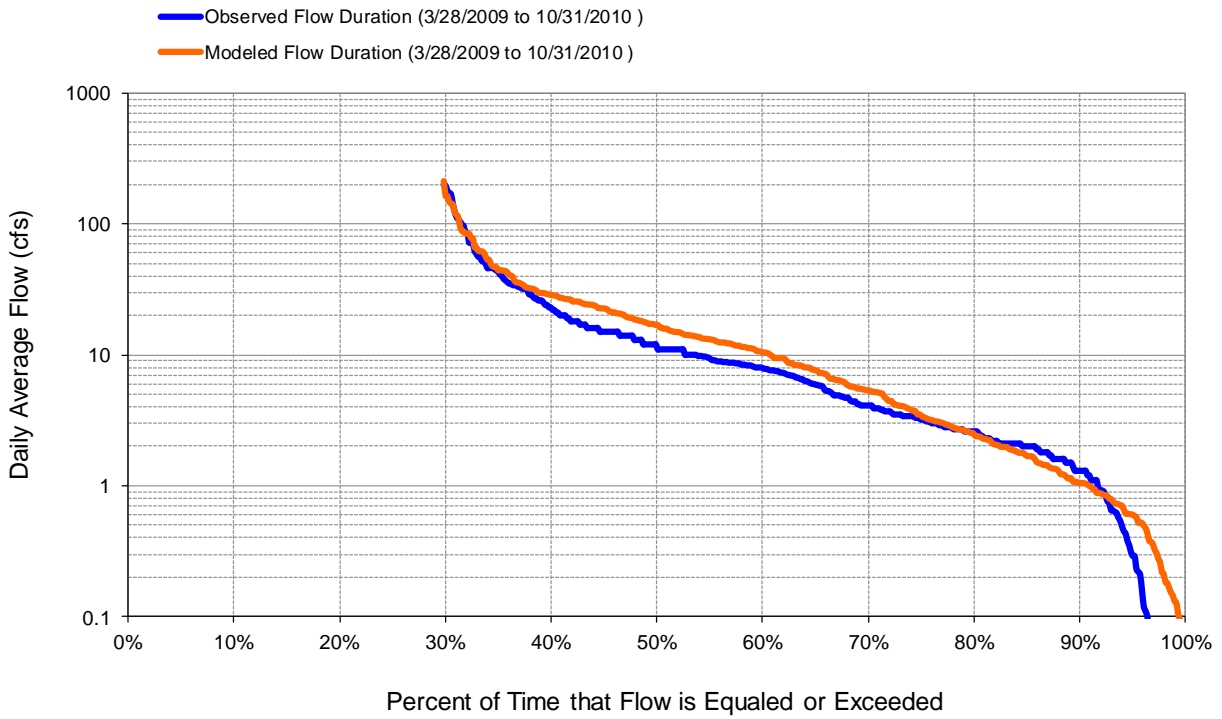


Figure 150. Flow exceedence at Fourmile Creek near Dunnell

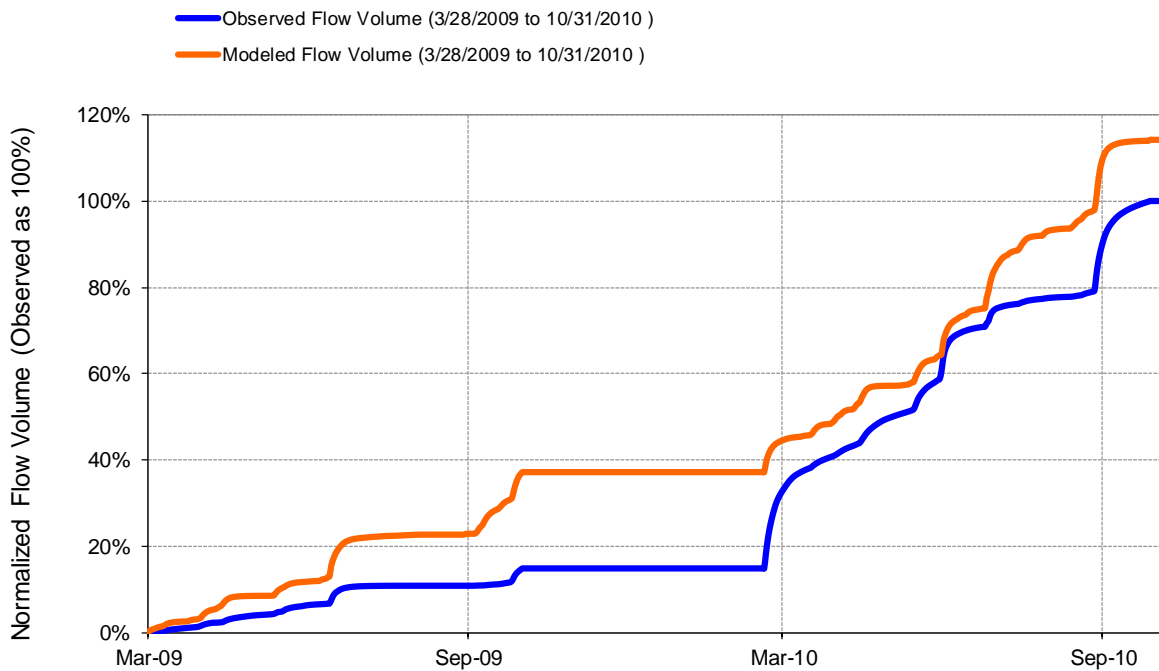


Figure 151. Flow accumulation at Fourmile Creek near Dunnell

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# Appendix C. Detailed Flow Validation Results

## DES MOINES RIVER AT JACKSON (USGS 05476000)

Table 27. Summary statistics at Des Moines River at Jackson

HSPF Simulated Flow		Observed Flow Gage	
<b>REACH OUTFLOW FROM DSN 12</b>  9-Year Analysis Period: 10/1/1995 - 9/30/2004 Flow volumes are (inches/year) for upstream drainage area		<b>Des Moines River at Jackson</b>  Manually Entered Data Drainage Area (sq-mi): 1250	
Total Simulated In-stream Flow:	<b>4.52</b>	Total Observed In-stream Flow:	<b>4.97</b>
Total of simulated highest 10% flows:	<b>2.30</b>	Total of Observed highest 10% flows:	<b>2.52</b>
Total of Simulated lowest 50% flows:	<b>0.32</b>	Total of Observed Lowest 50% flows:	<b>0.30</b>
Simulated Summer Flow Volume (months 7-9):	<b>1.19</b>	Observed Summer Flow Volume (7-9):	<b>0.92</b>
Simulated Fall Flow Volume (months 10-12):	<b>0.44</b>	Observed Fall Flow Volume (10-12):	<b>0.55</b>
Simulated Winter Flow Volume (months 1-3):	<b>0.58</b>	Observed Winter Flow Volume (1-3):	<b>0.48</b>
Simulated Spring Flow Volume (months 4-6):	<b>2.32</b>	Observed Spring Flow Volume (4-6):	<b>3.02</b>
Total Simulated Storm Volume:	<b>1.33</b>	Total Observed Storm Volume:	<b>1.16</b>
Simulated Summer Storm Volume (7-9):	<b>0.41</b>	Observed Summer Storm Volume (7-9):	<b>0.24</b>
<i>Errors (Simulated-Observed)</i>	<i>Error Statistics</i>	<i>Recommended Criteria</i>	
Error in total volume:	-8.98	10	
Error in 50% lowest flows:	6.03	10	
Error in 10% highest flows:	-8.83	15	
Seasonal volume error - Summer:	29.81	30	
Seasonal volume error - Fall:	-20.57	30	
Seasonal volume error - Winter:	20.37	30	Clear
Seasonal volume error - Spring:	-23.31	30	
Error in storm volumes:	15.08	20	
Error in summer storm volumes:	71.92	50	
Nash-Sutcliffe Coefficient of Efficiency, E:	0.724	Model accuracy increases	
Baseline adjusted coefficient (Garrick), E':	0.573		
Monthly NSE	0.794		

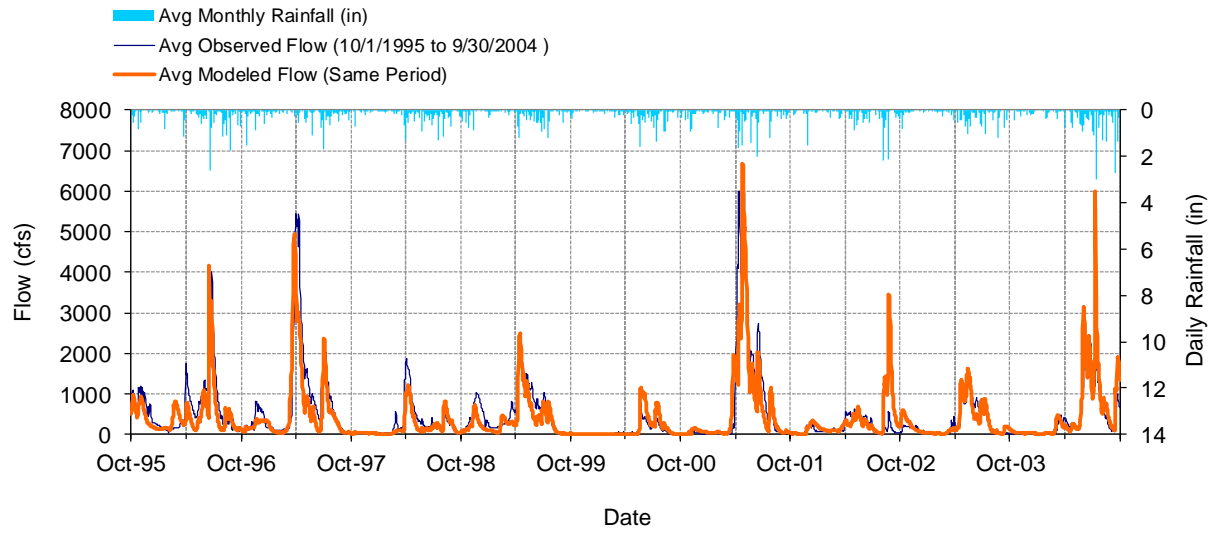


Figure 152. Mean daily flow at Des Moines River at Jackson

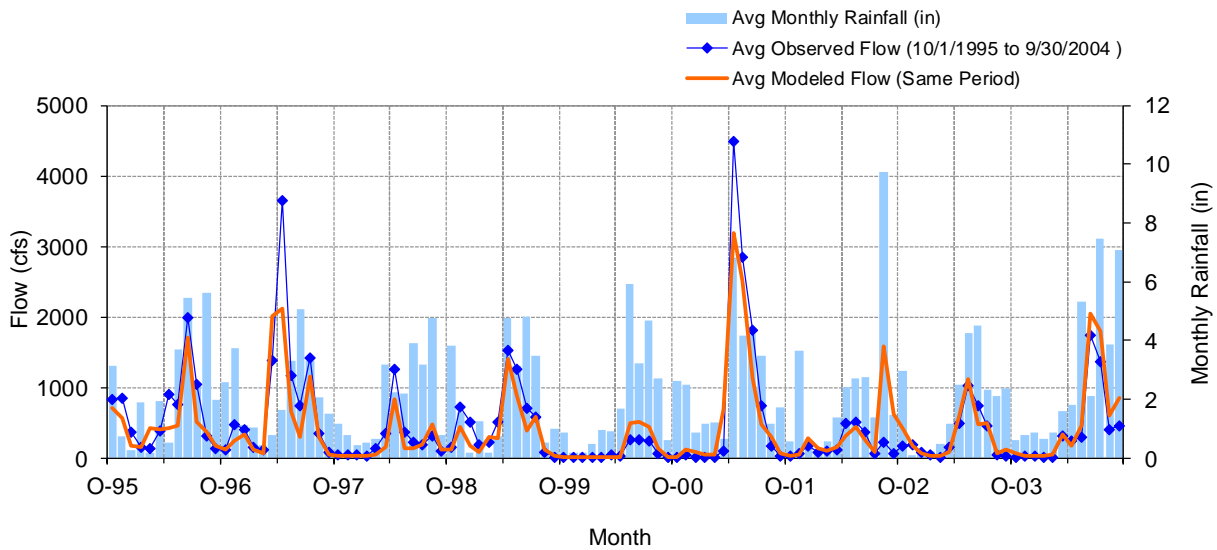


Figure 153. Mean monthly flow at Des Moines River at Jackson

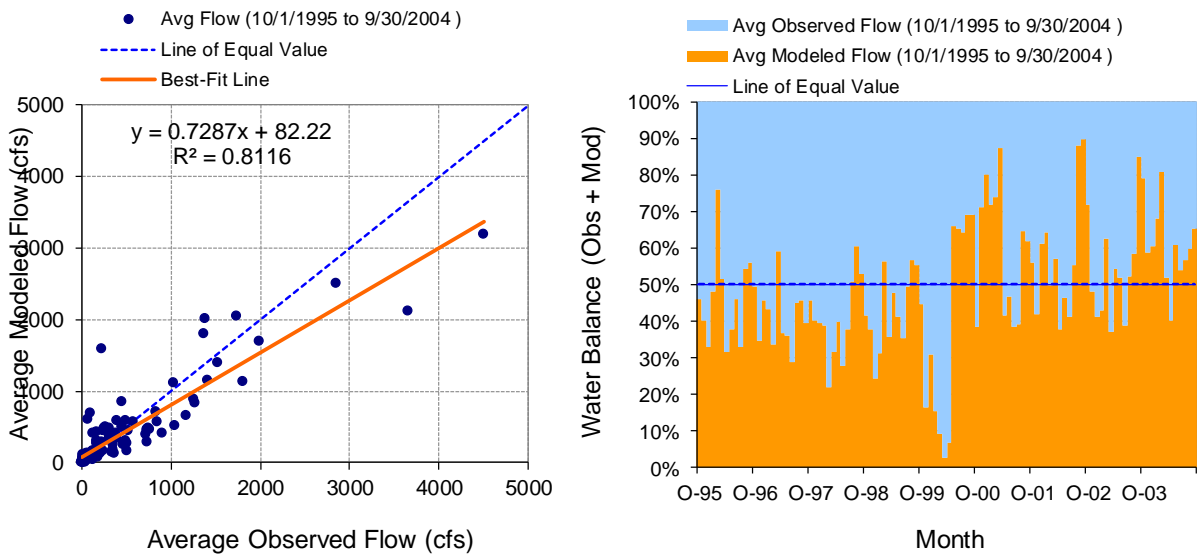


Figure 154. Monthly flow regression and temporal variation at Des Moines River at Jackson

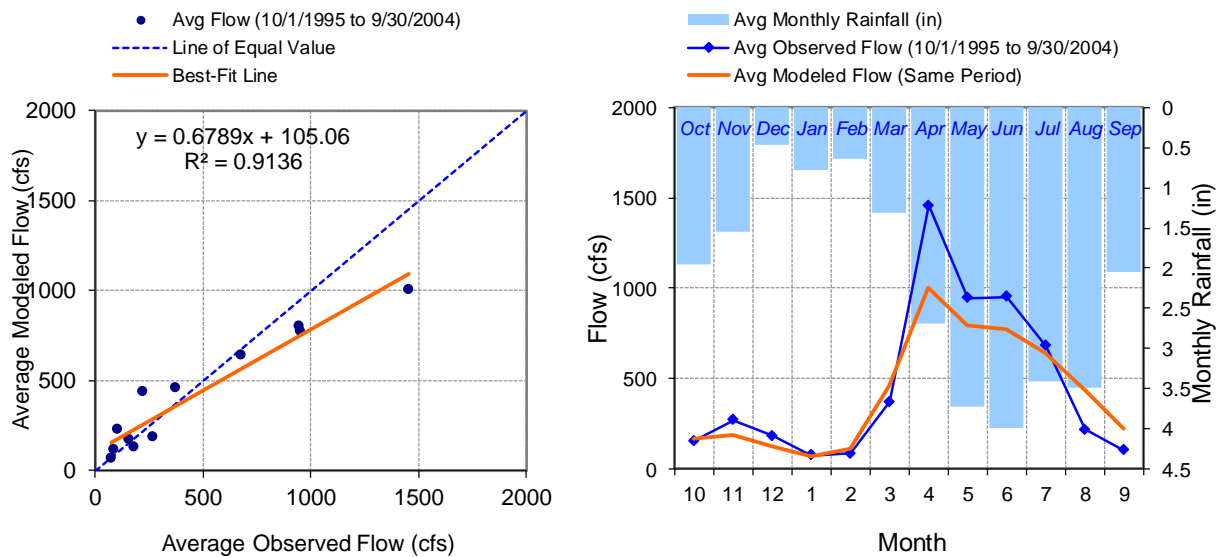


Figure 155. Seasonal regression and temporal aggregate at Des Moines River at Jackson

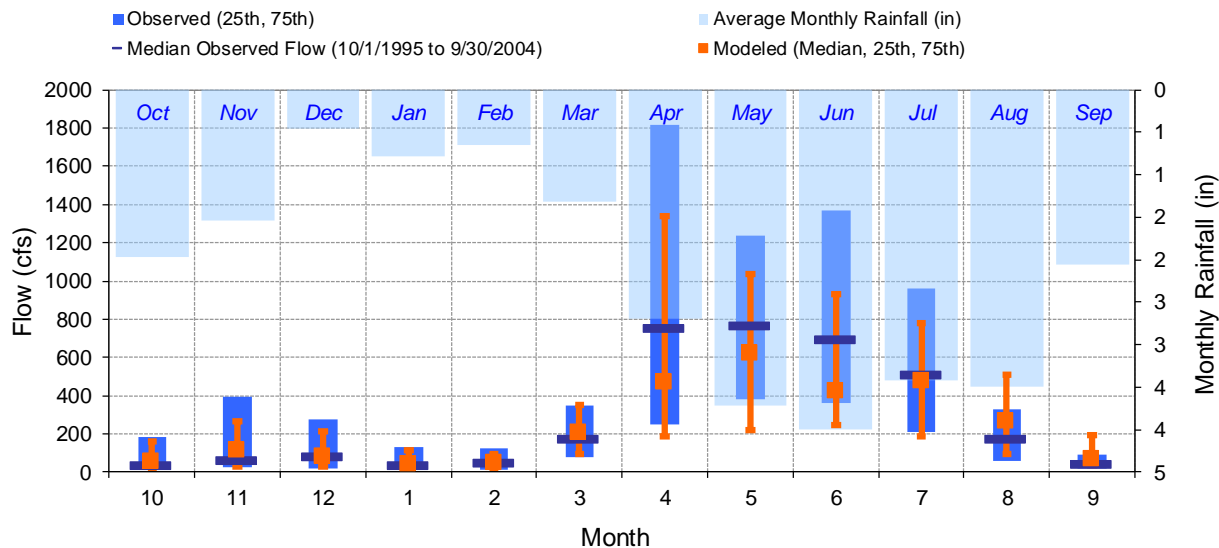


Figure 156. Seasonal medians and ranges at Des Moines River at Jackson

Table 28. Seasonal summary at Des Moines River at Jackson

MONTH	OBSERVED FLOW (CFS)				MODELED FLOW (CFS)			
	MEAN	MEDIAN	25TH	75TH	MEAN	MEDIAN	25TH	75TH
Oct	154.76	36.00	19.00	186.00	168.23	58.31	22.44	162.70
Nov	269.45	62.50	24.00	396.50	183.59	111.96	27.88	263.22
Dec	180.31	82.00	20.00	273.50	127.39	80.67	30.18	211.99
Jan	74.18	38.00	15.50	130.00	65.95	40.05	20.93	111.47
Feb	83.64	50.00	14.00	125.00	112.28	51.79	23.03	92.62
Mar	370.16	177.00	79.50	349.50	458.29	208.40	92.79	352.70
Apr	1457.82	756.00	247.50	1817.50	1003.36	470.08	188.55	1338.41
May	944.68	769.00	379.50	1235.00	796.67	621.84	223.00	1035.44
Jun	952.67	692.50	364.75	1367.50	770.67	426.04	244.61	930.51
Jul	678.67	512.00	213.00	964.00	636.63	477.71	188.40	780.35
Aug	217.51	175.00	62.00	326.00	438.00	263.88	96.09	512.69
Sep	101.54	42.00	19.00	89.75	223.50	67.91	33.83	195.19

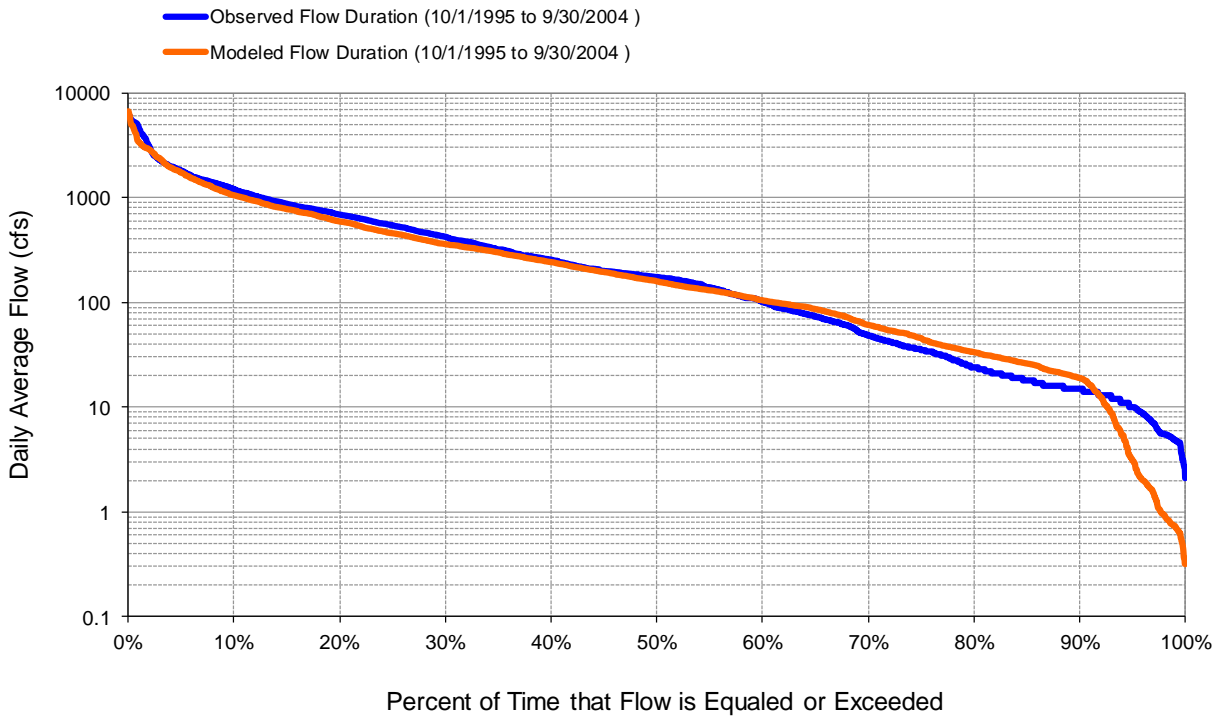


Figure 157. Flow exceedance at Des Moines River at Jackson

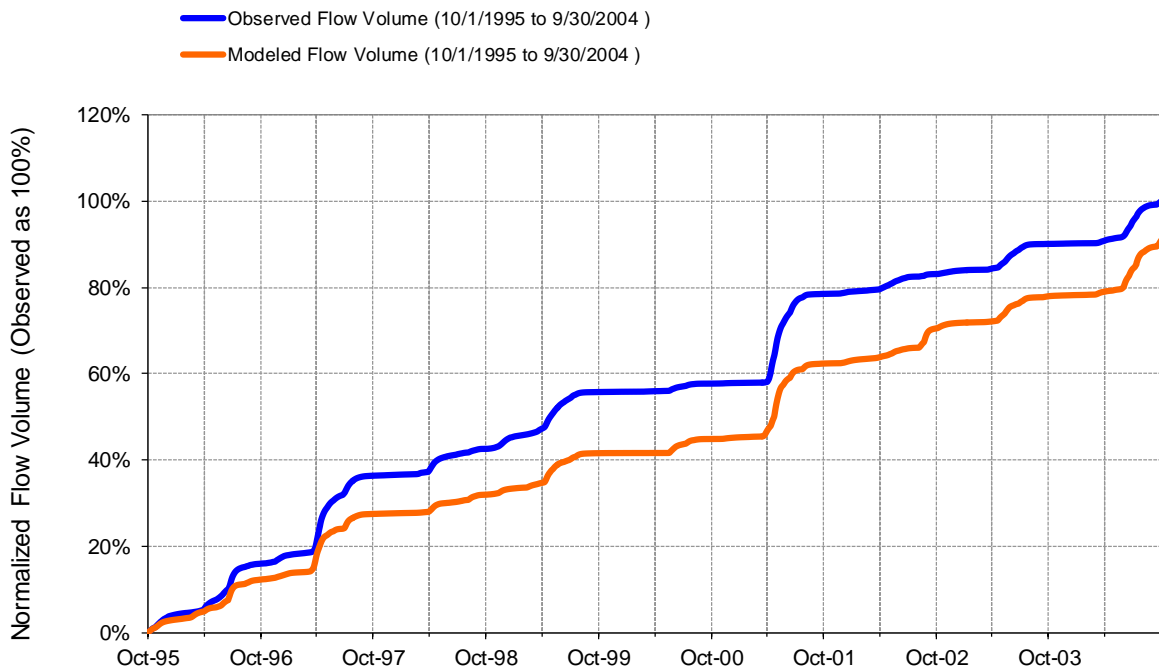


Figure 158. Flow accumulation at Des Moines River at Jackson