STREAMFLOW TREND ANALYSIS OF UPPER MULLICA RIVER BASIN STREAMS

by

Nicholas A. Procopio

July 21, 2003

INTRODUCTION

In 1991, the Pinelands Commission initiated a stream-discharge monitoring program in cooperation with the U.S. Geological Survey (USGS) and the Camden County Municipal Utilities Authority (CCMUA). The program is designed to monitor the potential impact of inter-basin transfers of water on the streamflows of 12 upper Mullica River basin streams. The primary source of water withdrawal in the study area is currently groundwater pumped from individual private water-supply wells. Treated water is eventually discharged to the Delaware River.

An initial trend analysis of the same streams revealed no changes in streamflow during the period 1991 – 1998 (Zampella et al. 2001). Using the same trend-analysis methodology, I evaluated changes in streamflow at the Mullica River basin sites from 1991 through 2002. The results of the 12-year analysis are described in this report. A detailed assessment of the trend-analysis methodology is presented in Dow (1999).

METHODS

Study Sites

The 12 study sites are located in the western portion of the Mullica River basin in Camden County (Table 1, Figure 1). Watershed areas for the sites ranges from 5.0 to 44.3 km^2. The USGS completed discharge measurements at each study site under base flow conditions from April 1991 - September 2002. Base flow represents the groundwater component of stream discharge with little or no contribution from runoff. Based on the recommendation by the USGS, monitoring at Cooper Branch near Chesilhurst and Great Swamp Branch at Elm was discontinued in October 2001.

The number of annual stream-gaging events completed at each site varied from monthly to quarterly (Table 2). Autocorrelation between sampling events, which tends to inflate the significance of the statistical relationships, can be minimized with the use of quarterly discharge measurements (Dow 1999). For those years when gaging was completed more than four times, the first available discharge measurement in each quarter was used. Study sites were analyzed separately, except for Sleeper Branch near Atsion and Sleeper Branch Diversion Channel (Saltars Ditch). Saltars Ditch is a small channel that diverts water from the Sleeper Branch to the Mullica River directly above the gaging sites. The relative flow contribution of Saltars ditch to the Mullica River is low (about 2.8%). To account for water lost from Sleeper Branch via Saltars Ditch, streamflows for these two sites were combined prior to analysis. This combination resulted in 11 study sites.

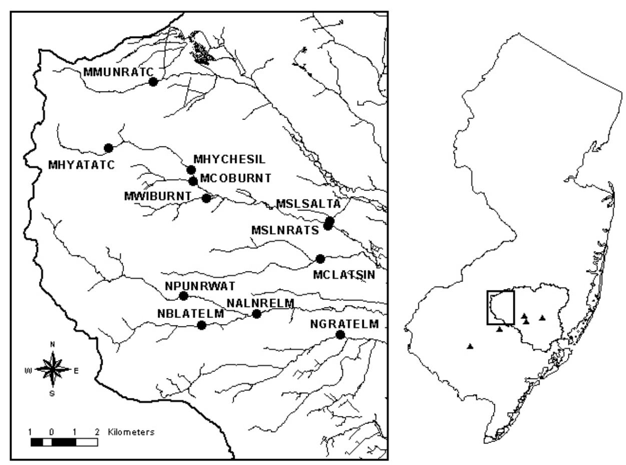


Figure 1. Location of study sites in the upper Mullica River basin. The inset shows five USGS index sites as triangles.

Table 1. Study sites in the upper Mullica River Basin.

Study Site Code	Study Site Description	USGS Station #	Drainage Area (km^2)
MCLATSIN	Clark Branch near Atsion	0140940480	16.6
MCOBURNT	Cooper Branch near Chesilhurst	0140940250	5.0
MHYATATC	Hays Mill Creek near Atco	01409401	9.8
MHYCHESI	Hays Mill Creek near Chesilhurst	01409402	18.5
MMUNRATC	Mullica River near Atco	01409375	8.3
MSLNRATS	Sleeper Branch near Atsion	0140940370	41.7
MSLSALTA	Sleeper Branch Diversion (Saltars Ditch) near Atsion	0140940365	-
MWIBURNT	Wildcat Branch near Chesilhurst	0140940310	5.9
NALNRELM	Albertson Brook near Elm	0140940970	44.3
NBLATELM	Blue Anchor Brook at Elm	0140940950	12.6
NGRATELM	Great Swamp Branch at Elm	0140941050	7.3
NPUNRWAT	Pump Branch near Waterford Works	01409408	25.3

Table 2. Number of stream-gaging events performed by USGS at each study site.

Study Site	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
MCLATSIN	6	11	10	4	4	12	4	4	4	4	4	4
MCOBURNT	6	11	10	4	4	12	4	4	4	4	4	-
MHYATATC	6	11	10	4	4	12	4	4	4	4	4	4
MHYCHESIL	6	11	10	4	4	12	4	4	4	4	4	4
MMUNRATC	6	11	10	4	4	12	4	4	4	4	4	5
MSLNRATS	6	11	10	4	4	12	4	4	4	4	4	4
MSLSALTA	6	11	10	4	4	12	4	4	4	4	4	4
MWIBURNT	6	11	10	4	4	12	4	4	4	4	4	4
NALNRELM	6	11	10	4	4	12	4	4	4	4	4	4
NBLATELM	6	11	10	4	4	12	4	4	4	8	4	7
NGRATELM	6	11	10	4	4	12	4	4	4	4	4	-
NPUNRWAT	5	11	10	4	4	12	4	4	4	4	4	4

Index Sites

Seven stream sites were selected as index sites (Table 3). The index sites, which were used to evaluate changes in streamflow at the study sites, were monitored continuously by USGS throughout the study period. Mean daily streamflow values for each index site were obtained from the USGS and matched with corresponding study-site discharge dates.

Table 3. USGS Index sites.

Index Site Name	USGS Station #	Drainage Area (km^2)
Batsto River at Batsto	01409500	175.6
East Branch Bass River	01410150	21.0
Great Egg Harbor River at Folsom	01411000	147.9
Maurice River at Norma	01411500	290.1
Mullica River near Batsto	01409400	121.0
North Branch Rancocas Creek	01467000	305.6
Oswego River at Harrisville	01410000	187.8

Trend Analyses

I evaluated the relationship between study-site and index-site streamflow values using Pearson product moment correlation. The Pearson r-value provides a measure of the strength of the relationship between discharge at the study-sites and index-sites.

For the trend analysis, streamflow data from the seven index sites were used to remove some of the background variability in the study-site discharge data. Background variability includes seasonal and annual variations in stream discharge unrelated to external stresses imposed by water withdrawals. Removing background variability improves the chances of detecting an existing streamflow trend. To remove variability, I used simple linear regression to relate streamflow at a study site to that at an index site. The resulting regression model was then used to predict study-site streamflows based on the measured index-site values. The difference between the predicted and the actual study-site streamflow values are referred to as residuals. A change in the residuals through time indicates that a change in baseflow has occurred. A total of 77 regression models (7 index sites x 11 study sites) were developed and residuals were calculated.

To determine whether significant monotonic changes in the residuals occurred through time, I used the Mann-Kendall test. This test utilizes Kendall's tau statistic to indicate the direction of trends. For example, a negative tau statistic indicates a trend of decreasing streamflow through time relative to the index site streamflows. The Mann-Kendall test is preferred over regression for trend tests because Kendall's tau is resistant to outliers and does not require normally distributed data (Helsel and Hirsch 1992).

For each study site-index site comparison, I also calculated a Theil slope, which is a measure of the magnitude of the trend slope (Helsel and Hirsch 1992). Theil slope estimates were multiplied by four to express the trend magnitude as an annual change in streamflow rather than a quarterly change. The annual change was then converted to an annual percentage change in streamflow using $(10^{\beta}-1)*100$, where β is equal to the Theil slope (Hirsch et al. 1991).

The same trend analysis was completed for the index sites. Results of this analysis were used to determine if the index sites displayed changes in streamflow during the study period.

The results of the Mann-Kendall tests were evaluated using an alpha value of 0.05 and 0.10. For both significance levels, I applied the sequential Bonferroni significance-level adjustment to groups of related Mann-Kendall tests (Rice 1989). This technique corrects for multiple comparisons by reducing the chance of making an erroneous conclusion that streamflow is changing in a particular index or study stream. All data were log transformed prior to analysis. Statistical analyses were completed using Intercooled Stata 6.0 (Stata Corp., College Station, TX, 1999).

RESULTS

The correlation between study-site and index-site streamflows was generally high for nine of the 11 study sites (Table 4). The remaining two study sites, Pump Branch near Waterford Works and Wildcat Branch near Chesilhurst, showed the weakest relationships with index-site streamflows. Of the seven index sites, the Great Egg Harbor River and Maurice River had the largest Pearson r-values for the majority of the study sites, indicating the strongest relationships with study-site streamflows (Table 4). In contrast, the East Branch Bass River and Oswego River index sites showed the weakest relationship with streamflows for most study-sites.

A statistically significant decrease in streamflow was found for nine of the eleven study sites (Table 4, Figure 2). Six of these sites showed a decrease in flow even after correcting for multiple comparisons. The six sites were Clark Branch near Atsion, Hays Mill Creek near Atco, Hays Mill Creek near Chesilhurst, Mullica River near Atco, Sleeper Branch/Saltars Ditch, and Albertson Brook near Elm. The number of index sites that indicated a decrease in flow for these six study sites ranged from five, for the Mullica River near Atco site, to one or two for the other study sites. Based on the Theil slope values, the largest estimated annual percentage decreases in discharge generally occurred for the same six study sites (Table 4). Statistically significant decreases in streamflow were not detected for any study site using the Batsto River and Mullica River index sites.

Streamflow relationships among the seven index sites were strong (Table 5). Pearson r-values were >0.71 for all comparisons. After correcting for multiple comparisons, several index sites showed significant changes in streamflow during the study period when compared to other index sites. Four of the index sites indicated that a decrease in streamflow occurred for the Batsto River index site. Based on the East Branch Bass River index site, streamflow for three other index sites also decreased. In contrast to these decreases, six index sites showed that streamflow for the East Branch Bass River site increased during the period.

DISCUSSION

The results of this trend analysis are ambiguous. Graphical analysis of the residuals from the various study-site and index-site comparisons suggests that streamflows decreased in the Mullica River basin study area towards the end of the 12-year study period. However, after correcting for multiple comparisons, statistically significant decreases were found for only some study sites and these relationships were generally associated with the same index-sites.

The significant decrease in Albertson Brook flows was not reflected in the flows of the two contributing streams, Pump Branch and Blue Anchor Brook. These two tributaries are the planned source of water-diversion impacts.

The lack of a significant relationship between the Mullica River index site and the Mullica River near Atco study site may be because this index station is downstream from the study site. Impacts to a lower-order stream may influence flows at the downstream site, thus masking any real decreases. Conversely, if the decrease in upstream flow is real, the Mullica River index site should show a significant decrease when compared to the other index sites. After correcting for multiple comparisons, only the East Branch Bass River site indicated that Mullica River flows decreased.

The effect of regional differences in precipitation patterns and recent prolonged drought conditions on the results of the analysis cannot be discounted. The Batsto River index site displayed a decrease in streamflow even though there was no major transfer of water from this basin. When compared to the East Branch Bass River site, flow decreased at most of the other index sites.

CONCLUSION

The decreases in streamflows detected within the Camden County study area appear to coincide with an obvious increase in wastewater flows to the Delaware River (Figure 3). However, for most of the study sites that showed a significant decrease in flow, the annual percentage decreases estimated through the analysis far exceeded the amount of water withdrawn. The surest way to resolve the ambiguity of the results of the analysis is to conduct a subbasin by subbasin assessment of water withdrawals to determine if the significant decreases in streamflow are associated with actual withdrawals.

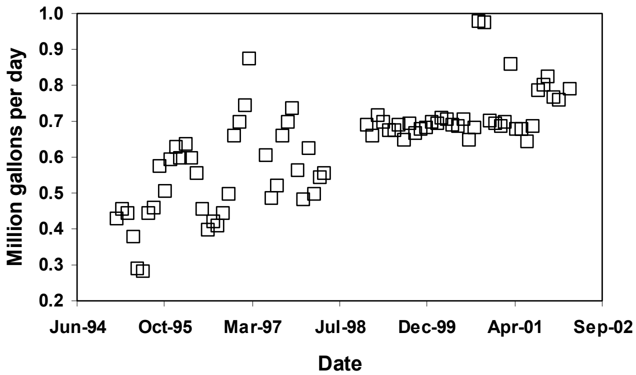


Figure 3. Wastewater flows from the upper Mullica River basin.

LITERATURE CITED

Dow, C. L. 1999. Detecting Base Flow Impacts in Coastal Plain Streams. *Journal of American Water Resources Association*, 35:349-362.

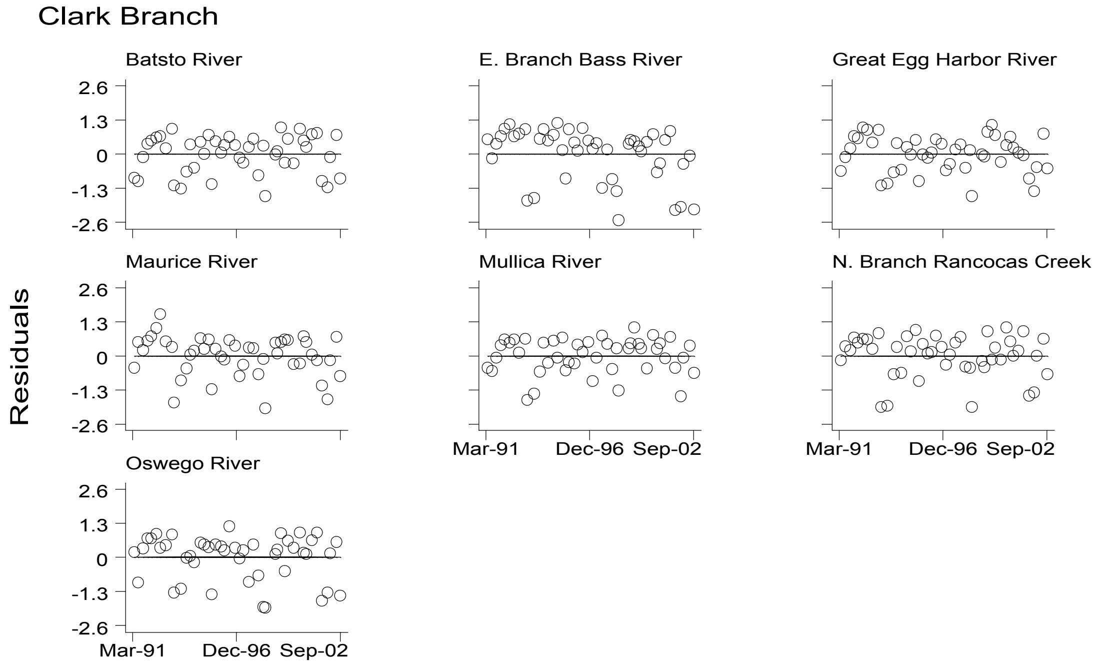
Helsel, D.R. and R.M. Hirsch. 1992. Statistical Methods in Water Resources. Elsevier, New York, NY.

Hirsch, R. M., R. B. Alexander, and R. A. Smith. 1991. Selection of Methods for the Detection and Estimation of Trends in Water Quality. Water Resources Research. 27:803-813.

Rice, W. R. 1989. Analyzing tables of statistical tests. Evolution 43:223-225.

Zampella, R. A., J. F. Bunnell, K. J. Laidig, and C. L. Dow. 2001. The Mullica River Basin: A report to the Pinelands Commission on the status of the landscape and selected aquatic and wetland resources. Pinelands Commission, New Lisbon, NJ.

Figure 2. Plots of residuals versus time for each study site-index site comparison. See Table 1 for study-site descriptions and Table 3 for index-site descriptions.



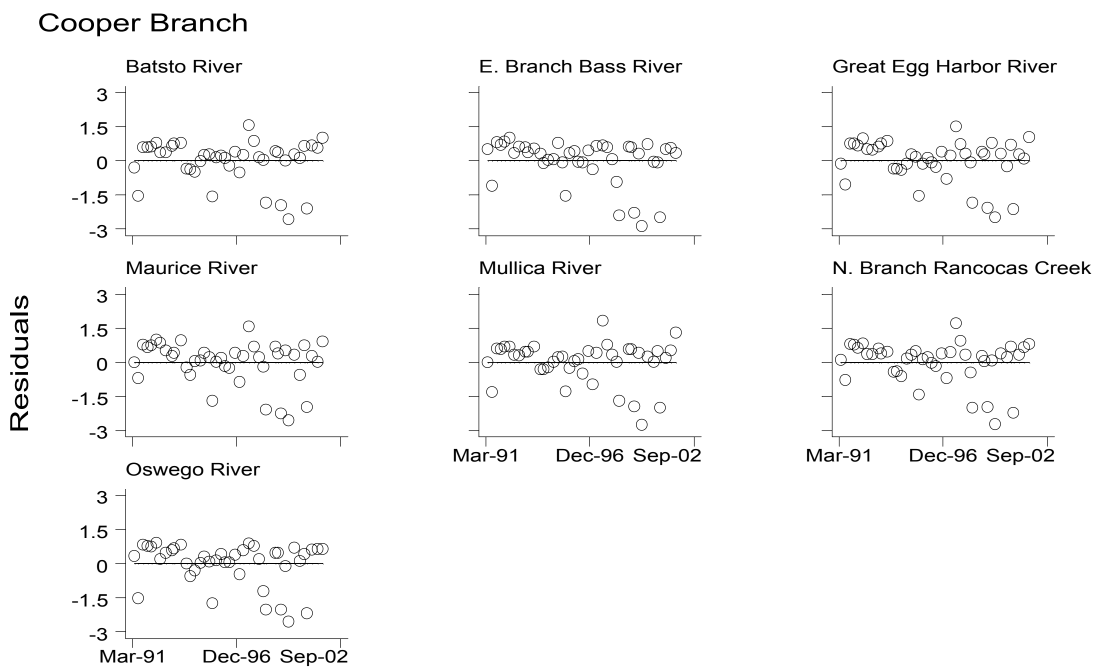
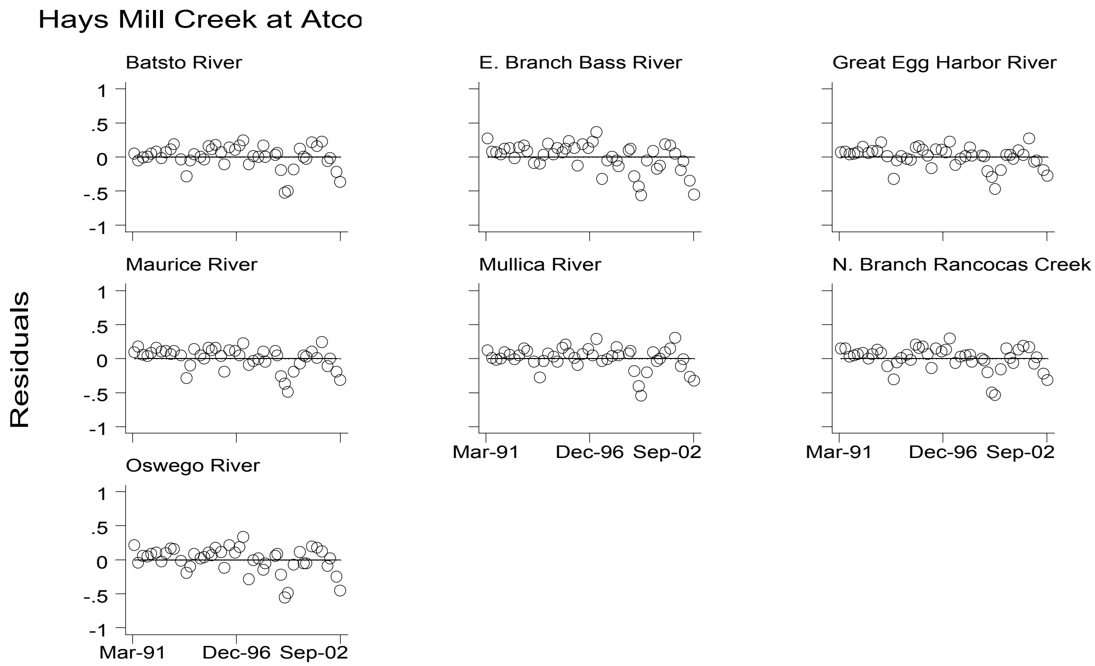


Figure 2 continued.



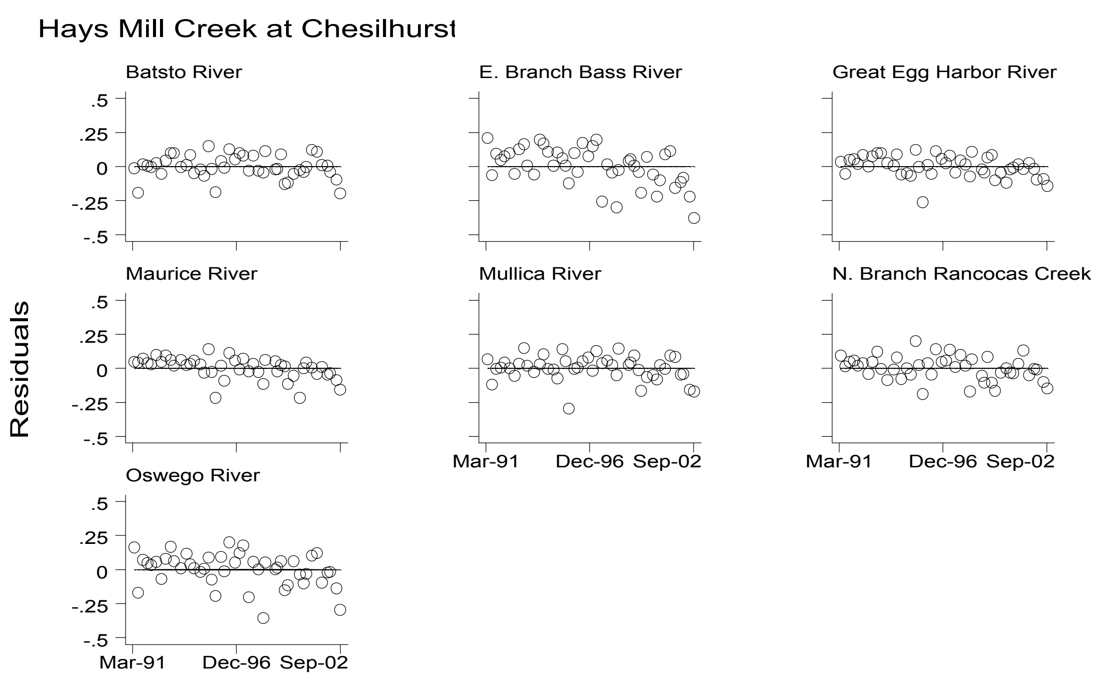
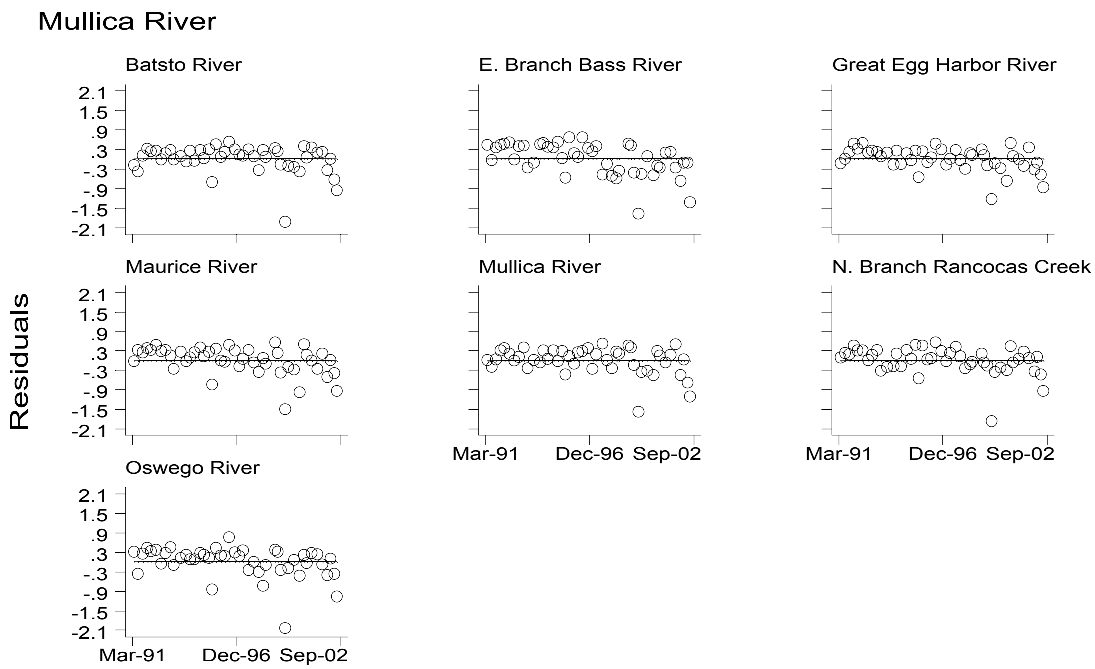


Figure 2 continued.



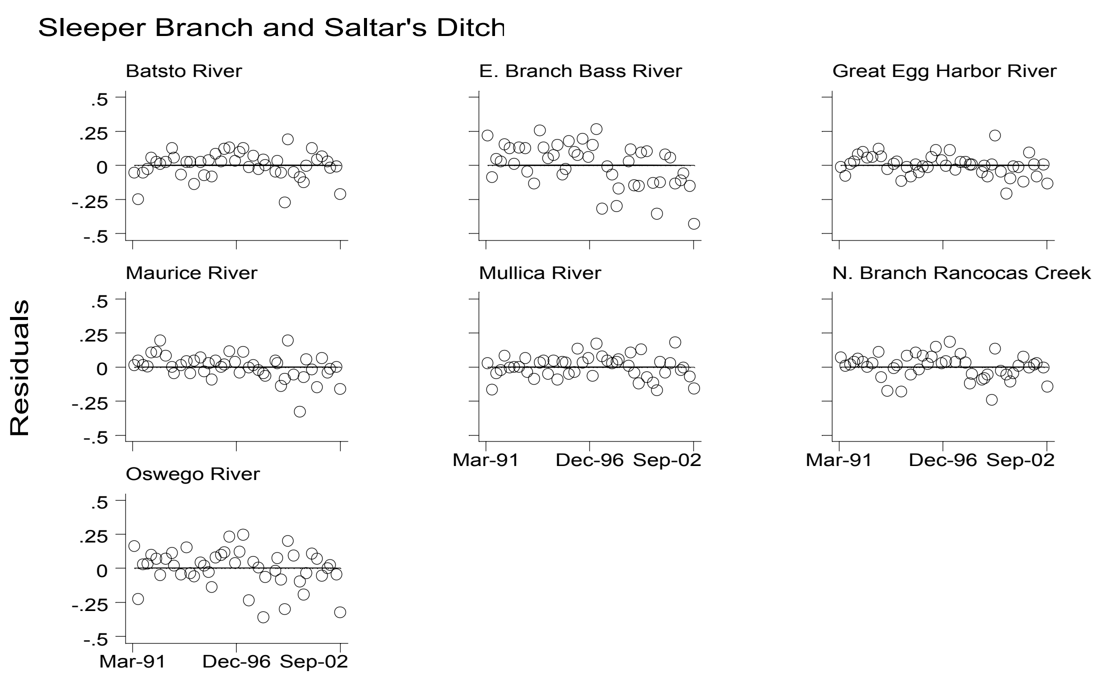
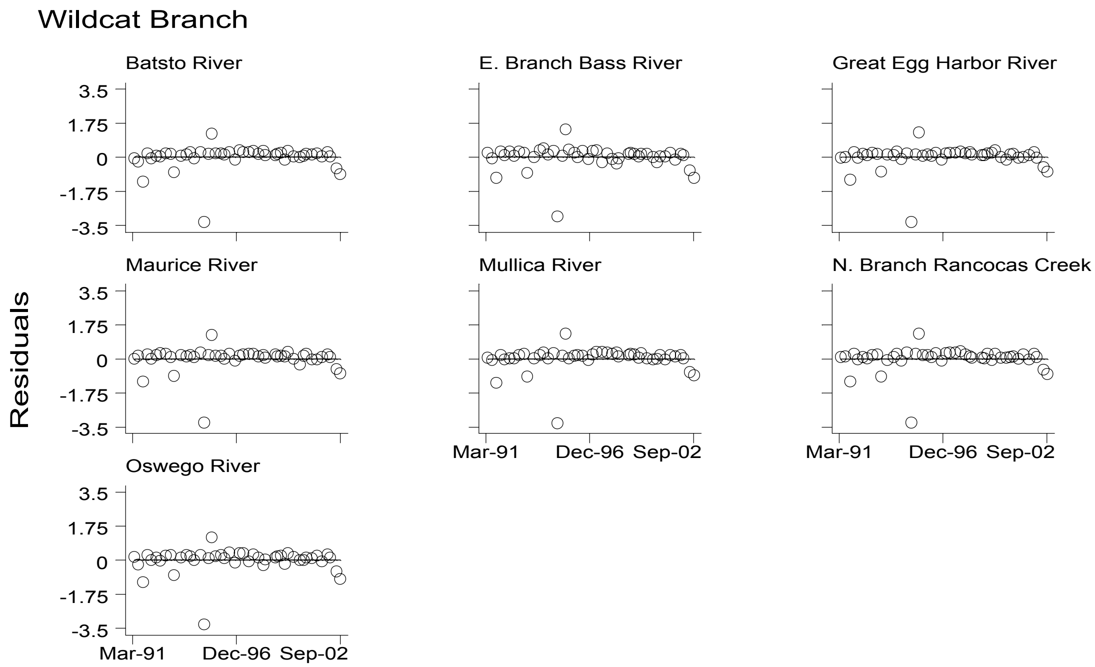


Figure 2 continued.



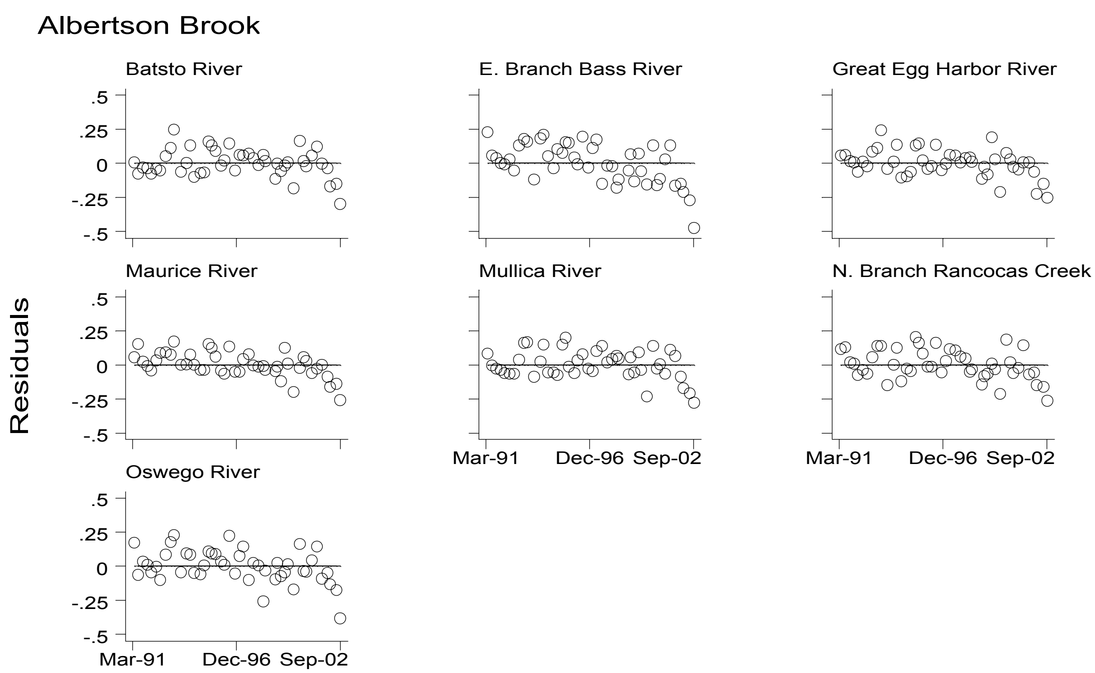
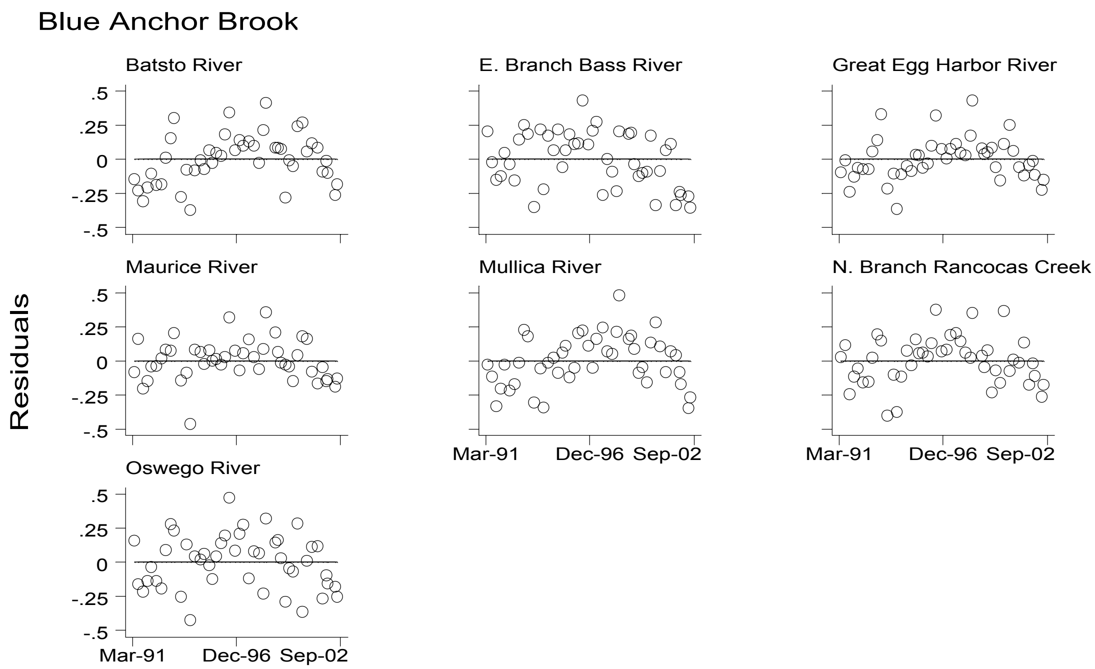


Figure 2 continued.



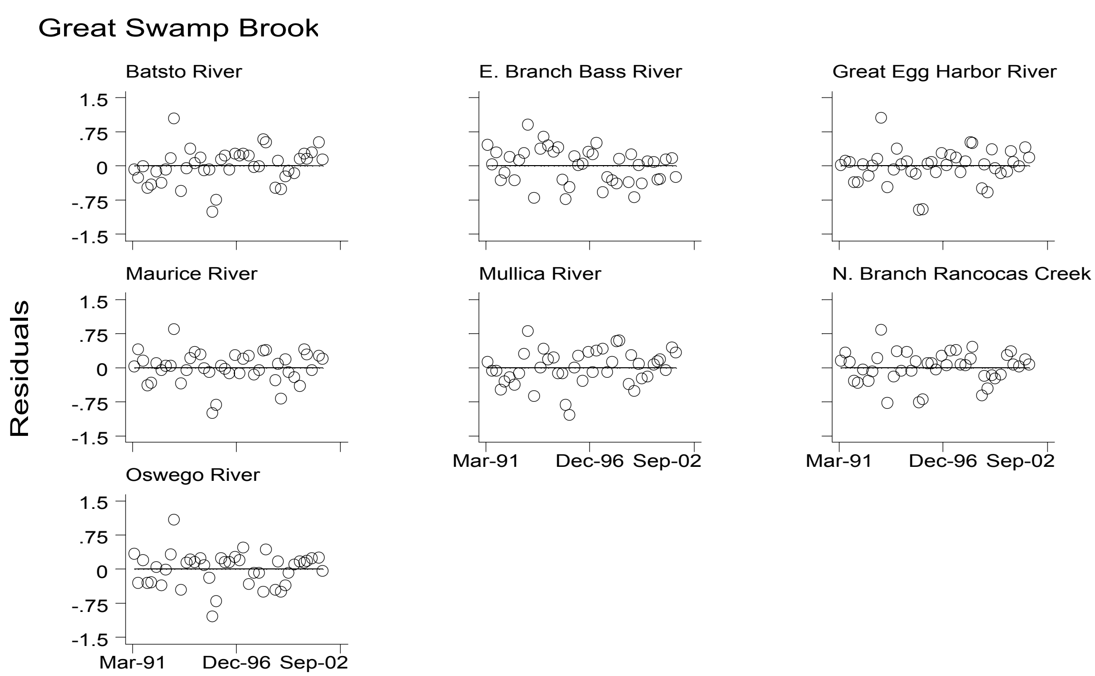


Figure 2 continued.

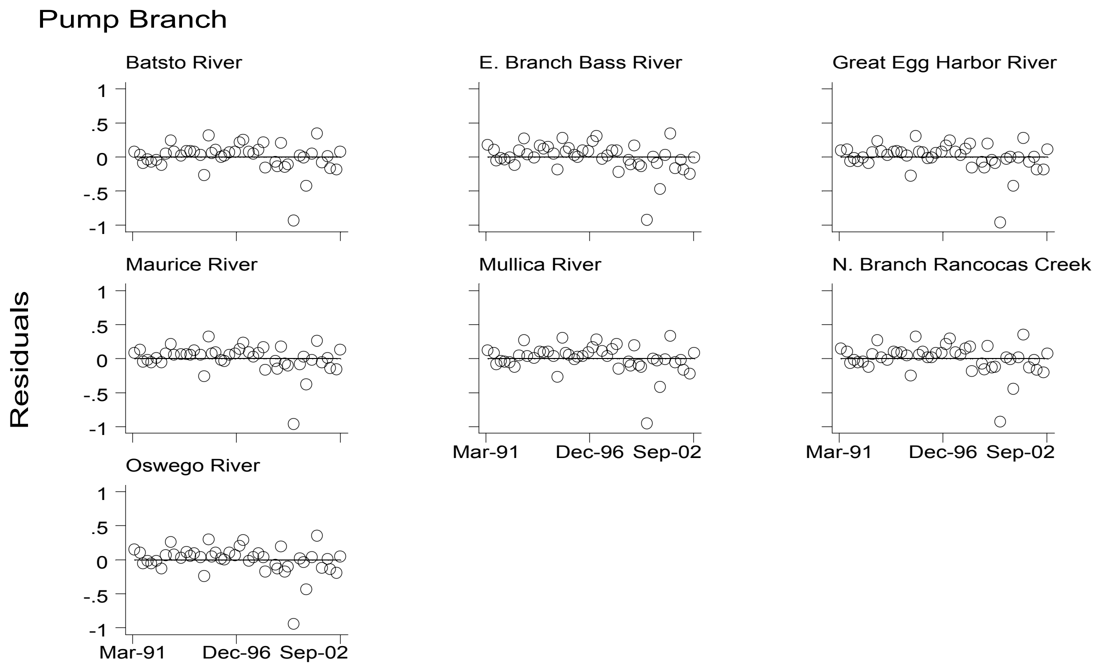


Table 4. Results of Pearson product moment correlations and Mann-Kendall trend tests. All Pearson correlations are significant at alpha = 0.05. Mann-Kendall tests significant at alpha = 0.05 and after sequential Bonferroni significance-level adjustment (k = 7 tests, alpha = 0.10 and 0.05) are shaded. The initial *p*-level from Kendall tests and both Bonferroni adjusted *p*-levels are shown for comparison. Shaded results indicate a decrease in study-site streamflow relative to index-site streamflow. See Table 1 for study-site names.

Site	N	Pearson r	Kendall's tau	Initial Kendall *p*-level	Bonferroni Adjusted *p*-level (0.10)	Bonferroni Adjusted *p*-level (0.05)	Thiel Slope	Annual % Change
MCLATSIN								
Batsto R at Batsto	46	0.89	0.04	0.677	0.050	0.025	0.0031	2.9
E B Bass River near New Gretna	46	0.63	-0.29	0.005	0.014	0.007	-0.0210	-17.6
Great Egg Harbor R at Folsom	46	0.85	-0.08	0.449	0.025	0.013	-0.0065	-5.8
Maurice R at Norma	46	0.81	-0.13	0.198	0.017	0.008	-0.0097	-8.6
Mullica R near Batsto	46	0.85	0.01	0.895	0.100	0.050	0.0011	1.0
N B Rancocas Creek at Pemberton	46	0.79	-0.08	0.443	0.020	0.010	-0.0063	-5.6
Oswego R at Harrisville	46	0.76	-0.07	0.489	0.033	0.017	-0.0061	-5.4
MCOBURNT								
Batsto R at Batsto	42	0.53	-0.04	0.696	0.100	0.050	-0.0041	-3.7
E B Bass River near New Gretna	42	0.41	-0.22	0.044	0.014	0.007	-0.0125	-10.9
Great Egg Harbor R at Folsom	42	0.53	-0.12	0.279	0.020	0.010	-0.0104	-9.1
Maurice R at Norma	42	0.49	-0.14	0.201	0.017	0.008	-0.0130	-11.3
Mullica R near Batsto	42	0.53	-0.05	0.634	0.050	0.025	-0.0037	-3.3
N B Rancocas Creek at Pemberton	42	0.52	-0.11	0.319	0.025	0.013	-0.0070	-6.3
Oswego R at Harrisville	42	0.48	-0.11	0.324	0.033	0.017	-0.0080	-7.1
MHYATATC								
Batsto R at Batsto	46	0.68	-0.07	0.484	0.100	0.050	-0.0010	-0.9
E B Bass River near New Gretna	46	0.47	-0.29	0.005	0.017	0.008	-0.0058	-5.2
Great Egg Harbor R at Folsom	46	0.77	-0.23	0.028	0.020	0.010	-0.0031	-2.8
Maurice R at Norma	46	0.73	-0.29	0.005	0.014	0.007	-0.0040	-3.6
Mullica R near Batsto	46	0.70	-0.11	0.280	0.050	0.025	-0.0019	-1.8
N B Rancocas Creek at Pemberton	46	0.68	-0.20	0.049	0.025	0.013	-0.0031	-2.8
Oswego R at Harrisville	46	0.60	-0.17	0.108	0.033	0.017	-0.0032	-2.9
MHYCHESIL								
Batsto R at Batsto	46	0.89	-0.09	0.363	0.100	0.050	-0.0008	-0.7
E B Bass River near New Gretna	46	0.65	-0.34	0.001	0.017	0.008	-0.0051	-4.6
Great Egg Harbor R at Folsom	46	0.90	-0.25	0.015	0.020	0.010	-0.0020	-1.9
Maurice R at Norma	46	0.90	-0.41	0.000	0.014	0.007	-0.0026	-2.3
Mullica R near Batsto	46	0.87	-0.13	0.215	0.050	0.025	-0.0011	-1.0
N B Rancocas Creek at Pemberton	46	0.88	-0.20	0.053	0.033	0.017	-0.0018	-1.7
Oswego R at Harrisville	46	0.75	-0.22	0.034	0.025	0.013	-0.0027	-2.4
MMUNRATC								
Batsto R at Batsto	46	0.74	-0.12	0.256	0.100	0.050	-0.0041	-3.7
E B Bass River near New Gretna	46	0.62	-0.35	0.001	0.014	0.007	-0.0160	-13.7
Great Egg Harbor R at Folsom	46	0.83	-0.30	0.003	0.020	0.010	-0.0106	-9.3
Maurice R at Norma	46	0.75	-0.34	0.001	0.017	0.008	-0.0128	-11.1
Mullica R near Batsto	46	0.77	-0.16	0.130	0.050	0.025	-0.0057	-5.1
N B Rancocas Creek at Pemberton	46	0.76	-0.26	0.011	0.033	0.017	-0.0088	-7.8
Oswego R at Harrisville	46	0.67	-0.28	0.006	0.025	0.013	-0.0099	-8.7
MSLNRATS and MSLSALTA								
Batsto R at Batsto	46	0.91	0.02	0.880	0.100	0.050	0.0001	0.1
E B Bass River near New Gretna	46	0.70	-0.31	0.003	0.014	0.007	-0.0050	-4.5
Great Egg Harbor R at Folsom	46	0.94	-0.23	0.024	0.020	0.010	-0.0018	-1.6
Maurice R at Norma	46	0.91	-0.28	0.007	0.017	0.008	-0.0024	-2.2
Mullica R near Batsto	46	0.93	-0.03	0.791	0.050	0.025	-0.0002	-0.2
N B Rancocas Creek at Pemberton	46	0.92	-0.15	0.156	0.033	0.017	-0.0015	-1.3
Oswego R at Harrisville	46	0.80	-0.15	0.135	0.025	0.013	-0.0019	-1.7
MWIBURNT								
Batsto R at Batsto	46	0.38	0.06	0.557	0.020	0.010	0.0016	1.5
E B Bass River near New Gretna	46	0.40	-0.17	0.090	0.014	0.007	-0.0049	-4.5
Great Egg Harbor R at Folsom	46	0.41	-0.02	0.880	0.050	0.025	-0.0003	-0.3
Maurice R at Norma	46	0.42	-0.12	0.248	0.017	0.008	-0.0022	-2.0
Mullica R near Batsto	46	0.34	0.03	0.806	0.025	0.013	0.0003	0.2
N B Rancocas Creek at Pemberton	46	0.39	-0.01	0.895	0.100	0.050	-0.0003	-0.3
Oswego R at Harrisville	46	0.37	-0.02	0.850	0.033	0.017	-0.0007	-0.6
NALNRELM								
Batsto R at Batsto	46	0.84	-0.08	0.460	0.100	0.050	-0.0010	-0.9
E B Bass River near New Gretna	46	0.62	-0.41	0.000	0.014	0.007	-0.0060	-5.4
Great Egg Harbor R at Folsom	46	0.84	-0.25	0.015	0.025	0.013	-0.0025	-2.3
Maurice R at Norma	46	0.88	-0.37	0.000	0.017	0.008	-0.0035	-3.1
Mullica R near Batsto	46	0.83	-0.12	0.248	0.050	0.025	-0.0014	-1.3
N B Rancocas Creek at Pemberton	46	0.81	-0.25	0.015	0.025	0.013	-0.0032	-2.9
Oswego R at Harrisville	46	0.77	-0.26	0.012	0.020	0.010	-0.0034	-3.1
NBLATELM								
E B Bass River near New Gretna	46	0.76	-0.22	0.034	0.014	0.007	0.0042	3.9
Batsto R at Batsto	46	0.81	0.20	0.053	0.017	0.008	-0.0046	-4.2
Great Egg Harbor R at Folsom	46	0.87	0.11	0.298	0.020	0.010	0.0016	1.5
Maurice R at Norma	46	0.88	-0.07	0.520	0.033	0.017	-0.0009	-0.8
Mullica R near Batsto	46	0.80	0.11	0.298	0.025	0.013	0.0024	2.3
N B Rancocas Creek at Pemberton	46	0.83	-0.03	0.791	0.100	0.050	-0.0004	-0.4
Oswego R at Harrisville	46	0.77	-0.05	0.650	0.050	0.025	-0.0012	-1.1
NGRATELM								
Batsto R at Batsto	42	0.75	0.23	0.036	0.014	0.007	0.0091	8.8
E B Bass River near New Gretna	42	0.74	-0.17	0.111	0.017	0.008	-0.0075	-6.7
Great Egg Harbor R at Folsom	42	0.76	0.12	0.288	0.025	0.013	0.0043	4.0
Maurice R at Norma	42	0.79	0.02	0.862	0.100	0.050	0.0007	0.6
Mullica R near Batsto	42	0.74	0.17	0.114	0.020	0.010	0.0069	6.6
N B Rancocas Creek at Pemberton	42	0.80	0.06	0.580	0.033	0.017	0.0020	1.8
Oswego R at Harrisville	42	0.76	0.03	0.762	0.050	0.025	0.0010	0.9
NPUNRWAT								
Batsto R at Batsto	46	0.35	-0.11	0.298	0.100	0.050	-0.0013	-1.2
E B Bass River near New Gretna	46	0.26	-0.24	0.019	0.014	0.007	-0.0043	-3.9
Great Egg Harbor R at Folsom	46	0.37	-0.15	0.150	0.025	0.013	-0.0024	-2.2
Maurice R at Norma	46	0.42	-0.16	0.125	0.020	0.010	-0.0023	-2.1
Mullica R near Batsto	46	0.32	-0.14	0.185	0.050	0.025	-0.0023	-2.1
N B Rancocas Creek at Pemberton	46	0.28	-0.14	0.167	0.033	0.017	-0.0026	-2.4
Oswego R at Harrisville	46	0.34	-0.20	0.049	0.017	0.008	-0.0028	-2.6

Table 5. Results of Pearson product moment correlations and Mann-Kendall trend tests. All Pearson correlations are significant at a alpha = 0.05. Mann-Kendall tests significant at alpha = 0.05 and after sequential Bonferroni significance-level adjustment (k = 6 tests, alpha = 0.10 and 0.05) are shaded. The initial *p*-level from Kendall tests and both Bonferroni adjusted *p*-levels are shown for comparison. Shaded results indicate a decrease in index-site streamflow relative to other index sites.

Site	N	Pearson r	Kendall tau	Kendall *p*-level	Bonferroni Adjusted *p*-level (0.01)	Bonferroni Adjusted *p*-level (0.05)
Batsto River						
East Branch Bass River at New Gretna	46	0.74	-0.44	0.000	0.017	0.008
Great Egg Harbor River at Folsom	46	0.94	-0.36	0.001	0.020	0.010
Maurice River at Norma	46	0.89	-0.32	0.002	0.025	0.013
Mullica River near Batsto	46	0.94	-0.15	0.156	0.100	0.050
North Branch Rancocas Creek at Pemberton	46	0.94	-0.22	0.031	0.050	0.025
Oswego River at Harrisville	46	0.89	-0.31	0.002	0.033	0.017
Great Egg Harbor River						
Batsto River at Batsto	46	0.94	0.28	0.006	0.017	0.008
East Branch Bass River at New Gretna	46	0.74	-0.25	0.016	0.020	0.010
Maurice River at Norma	46	0.96	-0.17	0.100	0.025	0.013
Mullica River near Batsto	46	0.95	0.14	0.185	0.033	0.017
North Branch Rancocas Creek at Pemberton	46	0.92	-0.03	0.806	0.100	0.050
Oswego River at Harrisville	46	0.84	-0.04	0.677	0.050	0.025
Maurice River						
Batsto River at Batsto	46	0.89	0.18	0.072	0.020	0.010
East Branch Bass River at New Gretna	46	0.74	-0.22	0.031	0.017	0.008
Great Egg Harbor River at Folsom	46	0.96	0.10	0.344	0.033	0.017
Mullica River near Batsto	46	0.92	0.15	0.140	0.025	0.013
North Branch Rancocas Creek at Pemberton	46	0.90	0.03	0.806	0.050	0.025
Oswego River at Harrisville	46	0.82	0.00	0.970	0.100	0.050
Mullica River						
Batsto River at Batsto	46	0.94	0.06	0.557	0.100	0.050
East Branch Bass River at New Gretna	46	0.71	-0.36	0.000	0.017	0.008
Great Egg Harbor River at Folsom	46	0.95	-0.22	0.031	0.025	0.013
Maurice River at Norma	46	0.92	-0.23	0.026	0.020	0.010
North Branch Rancocas Creek at Pemberton	46	0.93	-0.12	0.256	0.050	0.025
Oswego River at Harrisville	46	0.82	-0.17	0.105	0.033	0.017
Oswego River						
Batsto River at Batsto	46	0.89	0.23	0.026	0.020	0.010
East Branch Bass River at New Gretna	46	0.89	-0.42	0.000	0.017	0.008
Great Egg Harbor River at Folsom	46	0.84	0.01	0.925	0.100	0.050
Maurice River at Norma	46	0.82	-0.05	0.636	0.033	0.017
Mullica River near Batsto	46	0.82	0.03	0.755	0.050	0.025
North Branch Rancocas Creek at Pemberton	46	0.88	0.05	0.609	0.025	0.013
East Branch Bass River						
Batsto River at Batsto	46	0.74	0.39	0.000	0.017	0.008
Great Egg Harbor River at Folsom	46	0.74	0.25	0.016	0.050	0.025
Maurice River at Norma	46	0.74	0.20	0.049	0.100	0.050
Mullica River near Batsto	46	0.71	0.32	0.002	0.025	0.013
North Branch Rancocas Creek at Pemberton	46	0.77	0.32	0.002	0.033	0.017
Oswego River at Harrisville	46	0.89	0.37	0.000	0.020	0.010
North Branch Rancocas Creek						
Batsto River at Batsto	46	0.94	0.13	0.218	0.025	0.013
East Branch Bass River at New Gretna	46	0.77	-0.34	0.001	0.017	0.008
Great Egg Harbor River at Folsom	46	0.92	-0.06	0.596	0.050	0.025
Maurice River at Norma	46	0.90	-0.12	0.264	0.033	0.017
Mullica River near Batsto	46	0.93	0.00	1.000	0.100	0.050
Oswego River at Harrisville	46	0.88	-0.15	0.156	0.020	0.010