

Water Quality Index Supplemental Sampling

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INTRODUCTION

In 2019, the Susquehanna River Basin Commission (Commission) developed a water quality index (WQI) for the streams and rivers of the Susquehanna River Basin (basin) (Berry et al., 2020). The primary goals for the WQI were to 1) assess water quality during baseflow conditions and allow for comparisons between sites in the basin, 2) easily communicate information about water quality to decision makers and the public, and 3) provide a basis for evaluation of biological conditions across a stressor gradient. The WQI produces three separate category scores for metals, nutrient enrichment, and development, which are then averaged to produce an overall water quality score between 0 and 100. Higher scores indicate better water quality, and lower scores indicate worse water quality. Sites are also be assigned a condition rating of very poor, poor, fair, good, or excellent based on the WQI score.

In 2020, the Commission launched the web-based Water Quality Index Map (WQI Map) which displays WQI scores and condition ratings for each of the 170 HUC-10 watersheds within the basin. This interactive mapping tool was developed to allow for easy interpretation of spatial water quality patterns by stakeholders and the general public. The WQI Map utilized a dataset consisting of 15,874 samples collected from 1,781 unique sites between the years 2000 and 2019. The HUC-10 scores were obtained by averaging the WQI scores for all sites within the watershed, and the condition ratings were assigned based on this average score.

The original dataset used to develop the WQI map was sourced from the Commission's in-house database. While most HUCs were well represented in the dataset, the average WQI scores and associated condition ratings for 26 of the HUC-10s were based on two or fewer samples. The goals of this project were two-fold:

1. To collect water samples from sites in these data-deficient watersheds, and
2. To incorporate WQI scores into the existing WQI Map to provide a more complete representation of water quality conditions throughout the basin.

This document has two purposes:

1. To present the results of this supplemental sampling effort, and
2. To reintroduce the WQI Map with the updated information.

METHODS

The Commission identified 26 HUC-10 watersheds within the WQI Map where two or fewer water quality samples had been collected through Commission projects in the past. The Commission collected samples at 39 sites so each of the 26 data-deficient watersheds could have a WQI Score based on at least three samples (Figure 1, Appendix A).

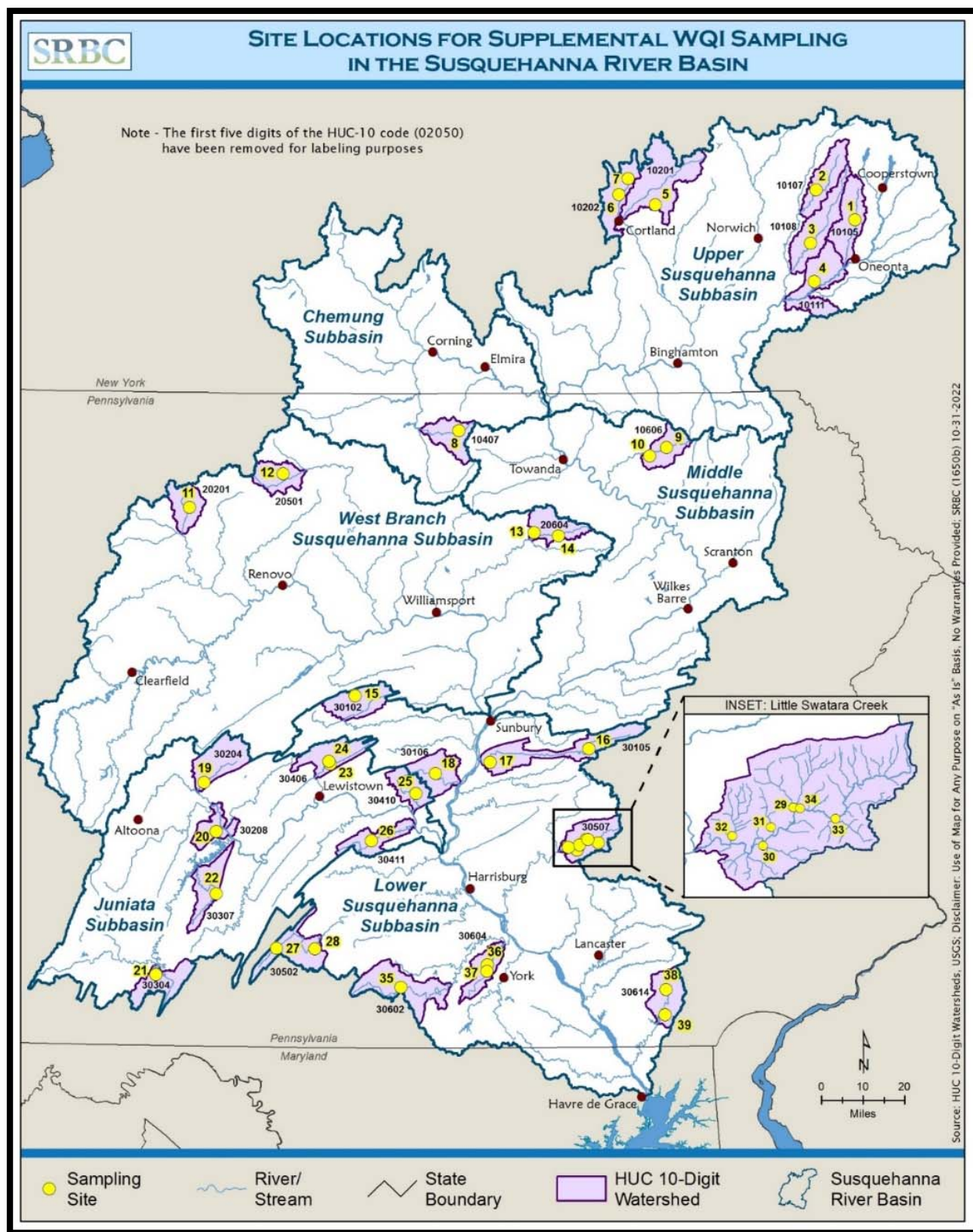


Figure 1. Data-Deficient HUC-10 Watersheds and Supplemental Sampling Sites

Depth-integrated water samples were collected at each site and sent to Pace Analytical Services, LLC, for analysis of nine WQI parameters: aluminum, iron, manganese, nitrate, phosphorus, total organic carbon, chloride, sodium, and sulfate. The lab values were then used to calculate numeric WQI scores for each sample. These new WQI scores were integrated into the existing dataset for the WQI Map and the average WQI scores/condition ratings were subsequently updated. Upon the conclusion of this effort, all HUC10s in the basin are now represented by a minimum of three samples.

For a full description of site selection procedures, sample collection, and lab analyses, please refer to the associated Quality Assurance Project Plan (SRBC, 2021). Details regarding calculation of WQI scores can be found in Berry et al. (2020).

RESULTS

Water quality results were obtained for all 39 sites sampled during summer 2021. Due to a clerical error, the lab did not analyze any samples for sodium. The WQI requires values for two of the three parameters in each category (metals, nutrient enrichment, and development) in order to calculate category scores and an overall score. Therefore, WQI scores were still able to be calculated despite the missing sodium values. Raw concentration values for each site can be found in Appendix B.

Category scores and overall WQI scores were calculated. Different ratings are assigned to a site based on the WQI score (Table 1). WQI scores for the 39 sites ranged from 17.80 to 84.65 (Table 2). Overall, the lowest scores were in the nutrient category (average of 40), and the highest scores were in the development category (average of 58). These results have been incorporated into the interactive WQI Map, which can be viewed at the following URL: <https://www.srbc.net/portals/water-quality-projects/water-quality-index/>.

DISCUSSION

Since it was launched in 2020, Commission staff has referenced the WQI Map in presentations to watershed groups and at other community events where it has been well-received by stakeholders and the general public. An accurate portrayal of conditions is important when conveying information to a general audience about the water quality in their local streams and rivers and how those systems compare to others in the basin. Inclusion of the supplemental sites into the WQI Map dataset increased the sample size for the data-deficient HUC-10s, thereby creating a more representative picture of water quality within those watersheds.

The additional data from the supplemental sampling effort also increase confidence in the overall water quality picture of the entire basin. The ratings for three HUC-10s – East Branch Tioughnioga River, West Branch Tioughnioga River, and Upper Conodoguinet Creek – changed following inclusion of the new data. On the original WQI Map, East Branch Tioughnioga River and Upper Conodoguinet Creek received Poor ratings and were upgraded to Fair once the supplemental sites were added to the dataset. The rating for West Branch Tioughnioga River decreased from Fair to Poor.

Table 1. Condition Ratings Based on WQI Scores

Rating	WQI Score Range
EXCELLENT	≥ 85
GOOD	62.01 - 84.99
FAIR	42.93 - 62.00
POOR	30.99 - 42.92
VERY POOR	≤ 30.98

The majority of the HUC-10 watersheds in the basin are rated Fair or Good. The best water quality conditions are found in the West Branch Susquehanna River Subbasin, which has a high percentage of forest and low levels of development. The only HUC-10 with a rating of Excellent, Young Womans Creek, is located in the West Branch Subbasin. The most degraded water quality conditions in the basin are concentrated in the Lower Susquehanna Subbasin. Agricultural land uses are extensive in this area, which is also currently experiencing a high degree of urban sprawl. Low scores for nutrients as well as development drive the overall WQI scores down in several HUC-10s, resulting in Very Poor ratings, particularly in Lancaster County. Another pocket of low scores and Poor ratings exists in the Middle Susquehanna Subbasin. Water quality in this region has been intensely impacted by coal mining, and pollutants from mine drainage negatively impact WQI metals scores.

Table 2. Category Scores (Metals, Nutrient Enrichment, and Development), Overall WQI Scores, and Ratings for Sites Sampled in Summer 2021

Stream Name	HUC10	Category Score			WQI Score	Condition Rating
		Metals	Nutrient Enrichment	Development		
West Branch Otego	0205010105	13	36	87	45.33	FAIR
Mill Creek	0205010107	69	45	75	63.08	GOOD
Butternut Creek	0205010108	41	42	65	48.99	FAIR
Sand Hill	0205010111	81	46	87	71.29	GOOD
Chenango Creek	0205010201	23	31	95	49.55	FAIR
Cold Brook	0205010202	0	38	83	40.35	POOR
West Branch Tioughnioga		0	51	29	26.88	VERY POOR
Mill Creek	0205010407	48	38	75	53.73	FAIR
East Branch Wyalusing	0205010606	71	40	65	58.58	FAIR
Elk Lake Stream		84	38	76	65.83	GOOD
West Branch Cowley Run	0205020201	42	58	81	60.32	FAIR
Lyman Run	0205020501	65	79	96	79.95	GOOD
Lick Creek	0205020604	94	74	86	84.64	GOOD
Little Loyalsock Creek		72	51	80	67.68	GOOD
Elk Creek	0205030102	51	55	89	64.86	GOOD
Mahanoy Creek	0205030105	0	88	21	36.21	POOR
Schwaben Creek		71	40	60	56.90	FAIR
West Branch Mahantango	0205030106	72	30	51	50.89	FAIR
Warrior's Mark Run	0205030204	83	33	55	57.24	FAIR
Crooked Creek	0205030208	78	51	39	56.08	FAIR
Shaffer Creek	0205030304	56	29	65	50.08	FAIR
Great Trough Creek	0205030307	54	54	52	53.44	FAIR
Honey Creek	0205030406	61	63	88	70.79	GOOD
Treaster Run		65	75	92	77.48	GOOD
Stony Run	0205030410	76	37	73	62.07	GOOD
Panther Creek	0205030411	68	42	45	51.71	FAIR
Conodoguinet Creek	0205030502	52	68	92	70.79	GOOD
Muddy Run		56	23	28	35.69	POOR
Crosskill Creek	0205030507	47	20	56	41.18	POOR
Deep Run		50	33	43	41.81	POOR
Earlakill Run		26	7	21	17.80	VERY POOR
Elizabeth Run		64	12	15	30.24	VERY POOR
Little Swatara Creek 1		50	20	41	36.76	POOR
Little Swatara Creek 2		49	15	36	33.12	POOR
Oppossum Creek	0205030602	69	30	40	46.41	FAIR
Fox Run	0205030604	62	13	25	33.13	POOR
Little Conewago Creek		47	18	24	29.84	VERY POOR
East Branch Octoraro	0205030614	80	26	18	41.32	POOR
Muddy Run		68	29	22	39.97	POOR

REFERENCES

- Berry, J.L., L.Y. Steffy, and M.K. Shank. 2020. Development of a Water Quality Index (WQI) for the Susquehanna River Basin. Publication No. 322. Susquehanna River Basin Commission, Harrisburg, Pennsylvania.
- Susquehanna River Basin Commission (SRBC). 2021. Quality Assurance Project Plan for Supplemental Water Quality Index Sampling. Commission QAPP #QA078. Harrisburg, Pennsylvania.

Appendix A.
Site Location Information

Site No	Stream Name	HUC10	Drainage Area (mi ²)	Latitude	Longitude
1	West Branch Otego	0205010105	19.6	42.59083	-75.06508
2	Mill Creek	0205010107	9.9	42.69794	-75.24337
3	Butternut Creek	0205010108	76.4	42.51288	-75.27544
4	Sand Hill	0205010111	10.6	42.37866	-75.26097
5	Chenango Creek	0205010201	24.0	42.65612	-76.00493
6	Cold Brook	0205010202	14.0	42.69245	-76.17740
7	West Branch Tioughnioga		20.2	42.74817	-76.13172
8	Mill Creek	0205010407	11.8	41.87246	-76.93363
9	East Branch Wyalusing	0205010606	27.4	41.80959	-75.96615
10	Elk Lake Stream		15.6	41.78015	-76.04548
11	West Branch Cowley Run	0205020201	10.9	41.59893	-78.18499
12	Lyman Run	0205020501	19.7	41.72106	-77.75130
13	Lick Creek	0205020604	16.2	41.51643	-76.58455
14	Little Loyalsock Creek		27.4	41.50569	-76.47086
15	Elk Creek	0205030102	21.0	40.94841	-77.41187
16	Mahanoy Creek	0205030105	43.5	40.76354	-76.33812
17	Schwaben Creek		30.1	40.71730	-76.79121
18	West Branch Mahantango	0205030106	18.6	40.67913	-77.04243
19	Warrior's Mark Run	0205030204	26.7	40.64196	-78.10030
20	Crooked Creek	0205030208	25.7	40.47158	-78.04182
21	Shaffer Creek	0205030304	36.3	39.97056	-78.30825
22	Great Trough Creek	0205030307	21.1	40.25539	-78.03983
23	Honey Creek	0205030406	20.7	40.70977	-77.52323
24	Treaster Run		30.7	40.72014	-77.53007
25	Stony Run	0205030410	14.7	40.60905	-77.13052
26	Panther Creek	0205030411	11.4	40.44255	-77.33421
27	Conodoguinet Creek	0205030502	21.3	40.06658	-77.76233
28	Muddy Run		43.0	40.06536	-77.58911
29	Crosskill Creek	0205030507	18.8	40.44722	-76.35491
30	Deep Run		5.8	40.40895	-76.39499
31	Earlakill Run		4.2	40.42766	-76.38423
32	Elizabeth Run		9.6	40.41884	-76.43540
33	Little Swatara Creek 1		27.5	40.43562	-76.29981
34	Little Swatara Creek 2		40.6	40.44603	-76.34606
35	Oppossum Creek	0205030602	33.5	39.93388	-77.19777
36	Fox Run	0205030604	14.1	40.01086	-76.80656
37	Little Conewago Creek		25.5	39.98894	-76.80828
38	East Branch Octoraro	0205030614	31.2	39.92062	-75.99652
39	Muddy Run		13.4	39.83262	-76.00371

Appendix B.
Raw Concentration Values for the Nine WQI Parameters

Stream Name	HUC 10	METALS (mg/l)			NUTRIENT ENRICHMENT (mg/l)			DEVELOPMENT (mg/l)		
		Al	Fe	Mn	NO ₃	P	TOC	Cl	Na	SO ₄
West Branch Otego	0205010105	0.2650	1.100	0.1300	0.20	0.086	3.9	5.2		2.9
Mill Creek	0205010107	0.0390	0.159	0.0229	0.30	0.022	4.1	12.2		3.0
Butternut Creek	0205010108	0.0837	0.372	0.0357	0.46	0.044	2.5	19.6		4.6
Sand Hill	0205010111	0.0230	0.155	0.0060	0.30	0.034	2.8	5.2		2.4
Chenango Creek	0205010201	0.2080	0.566	0.0453	0.75	0.026	6.0	1.8		3.1
Cold Brook	0205010202	0.7620	0.325	0.0302	0.68	0.018	4.9	7.3		3.6
West Branch Tioughnioga		4.9000	2.170	0.0320	0.46	0.010	5.6	59.0		10.2
Mill Creek	0205010407	0.0734	0.239	0.0299	0.41	0.028	4.1	8.8		6.1
East Branch Wyalusing	0205010606	0.0280	0.151	0.0192	0.22	0.096	2.8	16.7		5.7
Elk Lake Stream		0.0315	0.084	0.0109	0.25	0.100	2.9	7.2		6.4
West Branch Cowley Run	0205020201	0.1490	0.289	0.0253	0.44	0.038	1.3	4.0		6.5
Lyman Run	0205020501	0.0368	0.163	0.0303	0.52	0.010	1.1	1.0		5.2
Lick Creek	0205020604	0.0200	0.050	0.0033	0.65	0.010	1.4	4.5		5.3
Little Loyalsock Creek		0.0537	0.132	0.0084	0.97	0.010	3.2	8.5		4.7
Elk Creek	0205030102	0.1080	0.210	0.0183	0.51	0.014	2.7	3.5		5.1
Mahanoy Creek	0205030105	0.3300	10.800	4.7800	0.20	0.010	1.3	15.9		396.0
Schwaben Creek		0.0574	0.118	0.0109	4.30	0.020	2.5	8.2		9.9
West Branch Mahantango	0205030106	0.0613	0.131	0.0070	2.60	0.050	2.4	6.2		17.5
Warrior's Mark Run	0205030204	0.0200	0.089	0.0107	4.30	0.040	2.2	7.9		11.8
Crooked Creek	0205030208	0.0231	0.124	0.0126	1.60	0.010	2.8	10.6		26.3
Shaffer Creek	0205030304	0.0978	0.238	0.0106	2.30	0.034	3.0	8.8		7.9
Great Trough Creek	0205030307	0.1200	0.119	0.0264	0.34	0.026	2.3	4.1		21.2
Honey Creek	0205030406	0.0793	0.141	0.0149	0.22	0.022	2.1	3.6		5.4
Treaster Run		0.0887	0.124	0.0107	0.28	0.010	2.0	1.4		5.6
Stony Run	0205030410	0.0580	0.115	0.0049	4.90	0.034	2.0	7.2		6.8
Panther Creek	0205030411	0.0958	0.107	0.0096	3.40	0.018	2.5	11.3		15.4
Conodoguinet Creek	0205030502	0.0784	0.274	0.0164	0.52	0.010	2.1	2.3		4.0
Muddy Run		0.0870	0.206	0.0150	6.30	0.032	3.5	22.8		18.0
Crosskill Creek	0205030507	0.1140	0.240	0.0219	3.80	0.052	3.3	12.0		9.2
Deep Run		0.0722	0.173	0.0375	6.00	0.028	2.5	17.7		11.2
Earlakill Run		0.2840	0.362	0.0377	8.40	0.130	4.8	30.0		20.6
Elizabeth Run		0.0657	0.108	0.0189	5.40	0.120	3.8	50.9		22.3
Little Swatara Creek 1		0.1110	0.199	0.0209	4.10	0.042	3.8	17.5		12.0
Little Swatara Creek 2		0.1120	0.200	0.0234	5.00	0.062	3.9	19.1		13.9
Oppossum Creek	0205030602	0.0537	0.145	0.0105	1.60	0.034	3.0	14.6		14.9
Fox Run	0205030604	0.0630	0.166	0.0158	3.50	0.088	4.2	31.2		15.3
Little Conewago Creek		0.1070	0.210	0.0267	4.60	0.052	3.5	23.3		23.8
East Branch Octoraro	0205030614	0.0644	0.072	0.0042	8.30	0.088	2.0	30.2		27.1
Muddy Run		0.0661	0.096	0.0142	10.70	0.068	1.8	24.6		24.6