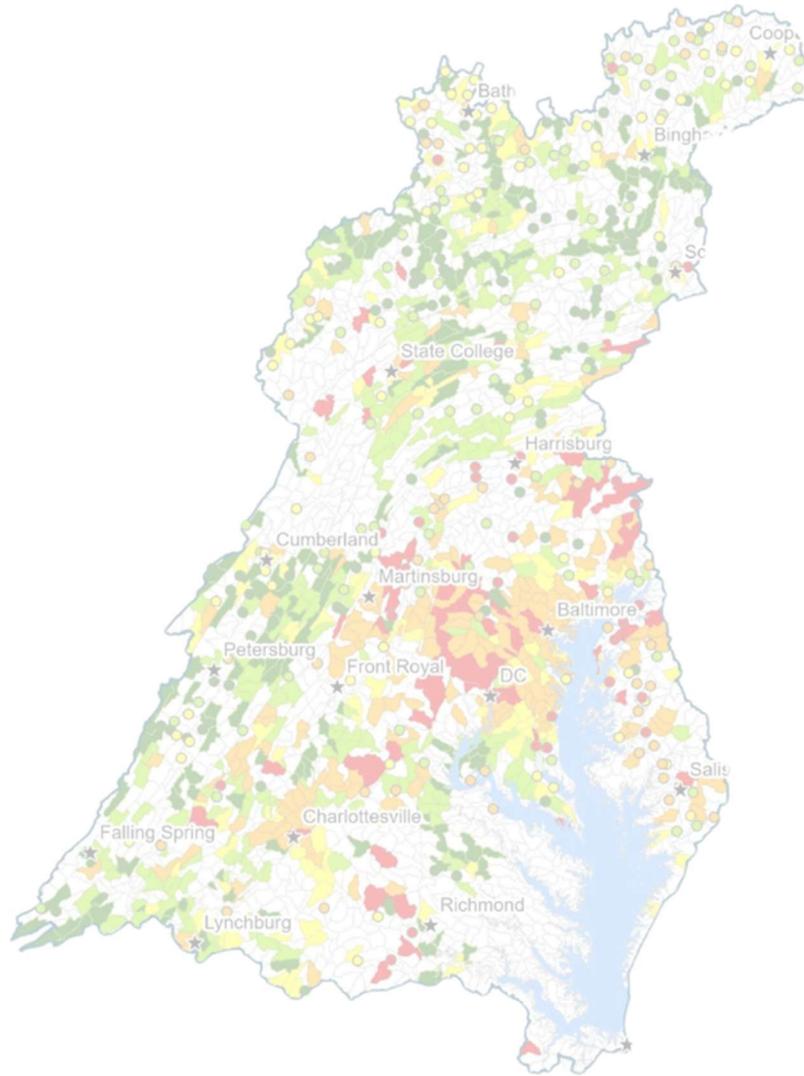


Stream Health in the Chesapeake Bay Watershed

2018 – 2023 Update



*Prepared by the Interstate Commission on the Potomac River Basin
for the Chesapeake Bay Program Stream Health Workgroup*





The Chesapeake Bay watershed

ICPRB Report #ICP25-1

This report can be downloaded from the Publications tab of the ICPRB's website, www.potomacriver.org. To receive hard copies of the report, please write:

Interstate Commission on the Potomac River Basin
401 North Washington St., Suite 300
Rockville, MD 20850
Or call 301-984-1908
Or email info@icprb.org

Disclaimer

The opinions expressed in this report are those of the authors and should not be construed as representing the opinions or policies of the U. S. Government, the U. S. Environmental Protection Agency, the Potomac basin states of Maryland, Pennsylvania, Virginia, and West Virginia, and the District of Columbia, or the Commissioners to the Interstate Commission on the River Basin.

Acknowledgements

Support was provided by U. S. Environmental Protection Agency CB-95326701 (Chesapeake Bay Program) and the Interstate Commission on the Potomac River Basin. We thank Alison Santoro (MDDNR) for her comments on the draft report and Renee Bourassa and Serena Moncion (ICPRB) for their editorial and graphical assistance.

Suggested citation for this report

C. Buchanan, R. D. Jepsen, and E. Young. 2025. Stream Biological Health in the Chesapeake Bay Watershed, 2018 - 2023 Update. ICPRB Report ICP25-1. Report Prepared for the Chesapeake Bay Program Stream Health Workgroup. Available online at: www.potomacriver.org.

Front Cover:

2018 - 2023 Chessie BIBI map

Stream Health in the Chesapeake Bay Watershed, 2018 – 2023 Update

19 December 2025

Executive Summary

Non-tidal stream health in the Chesapeake Bay watershed is evaluated every six years to accommodate rotational sampling schedules of the major stream monitoring programs. A 2024 Data Call brought in stream macroinvertebrate data and related water quality and habitat data collected by eighteen monitoring programs in the watershed between 2018 and 2023, the fourth 6-year interval. The percentage of stream miles with healthy macroinvertebrate communities increased an estimated 2,026 miles in this interval, for a 1.4% improvement over the previous interval. High flows in 2018 and 2019 and the COVID-19 pandemic in 2020 disrupted monitoring activities, and stream evaluations in the interval are based on less data. Since 2000 - 2005, the first 6-year interval, stream miles with healthy macroinvertebrate communities have increased 10.3% overall, and an estimated two-thirds (66.7%) of stream miles in the watershed are now thought to be healthy. Improvement is unevenly distributed in the watershed. Stream health appears to be improving in eight more rural western and southern bioregions; it is not improving in two central, heavily populated bioregions, and is degrading in two eastern, highly agricultural bioregions. Additional data and new criteria for separating streams from rivers have slightly changed the percentages of healthy streams for previous intervals but not the overall findings. The average rate of improvement is 3.4% over a 6-year interval, which suggests the revised Stream Health goal can be achieved in 2024 – 2029, the next 6-year interval, as ongoing efforts to restore and protect the Bay watershed continue.

Background

The Chesapeake Bay Program (CBP) partnership recognizes that healthier stream ecosystems can boost pollutant reduction efforts in the watershed while also supporting fish and wildlife and benefiting public uses such as drinking water and recreation. The partnership pledged to improve stream health and function in various agreements and established specific goals in the most recent ones:

2009 Executive Order 13508: Improve the health of streams so that 70% of sampled streams throughout the Chesapeake watershed are in fair, good, or excellent condition as measured by an Index of Biotic Integrity by 2025.

2014 Bay Agreement: Continually improve stream health and function throughout the watershed. Improve health and function of 10% of stream miles above the 2008 baseline for the Chesapeake Bay watershed.

Chesapeake Bay Watershed Agreement (revised, 2025): Improve the health and ecological integrity of at least an additional 4,340 (approx. 3%) nontidal stream miles every six years.

CBP currently measures stream health across the watershed using the Chessie BIBI (Chesapeake Basin-wide Index of Biotic Integrity), a macroinvertebrate multi-metric index of stream biological health and function. Benthic macroinvertebrates are used as indicators of stream health because their communities reflect integrated responses to multiple environmental stressors, some of which may be unknown or not monitored. The CBP partnership relies on an array of federal, state, local, and citizen monitoring programs to provide the benthic macroinvertebrate data needed to calculate the Chessie BIBI index. The CBP Data Center acquires, assembles, and quality-assures the raw data every six years and uploads them to the Chesapeake Environmental Data Repository (CEDR). It also obtains the water quality and physical habitat data associated with the samples. The 6-year cycle accommodates rotational sampling schedules of the state monitoring programs, which are major data providers, and ensures full coverage of the watershed in each 6-year interval. The Interstate Commission on the Potomac River Basin (ICPRB) calculates and reports the index.

Sampling sites are first grouped by their 12-digit hydrologic units (HUC12) and 6-year interval. Each site's narrative rating (excellent, good, fair, poor, or very poor) is weighted by equal proportions of the total stream miles (1:24,000) in the HUC12. The weighted ratings are then summed across all sampled HUC12s to the Chesapeake watershed scale to calculate the stream length-weighted percentage of healthy streams for each interval. A methodology document ([Young et al. 2025](#)) describes the data processing and analysis steps in greater detail. The 6-year intervals analyzed to-date are: 2000-2005, 2006-2011, 2012-2017, and 2018-2023.

Findings

Results of a previous analysis of the first three intervals ([Buchanan et al. 2023](#)) differ slightly from results of the current analysis. Additional data obtained in the most recent 2024 Data Call is the primary reason for the changes, but several data entry errors in the early years were also corrected and ICPRB made a method change in the analysis steps that affected results in all periods (discussed below). Consequently, estimates of healthy

streams dropped 1 – 3 percentage points in these three earlier intervals. The revised numbers are reported here.

The most recent interval, 2018-2023, was impacted by the very [wet period of 2018 and early 2019](#) and streams experienced numerous high flow events. [Nutrient loads to the Bay](#) spiked and several indicators of ecosystem health temporarily declined including the Bay's [submerged aquatic vegetation](#). The Covid-19 shutdown in 2020 disrupted monitoring program schedules and fewer sampling locations were visited.

Chesapeake Watershed

Analysis of macroinvertebrate data collected in 2018-2023 suggests an estimated 66.7% of stream miles in the Chesapeake watershed now have Chessie BIBI ratings of excellent, good, or fair status and can be considered healthy. Stream health in this interval continued to improve but at a slower rate compared to previous intervals. Improvement rates were +4.3% (~6,179 miles) in the second interval, +4.6% (~6,619 miles) in the third, and +1.4% (~2,026 miles) in the fourth (Table 1). The average rate of improvement in healthy streams (was 3.4% per interval, and an overall improvement of 10.3% (~14,824 miles) was achieved in the 24 years. Well over half of the watershed's 1,971 HUC12s with freshwater streams were sampled during each interval except the most recent one when only 962 (48.8%) were sampled.

Of the five Chessie BIBI narrative ratings, streams with excellent ratings increased the most, gaining 11.8% over the four 6-year intervals. Streams rated good increased by 2.4% over the same period. Conversely, declines occurred in streams rated very poor (-4.5%), poor (-5.8%), and fair (-3.9%). This noticeable shift over the four 6-year intervals suggests improvements are occurring in minimally to severely degraded streams (fair, poor, very poor) and their ratings are changing to better categories.

Table 1. Stream length-weighted estimates of the percentage of streams in the Chesapeake Bay watershed with Chessie BIBI ratings of excellent (E), good (G), fair (F), poor (P), and very poor (VP). # Sites, number of sampling sites visited one or more times in the interval; # HUC12, number of HUC12 subwatersheds sampled in the interval; %EGF, percentage of healthy streams (Chessie BIBI ratings of E, G, or F); +%EGF and +Miles, change from the preceding 6-year interval.

Interval	# Sites	# HUC12	%E	%G	%F	%P	%VP	%EGF	+%EGF	+Miles
2000-2005	7106	1171	16.4%	20.1%	20.0%	25.4%	18.2%	56.4%		
2006-2011	8380	1384	23.6%	20.7%	16.5%	24.3%	15.0%	60.7%	+4.3%	~6,179
2012-2017	6268	1177	26.7%	20.9%	17.7%	21.2%	13.5%	65.3%	+4.6%	~6,619
2018-2023	4670	962	28.2%	22.4%	16.1%	19.6%	13.7%	66.7%	+1.4%	~2,026
Change			+11.8%	+2.4%	-3.9%	-5.8%	-4.5%		+10.3%	~14,824

Maps of watershed stream health in the four intervals (Figures A-1 to A-4) illustrate the spatial distributions of sampling effort and the Chessie BIBI index ratings. Sampled HUC12s were evenly dispersed across the watershed in the first three intervals and randomly distributed but tending towards evenly dispersed in fourth interval (ArcGIS Pro v3.4.3, Average Nearest Neighbor tool). Visual comparisons of the maps suggest areas are not improving at the same rate. Change is especially apparent when the earliest and most recent intervals sampled in each HUC12 are illustrated separately (Figure A-5). Recent data

were not found for several areas (Figure A-6) and progress in these regions is less certain.

Chesapeake Bioregions

Analysis of the Chesapeake’s twelve bioregions reinforces the observation that streams are not improving at the same rate across the watershed (Figure 1). The steps used to calculate the watershed’s percentage of healthy streams were applied to the individual bioregions and while these estimates are more uncertain due to smaller sample sizes and monitoring gaps, the generalized results identify bioregions where stream health is improving, not changing, or degrading. Trends developing in the first three intervals continued and strengthened in the fourth interval for the most part.

Strong overall improvement (greater than 10%) appears to be happening in seven bioregions: Central Appalachians (CA), Piedmont (PIED), Northern Central Appalachians (NCA), Blue Ridge (BLUE), Northern Ridge & Valley (NRV), Northern Appalachian Plateau & Uplands (NAPU), Southern Ridge & Valley (SRV). Moderate

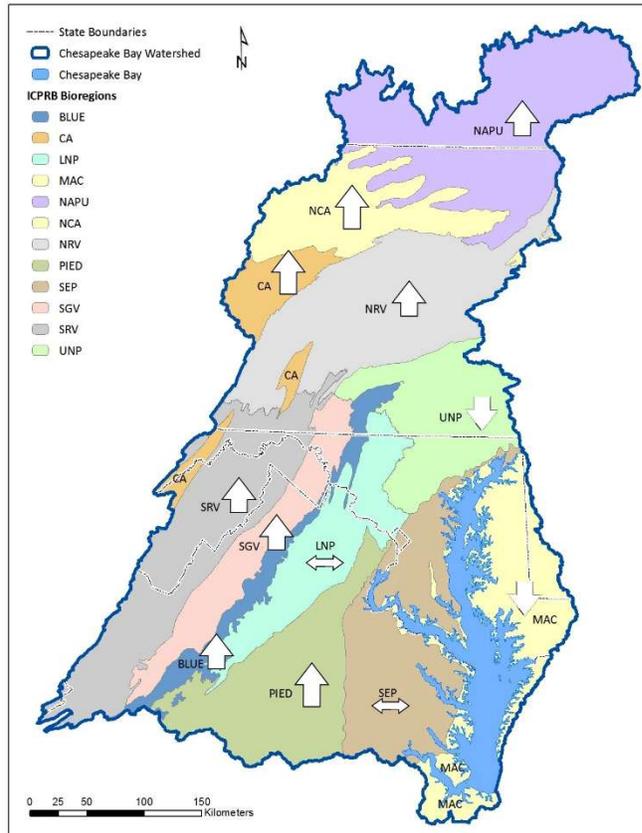


Figure 1. Bioregions of the Chesapeake Bay watershed (Smith et al. 2017). Arrows indicates direction of trend in %EGF (estimated percentage of stream miles in excellent, good, and fair condition). ↑, improving trend; ↔, no trend; ↓, degrading trend. Bioregions: BLUE, Blue Ridge; CA, Central Appalachians; LNP, Lower Northern Piedmont; MAC, MidAtlantic Coastal Plain; NAPU, Northern Appalachian Plateau & Uplands; NCA, North Central Appalachians; NRV, Northern Ridge & Valley; PIED, Piedmont; SEP, Southeastern Plains; SGV, Southern Great Valley; SRV, Southern Ridge & Valley; UNP, Upper Northern Piedmont.

improvement (5% to 10%) is occurring in the Southern Great Valley (SGV). Excellent and/or good Chessie BIBI ratings are increasing as poor and/or very poor ratings are decreasing in these eight bioregions. Each bioregion except SGV has the advantage of many miles of healthy streams, with the percentage of healthy streams in the 2018-2023 interval ranging from 56% (PIED) to 94% (SRV). Healthy streams help recolonize nearby degraded streams as the latter improve. These eight bioregions are currently driving the 10.3% improvement in stream health.

The Southeastern Plains (SEP) and Lower Northern Piedmont (LNP) bioregions show no improvement since the first 6-year interval, and the Upper Northern Piedmont (UNP) and Mid-Atlantic Coastal Plain (MAC) show degrading trends (-5% to -10%). The agricultural Lancaster, PA area and the large metropolitan corridor connecting Baltimore, MD, Washington D.C., and Richmond, VA lie in SEP, LNP, and UNP. The Mid-Atlantic Coastal Plain (MAC) on the eastern shore of the Bay is intensely farmed and heavily ditched. These four bioregions have fewer miles of healthy streams overall, with an estimated 54% in SEP, 31% in MAC, and 21% in LNP and UNP in the second interval period.

Index Variability

When analyzing sites that were often revisited, Buchanan et al. (2023) noticed the year-to-year variability in the 2000-2017 Chessie BIBI scores was greatest (least predictable) when a site's mean score was rated fair or poor and was smallest (most predictable) when its mean score was rated excellent or very poor. The relationship persists in 123 sites sampled twelve or more times over the twenty-four years between 2000 and 2023 (Figure 2). Greater year-to-year variability in a stream's condition makes change over time more difficult to

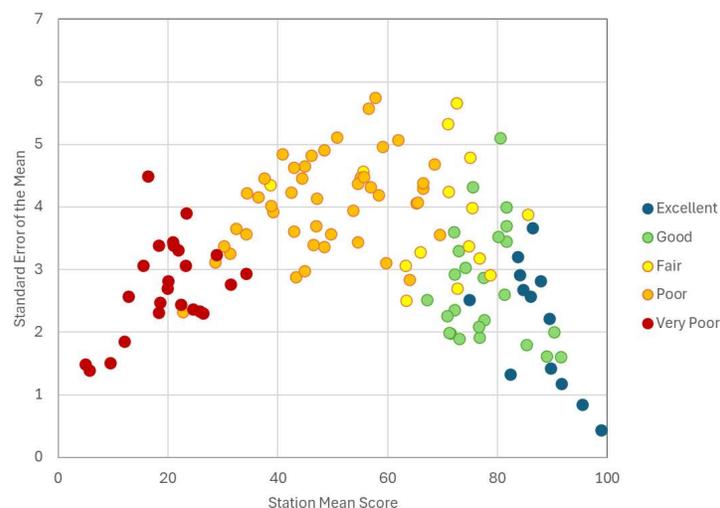


Figure 2. Variation (standard error) around the mean Chessie BIBI score at locations sampled twelve or more times in the twenty-four years between 2000 and 2023. Color indicates BIBI rating of mean score.

detect. Revisited locations are sampled for specific purposes (e.g., sentinel sites, before-and-after restoration, construction) and are not representative of general stream conditions in the Chesapeake watershed. However, they give an indication of variability associated with the index’s five narrative rating categories.

A Method Change

Smith et al. (2017) developed the Chessie BIBI index for streams and small wadeable rivers identified as 1st - 4th Strahler Stream Order (SSO) when mapped at a medium resolution (1:100,000) scale. Sampling sites with SSO greater than 4 were excluded from watershed estimates of healthy streams. We now use a high-resolution geospatial dataset (NHDPlus HR, [USGS 2020](#)) to identify SSO. More headwaters are identified in the higher resolution layer and nearly two-thirds of all sampling sites now have higher SSOs, some by several orders. Correspondence between medium and high resolution SSOs is poor, and there is no clear threshold in the high-resolution layer for identifying medium resolution 1st - 4th SSO streams (Figure 3).

After cursory examination, we also suspect about 5% of SSOs assignments are incorrectly identified by either the medium or high-resolution stream layers. Some misidentified sites were located on streams near the confluence with large river mainstems and were incorrectly assigned to the river’s SSO in the medium resolution layer. At other times, sites

		High Resolution SSO								
		1	2	3	4	5	6	7	8	N
Medium Resolution SSO	-9									15
	1	8423	9006	2756	357	22	19	8	2	20593
	2	960	2743	6713	1524	181	1	15	5	12142
	3	426	290	1960	4261	814	8		7	7766
	4	224	165	31	879	2552	216			4067
	5	115	56	12	2	332	1142	256		1915
	6	34	17	33	5		25	400	215	729
	7	80	26	25	1				217	349
N		10272	12308	11530	7029	3901	1411	679	446	47576

Figure 3. Comparison of Strahler Stream Order (SSO) at 47,576 macroinvertebrate sites sampled between 1983 and 2024, as determined with medium (1:100,000) and high (1:24,000) resolution NHD layers. Blue, SSO unchanged at the medium and high resolutions (30.19%); light green, SSO increases one to three SSO levels in high resolution (64.37%); dark green, SSO increases more than three SSO levels in high resolution (0.18%); purple, SSO decreases in high resolution (5.26%).

located near the shore of a large river mainstem were incorrectly identified by the higher resolution layer as 1st order. The Chessie BIBI database contains only samples collected with kick net methods. So, all sampling sites are wadeable, regardless of the SSO level. We considered including data for all

high resolution SSO (HR_SSO 1 – 8) in the %EGF estimates but decided against it. Table 2 compares %EGF for different high-resolution HR_SSO stream sizes and there is a slight upward drift in the estimated %EGF in all four analysis intervals as stream size increases. It is not clear if this reflects actual improvement in macroinvertebrate communities, natural changes in community composition (River Continuum Concept, [Vannote et al. 1980](#)), or coincidental reductions in anthropogenic stressors. However, it does slightly affect the %EGF estimates. For now, we are excluding HR_SSO 6 - 8 sites when estimating the percentage of healthy stream miles in the Chesapeake watershed. This ensures that only “streams” are considered when measuring progress in meeting the Chesapeake Bay Agreement stream health goal. About 6% of sampled sites in the analysis dataset are HR_SSO 6 – 8 and they included a few legitimate small streams misidentified as HR_SSO 6-8 and some larger streams that were included in previous calculations of %EGF. Excluding these sites is a possible reason why current %EGF estimates differ from earlier estimates in Buchanan et al. (2023) for the first, second, and third 6-year intervals, respectively.

Table 2. Comparison of the percentage of healthy streams (%EGF) in the Chesapeake watershed, by stream size. HR_SSO, high resolution Strahler Stream Order (NHDplusID @ 1:24,000 scale).

Intervals	HR_SSO=						
	1-5	1	2	3	4	5	6-8
2000-2005	56.4%	44.3%	50.1%	51.3%	57.4%	60.0%	60.2%
2006-2011	60.7%	49.8%	59.9%	55.3%	56.9%	61.5%	63.3%
2012-2017	65.3%	58.6%	63.0%	63.2%	56.4%	68.9%	69.5%
2018-2023	66.7%	61.0%	65.2%	65.1%	58.9%	65.6%	73.3%

In the future, raw data for the watershed’s HR_SSO 6 – 8 sites could be evaluated with the “semi-wadeable multimetric index” (SWMMI) developed by [Shull et al. \(2019\)](#) for large river macroinvertebrate communities. In that study, the underlying data were collected from Mid-Atlantic rivers in summer and autumn with kick nets along semi-wadeable transects. All Chesapeake sites in the study were HR_SSO 6 – 8 except where mainstem sites near the shore were misidentified as SSO 1 (~5%).

Estimates of the percentage of healthy streams in the three earlier intervals were relatively unaffected by the revised criteria for streams and rivers (Table 3). Streams identified as fourth order or less at the medium-resolution scale (1:100,000) indicate 67.0% are currently healthy while streams identified as fifth order or less at the high-resolution scale (1:24,000) indicate 66.7% are healthy. Overall improvement is 10.8% at the medium resolution instead of 10.3%, and the rate of improvement in the most recent interval (2018-2023) is still 1.4%. The largest cause of change in healthy streams from the previously reported percentages (Buchanan et al. 2023) is the data for additional sampling sites that were incorporated into the dataset (Table 3). This was especially true for 2012-2017.

Table 3. Comparison of percentage of health streams (%EGF), rates of improvement (+%EGF), and number of sampling sites (N) derived for 2000 - 2023 with high- and med-resolution map layers and additional data (this report) and for 2000 – 2017 with the medium-resolution map layer and the previous data call (Buchanan et al. 2023).

Interval	2000 – 2025						2000 – 2017		
	High-resolution (SSO 1-5)			Medium-resolution (SSO 1-4)			Medium-resolution (SSO 1-4)		
	%EGF	+%EGF	N	%EGF	+%EGF	N	%EGF	+%EGF	N
2000-2005	56.43%		7029	56.21%		7108	58.40%		7035
2006-2011	60.72%	4.29%	8273	60.55%	4.35%	8381	61.70%	3.30%	8016
2012-2017	65.31%	4.59%	6170	65.56%	5.01%	6269	67.80%	6.10%	4713
2018-2023	66.71%	1.41%	4614	67.00%	1.44%	4672	ND		

Progress Meeting CBP Goals

2009 Executive Order 13508 (70% of sampled streams throughout the Chesapeake watershed are in fair, good or excellent condition as measured by an Index of Biotic Integrity by 2025)

The 2014 Bay Agreement supersedes the executive order, but the order was the most precisely worded of the three goals and is easily tracked. Approximately 26,226 sampling locations in non-tidal, HR_SSO 1- 5 streams have been sampled in the watershed—some repeatedly—between 2000 and 2023. Between 45.8% and 51.3% were rated fair, good, or excellent in the four 6-year intervals. This calculation does not account for the fact that the density of sampling sites tends to be higher in suburban and urban areas where overlapping programs are monitoring streams. When the data are grouped by HUC12 and the ratings proportionally weighted, results for the most recent 6-year interval indicate that 66.7% of locations are in fair, good, and excellent condition. At the average rate of improvement (+3.4%), the CBP partnership could achieve this 2009 goal in the next 6-year interval (2024-2029).

2014 Bay Agreement (Improve health and function of 10% of stream miles above the 2008 baseline for the Chesapeake Bay watershed)

The Stream Health Outcome in this agreement led to the establishment of a “2008 Baseline” which was decided by consensus at a 2018 workshop to be the 6-year interval from 2006-2011. The Chessie BIBI index, and specifically the percentage of stream miles rated excellent, good, and fair, was selected as the stream health indicator by the CBP Stream Health Workgroup. Since the baseline period, that percentage has improved 6.0%, or about 8,645 miles. Technically, the CBP partnership has yet to meet the agreement’s goal of 10% improvement *above the baseline*. However, stream health has improved 10.3% since 2000-2005, the “pre-baseline” interval. Achieving this 2014 goal in the next 6-year interval is conceivable.

2025 Bay Agreement revision (Improve the health and the ecological integrity of at least an additional 4,340 (approx. 3%) nontidal stream miles every six years)

The revised language for the Stream Health Outcome stops measuring progress relative to a baseline and uses a rate of improvement of at least 3% or 4,340 stream miles every six years. The rate of improvement per interval since 2000-2005, the first 6-year interval, has averaged +3.4% (~4,941 miles) and varied between +4.6% (~6,619 miles) and +1.4% (~2,026 miles). The high-flow events in 2018 and 2019 and the COVID-19 pandemic in 2020 interrupted monitoring in the fourth interval and fewer sites were sampled (Table 1), making the stream health estimate for the interval less certain. Progress is still measured with the Chessie BIBI index ratings, but the Stream Health Workgroup is developing additional, non-biological indicators that will complement the Chessie BIBI.

Next Steps

The current version of the Chessie BIBI index was developed with 1992-2015 data and is now almost ten years old. Plans are underway to revisit the index development steps in 2026 and upgrade the index if necessary. This will involve 1) updating the family-level macroinvertebrate attribute tables used to calculate some metrics, 2) incorporating the associated water quality and physical habitat data into CEDR and re-examining the abiotic criteria used to select reference sites, 3) confirming the influence of bioregion on least-disturbed macroinvertebrate communities, and 4) revalidating the index with the additional 2012-2017 and 2018-2023 data. The adjustments will likely change the healthy stream percentages reported here but we are confident the overall improving trend will remain apparent.

Usefulness of the Chessie BIBI index as a stream health indicator is dependent on the systematic collection of macroinvertebrate samples across the entire Chesapeake watershed. Gaps are becoming apparent: several HUC12s have never been sampled (Figure A-5), and some areas have not been resampled in almost two decades (Figure A-6). Large temporal and spatial gaps in the data increase uncertainty in the progress attaining CBP partnership goals. Efforts will be made to locate more stream macroinvertebrate data collected in the watershed and include them in the CEDR database for future analyses.

APPENDIX

Maps of stream health in the Chesapeake Bay watershed

The proportional weighting method used to estimate the percentage of healthy streams in the Chesapeake watershed does not lend itself to mapping. To create a map of the watershed's stream conditions for illustration purposes, the interval-specific scores of all sampling locations in a HUC12-bioregion polygon are averaged and the average score is given its appropriate bioregion-specific rating. A green-to-red color gradient is used to indicate stream condition (excellent, good, fair, poor, and very poor) in each HUC12-bioregion polygon. A colored point is placed in a polygon if the polygon has only one sampling location; the entire polygon is shaded if it has two or more locations.

Figure A-1. Chessie BIBI ratings for 2000-2005

Figure A-2. Chessie BIBI ratings for 2006-2011 ("2008 Baseline")

Figure A-3. Chessie BIBI ratings for 2012-2017

Figure A-4. Chessie BIBI ratings for 2018-2023

Figure A-5. Comparison of earliest and most recent intervals sampled in the 2000-2023 period

Figure A-6. Most recent interval sampled (2000-2023)

2000 - 2005

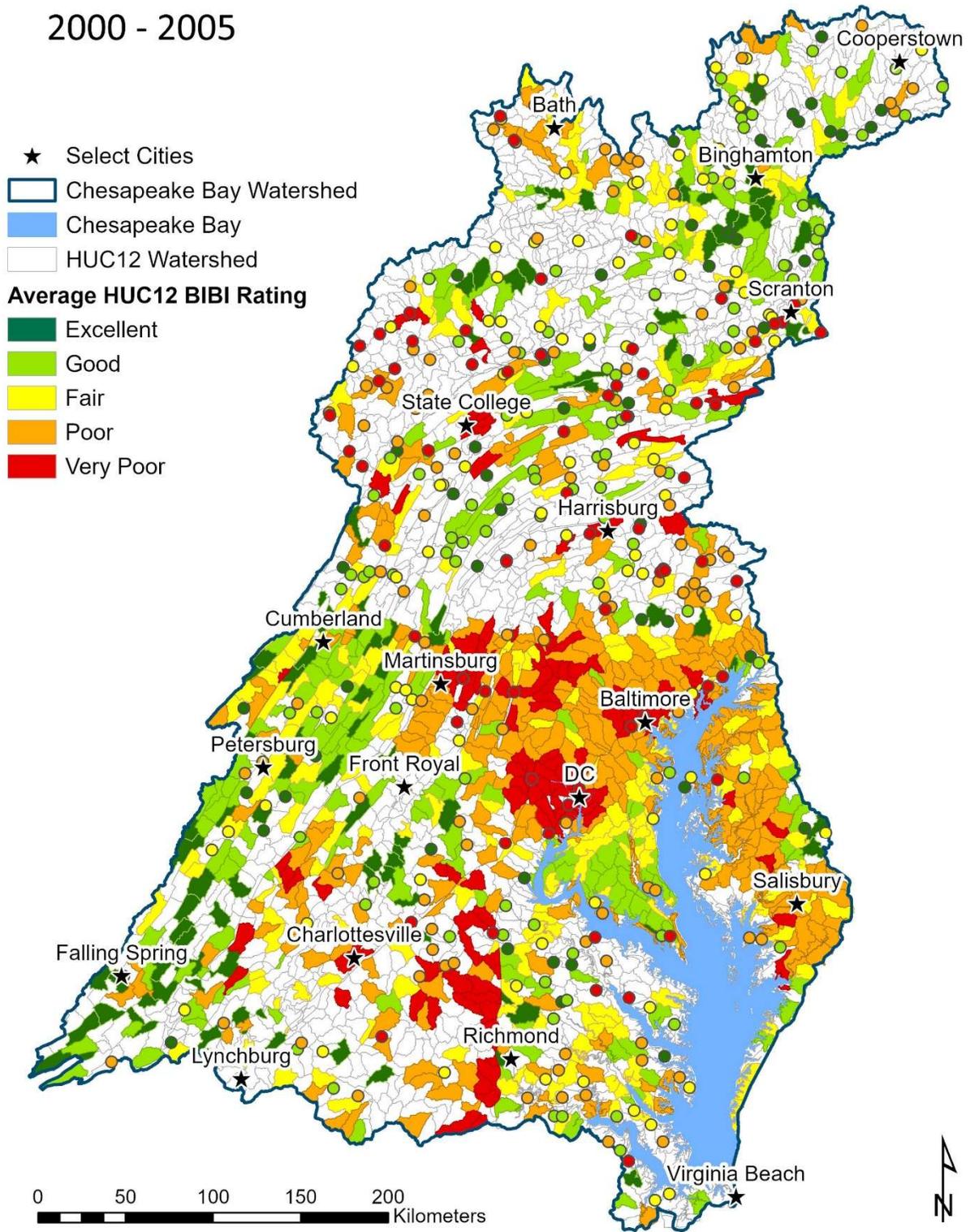


Figure A-1. Chessie BIBI ratings 2000 – 2005

2006 - 2011

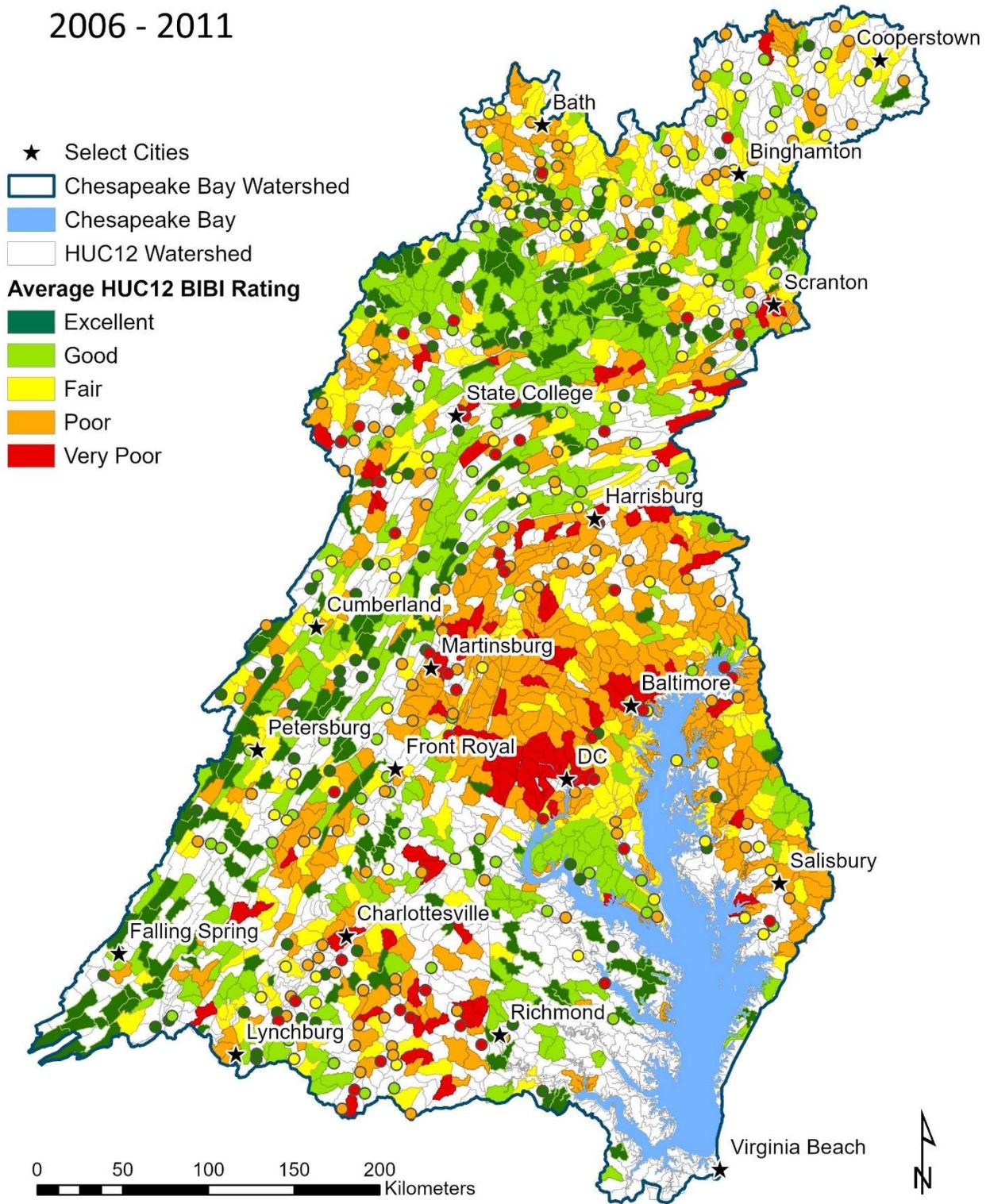


Figure A-2. Chessie BIBI ratings 2006 - 2011 ("2008 Baseline")

2012 - 2017

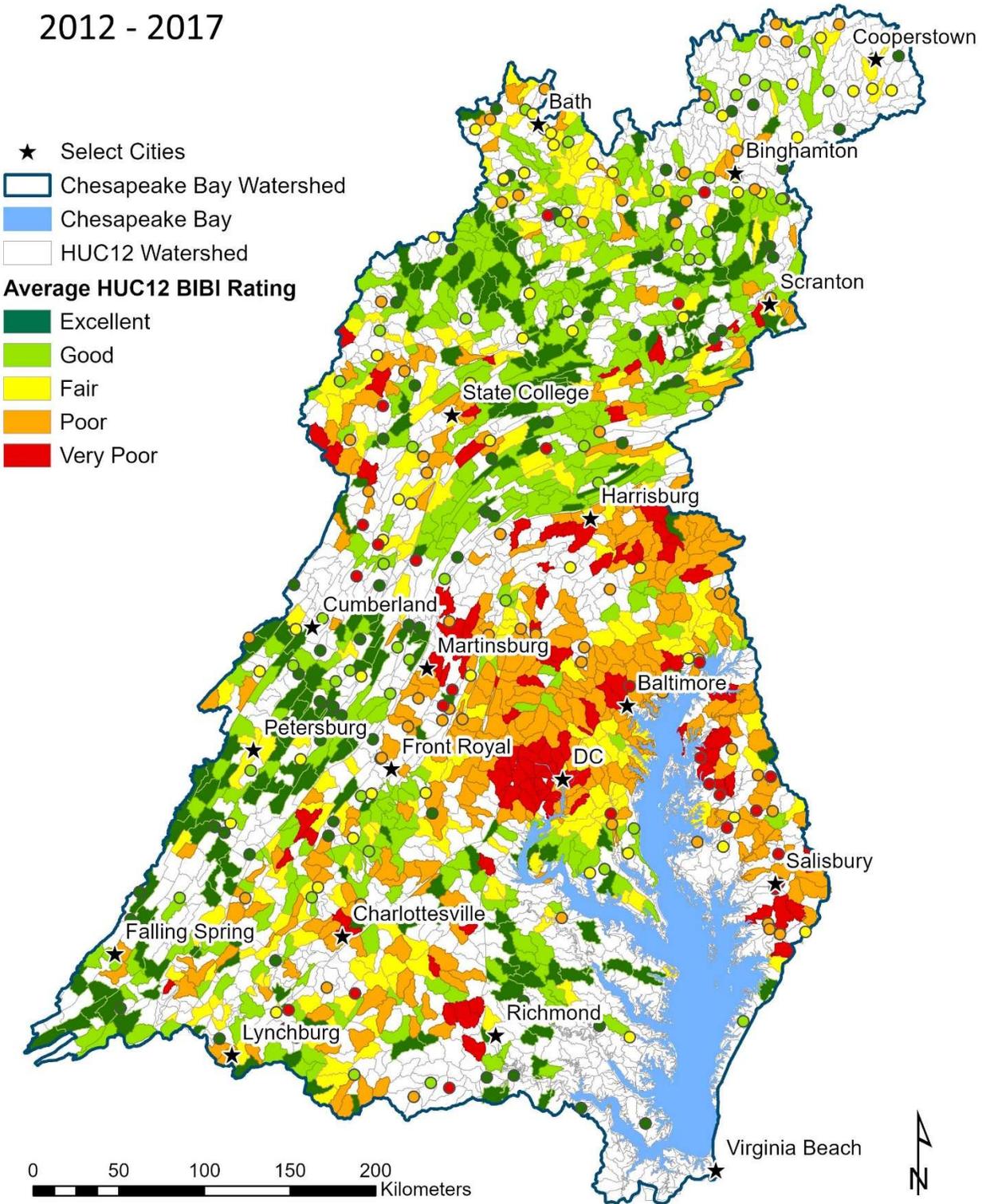


Figure A-3. Chessie BIBI ratings 2012 - 2017

2018 - 2023

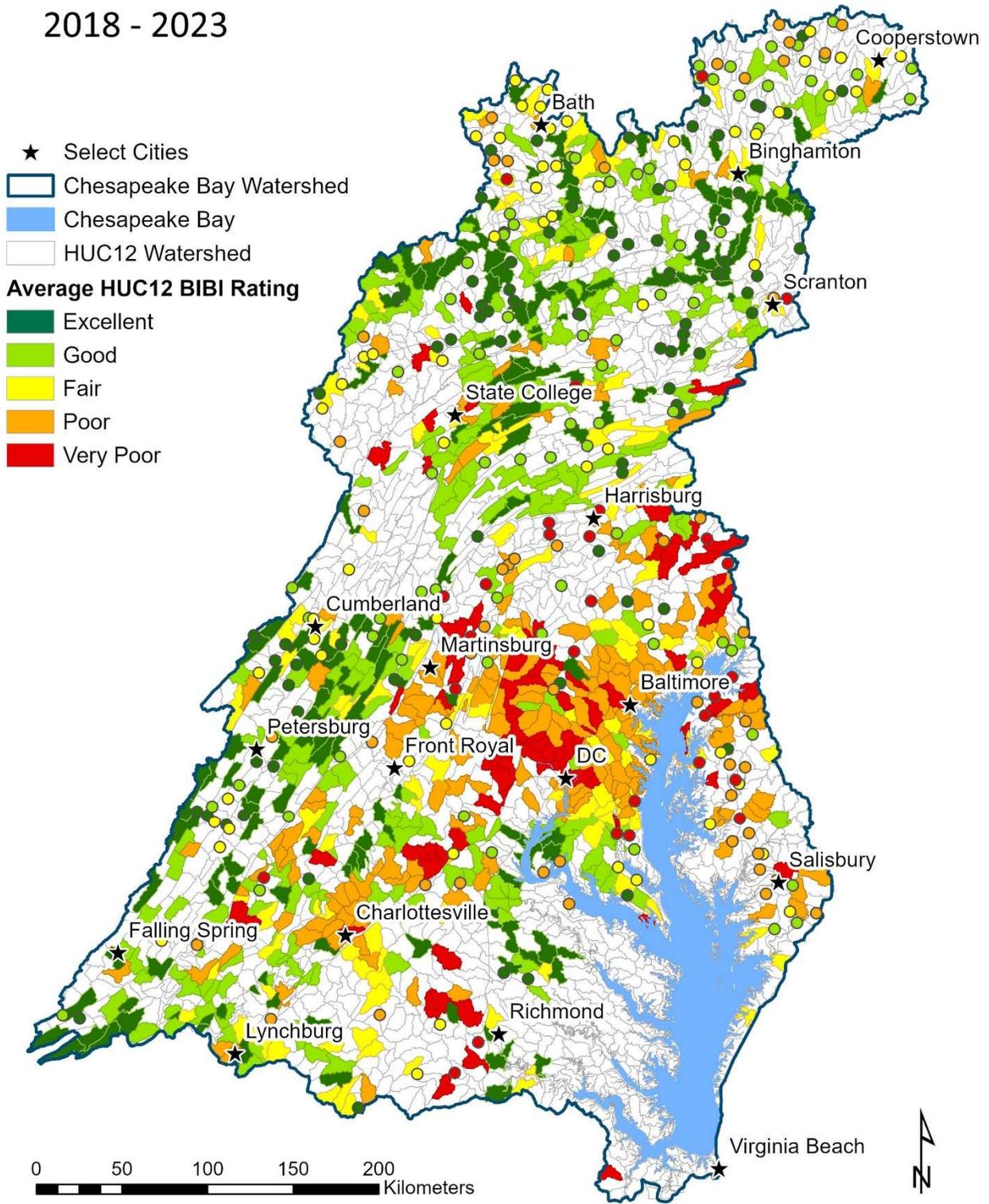


Figure A-4. Chessie BIBI ratings 2018 - 2023

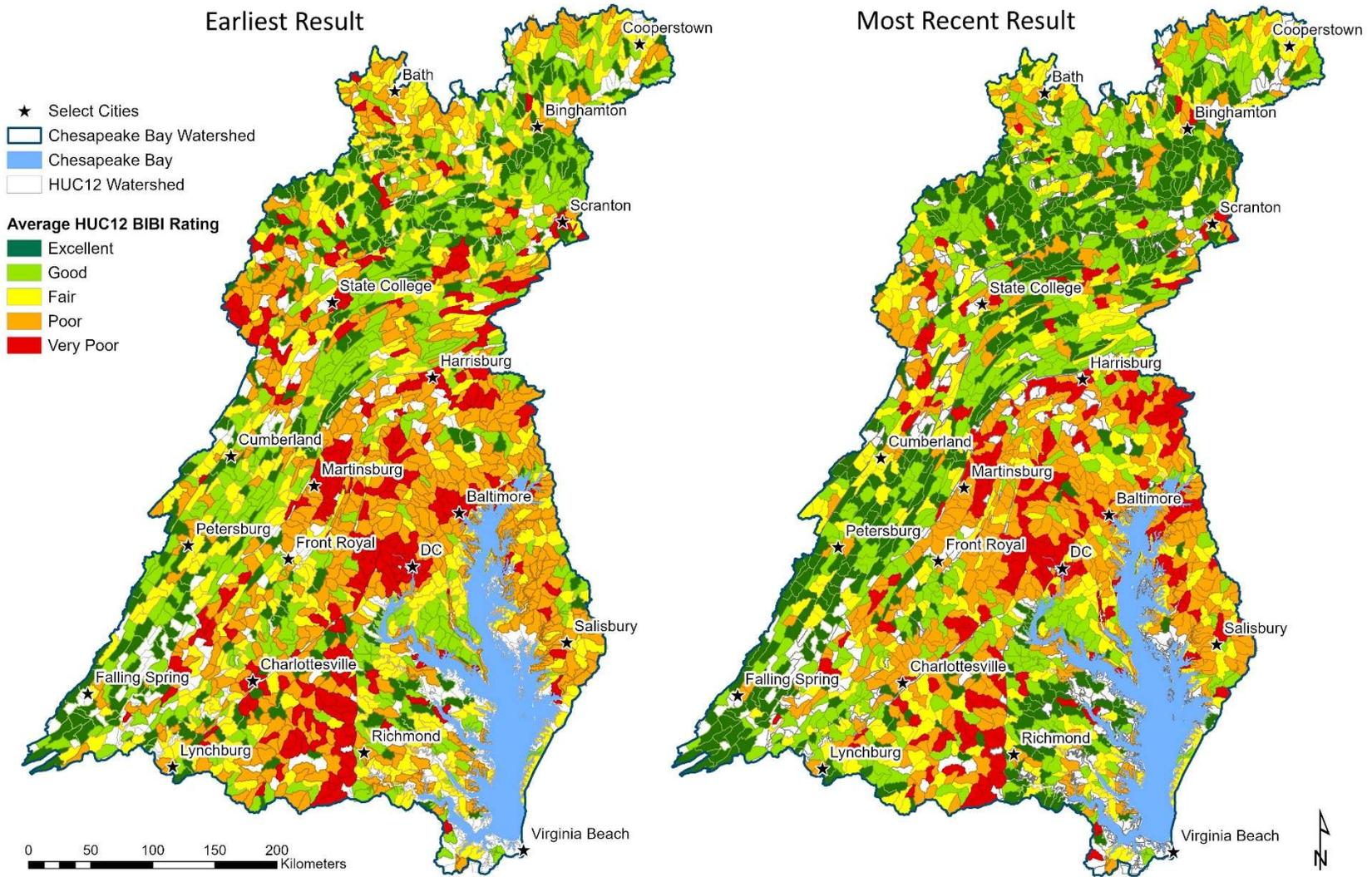


Figure A-5. Comparison of HUC12 results for the earliest and most recently sampled interval in the 2000 – 2023 period

Most Recently Sampled Interval

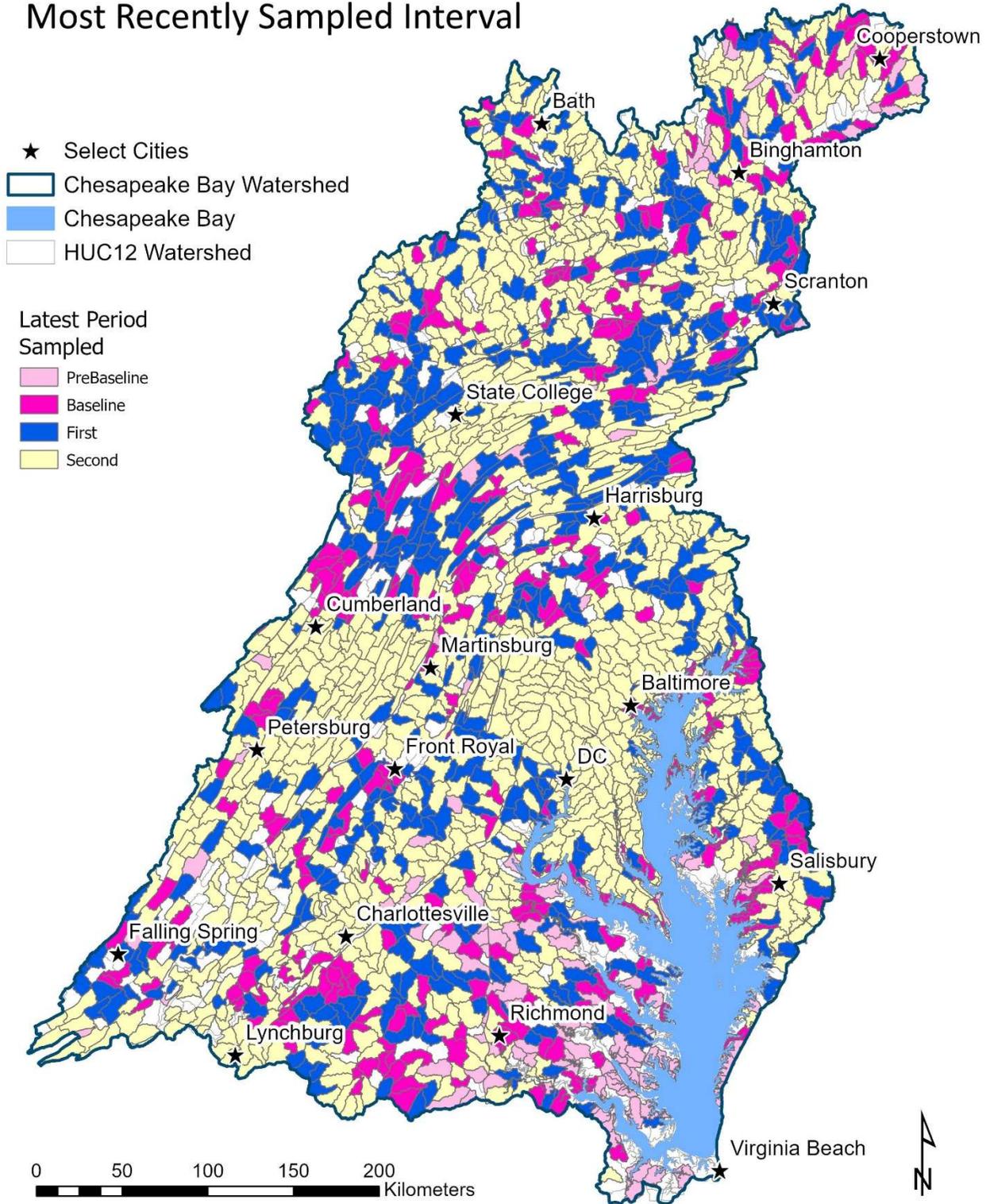


Figure A-6. Most recent interval sampled in the 2000 – 2023 period