MRRI 2023 Water Quality Report

2019-2023 5-year trends

1. Introduction

Water quality samples have been retrieved from the lower Hackensack River estuary by Meadowlands Research & Restoration Institute (MRRI) since 1993. In total, 14 different sites (HR 1, HR 2, HR 3, HR 4, HR 5, PHC 6, SMC 7, BC 8, MC 9, CKC 10, CKC 11, OPC 12, KM 13, and KM 14) are sampled each season during the low tide periods. The locations of the 14 monitoring sites along the Hackensack River are showed in Figure 1 and Table 1.

2. Methods and Materials

Water samples have been processed and analyzed based on EPA and Standard methods, NJDEP-certified procedures, and MRRI Standard Operating Procedure (QAPP). All the total and dissolved metals are analyzed by the Inductively Coupled Plasma-Mass Spectrometer (ICP-MS) (Agilent 7700X, Palo Alto, CA) based on EPA Method 200.8. In addition, different anions, which include fluoride, chloride, bromide, nitrate, nitrite, phosphate, and sulfate, are all measured using ion chromatography (Metrohm 881 Pro Compact IC) by EPA Method 300.1. Major cations including sodium, potassium, calcium, magnesium, and ammonia are also analyzed by Metrohm 881 Pro Compact IC with a Metrosep C4 150 column. Total trace mercury in water samples are analyzed by Brooks Rand total mercury analyzer MERX-T with the Model III Atomic Fluorescence detector based on EPA method 1631E. Biochemical oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), and total suspended solids (TSS) are analyzed according to the Standard Methods SM5210B, SM5220C, SM2540C, and SM2540D, respectively. Turbidity, temperature, specific conductance/salinity, pH, and dissolved oxygen (DO) are analyzed by YSI 6920 V2-2 multi-parameter sonde.

Table 1. Seasonal monitoring sites at the lower Hackensack River Estuary.

Site #	**Location**	**Easting**	**Northing**	**Latitude**	**Longitude**	Site Description
HR1	Hackensack River	622,046.89	734,717.65	40 50 58	74 01 49 00	located near the Route 46 Bridge in an industrial area
HR2	Hackensack River	620,646.76	725,696.86	40 49 29	74 02 08 00	located near the Turnpike Bridge in a non-industrial area.
HR3	Hackensack River	612,230.48	717,594.88	40 48 17	74 03 07 00	located near the Route 3 Bridge over-looked by Xanadu.
HR4	Hackensack River	605,426.28	708,697.08	40 47 19	74 04 55 00	on the Hackensack River located across from Laurel Hill Park and Saw Mill Creek.
HR5	Hackensack River	607,083.71	694,914.23	40 44 23	74 05 05 00	on the Hackensack River nearest the Hudson River
PH6	Penhorn Creek	609,875.18	701,456.72	40 45 29	74 04 29 00	off the bridge of Penhorn Creek, which is on the eastern side of the Hackensack at river mile 3.8
SMC7	Sawmill Creek (River)	603,245.45	705,643.92	40 46 10	74 05 55 00	Sawmill Creek at River mile 5.3 near the Conrail swing Bridge and the Eastern spur of the turnpike
BC8	Berry's Creek	604,971.06	720,794.16	40 48 41	74 05 31 00	Berry’s Creek at river mile 7.3 under the Route 3 bridge
MC9	Mill Creek	618,734.68	718,444.28	40 48 17	74 02 33 00	Mill Creek at river mile 9.2 and adjacent to the Secaucus mitigation Site
CKC10	Cromakill Creek (Lower, River)	620,504.73	718,291.69	40 48 16	74 02 10 00	the mouth of Cromakill Creek to Hackensack River
CKC11	Cromakill Creek (Upper)	620,016.44	712,859.48	40 47 22	74 02 17 00	0.9 miles further down Cromakill Creek near a sewage treatment plant.
OPC12	Overpeck Creek	625,915.73	730,805.50	40 50 19	74 00 59 00	Overpeck Creek, which has industry and PSE&G plant is near the site
K13	Kearny Marsh	598,011.45	701,980.12	40 45 37	74 07 13 00	Kearny Marsh, which is restricted from the tidal flow and is a result of rainfall and runoff from the town of Kearny
K14	Belleville Pike Drainage Lagoon	596,615.72	704,771.59	40 45 49	74 07 04 00	small stream located near the 1E landfill in the Meadowlands

Figure 1. MRRI water quality monitoring stations, located along the lower Hackensack River.

Fecal coliform is analyzed by using Membrane Filter Technique and modified EPA Method 1103.1 (mTEC). Based on our previous experience, we use different volume for analyzing each fecal sample from different sites. But sometimes we still have samples too numerous to count (TNTC), in this case, we make estimation that this samples has more than 400 colonies on the filter and record this sample as TNTC on the data logbook. In order to conduct the data analysis for the fecal coliform, we use the estimated 400 colonies multiplied by the dilution factor for the samples that were labeled as TNTC. This method ensures that all the samples are assigned a value for the fecal coliform and we will be able to conduct the statistical analysis.

3. Results and Discussion

Table 2, Table 3, and Table 4 show the water quality parameters for the Year 2023 average and the 5-year average (2019-2023). The data is divided into two sections, River and Creek, with each section containing seven sites that were sampled. The average concentration for each parameter was calculated for each season for the past 5 years before being graphed, resulting in 20 data points with standard deviation to identify any significant linear trends either increasing or decreasing. The data shows that most water quality parameters did not change significantly.

In addition, the NJ Surface Water Quality Standards (SWQS) for the water quality parameters are added in the table, and all parameters were compared with the SWQS. All water quality parameters are in compliance with the SWQS, except for fecal coliform. According to SWQS, fecal coliform should be less than 770 CFU/100ml for saline water. However, the average fecal coliform for 2023 is 991±1542 CFU/100ml in the River and 1039±1534 CFU/100ml in the Creek.

Generally, most of the total metals and dissolved metals, except manganese (Mn), have lower average values in 2023 compared to the 5-year average values. This indicates that metal concentrations in the water body are lower in 2023 than in previous years. As for location, the average total trace metal concentrations in the main river are lower than those in the creeks. However, the major cations, including Na, K, Ca, and Mg, have higher concentrations in the main river than in the creeks. Moreover, most of the water quality parameters in Table 2 and 4 are also lower in 2023 in comparison to the 5 year average. However, parameters such as TSS, BOD, turbidity, temperature, total Hg have higher average concentrations in 2023 than in the 5-year average.

Table 2. The average wet chemistry parameters for the year 2023 and the entire 5 years.

		River		Creek		
Parameters	**Units**	**2023 average**	**5 years average**	**2023 average**	**5 years average**	**NJ SWQS***
Hardness	**mg/L**	720±591	1070±591	455±265	535±360	n/a
Fecal Coliforms	**CFU/ 100ml**	991±1542	529±1383	1039±1534	819±1458	770CFU/100ml
BOD	**mg/L**	7.05±3.77	6.17±3.77	9.22±5.34	8.68±6.13	n/a
COD	**mg/L**	12.55±23.2	30.21±23.2	14.35±7.84	26.52±16.04	n/a
TSS	**mg/L**	21.98±9.42	13.45±9.42	27.77±26.64	24.48±27.53	n/a
TDS	**mg/L**	5786±4128	6667±4128	2954±2376	2998±2449	n/a
Turbidity	**NTU**	12.11±6.61	11.57±6.61	16.58±18.43	18.86±20.89	30 NTU
Temperature	**ºC**	16.61±8.96	16.11±8.96	16.92±7.84	16.22±8.68	29.4 ºC
Specific Conductivity	**mS/cm**	9.31±5.97	10.37±5.97	4.88±3.76	4.75±3.64	n/a
Salinity	**ppt**	5.33±3.69	6.05±3.69	2.67±2.18	2.63±2.16	n/a
pH	**SU**	7.42±0.31	7.50±0.31	7.61±0.60	7.57±0.46	6.5-8.5
DO	**mg/L**	7.70±2.81	6.45±2.81	7.26±3.10	7.32±3.25	4 mg/L

*N. J. A. C. 7:9B, Surface Water Quality Standards

Table 3. The average total metals and dissolved metals concentrations in the water samples for the year 2023 and the entire 5 years.

		River		Creek		
Parameters	**Units**	**2023 average**	**5 years average**	**2023 average**	**5 years average**	**NJ SWQS***
Total Metals	**Cd, ug/L**	<1.00	<1.00	<1.00	<1.00	H: 16
	Cr, ug/L	4.50±1.39	3.27±1.39	4.69±3.34	5.89±6.2	H: 750
	Cu, ug/L	4.87±2.51	4.04±2.51	6.88±4.65	11.43±17.92	n/a
	Fe, ug/L	807±608	679±608	1296±917	1577±1751	n/a
	Mn, ug/L	186±92	237±92	272±177	365±233	H: 100
	Ni, ug/L	5.92±3.21	2.66±3.21	9.78±11.77	4±5.69	H: 1700
	Pb, ug/L	3.28±1.27	2.65±1.27	4.33±2.68	6.48±9.81	n/a
	Zn, ug/L	14.8±6.7	14.5±6.7	20.0±12.2	24.8±22.1	H: 26000
Dissolved Metals	**Cd, ug/l**	<1.00	<1.00	<1.00	<1.00	A: 40 C: 8.8
	Cr, ug/l	2.14±0.67	1.46±0.67	1.77±0.74	1.59±1.00	n/a
	Cu, ug/l	1.78±1.26	2.23±1.26	3.03±2.36	4.43±3.74	A: 7.9 C: 5.6
	Fe, ug/l	59.1±88.0	105±88.0	198±397	304±458	n/a
	Mn, ug/l	150±86	204±86	233±185	278±229	n/a
	Ni, ug/l	1.78±55.02	15.7±55.0	1.86±1.12	23.2±93.7	A: 64 C: 22
	Pb, ug/l	N/A	1.27±0.44	N/A	2.01±1.98	A: 210 C:24
	Zn, ug/l	10.1±4.8	11.1±4.8	14.5±9.9	13.0±8.2	A:90 C:81
Total Hg	**ng/l**	35.6±14.6	24.0±14.6	45.9±49.4	45.8±65.2	A:1800 C:940 H: 51

*N. J. A. C. 7:9B, Surface Water Quality Standards; A means acute, C means Chronic, H means Human health non-carcinogen.

Table 4. The average anion and major cation concentrations in the water samples for the year 2023 and the past 5 years.

		River		Creek		
Parameters	**Units**	**2023 average**	**5 years average**	**2023 average**	**5 years average**	**NJ SWQS***
Chloride	**mg/L**	1990±1849	3049±1849	1270±1044	1400±1189	n/a
Nitrate	**mg/L**	1.67±0.91	2.09±0.91	2.22±1.34	1.81±1.63	n/a
Sulfate	**mg/L**	234±229	365±229	142±149	146±167	250 mg/L (freshwater)
Fluoride	**mg/L**	0.16±0.12	0.20±0.12	0.16±0.05	0.16±0.06	n/a
Nitrite	**mg/L**	0.60±0.62	0.52±0.62	1.21±1.26	0.43±0.76	n/a
Bromide	**mg/L**	5.41±4.32	7.12±4.32	4.00±2.79	3.12±3.13	n/a
Phosphate	**mg/L**	2.83±7.85	3.06±7.85	2.36±2.06	2.47±5.04	n/a
Ammonium	**mg/L**	2.37±1.86	2.35±1.86	1.75±2.00	1.71±1.86	n/a
Sodium	**mg/L**	1169±1015	1702±1015	666±456	769±596	n/a
Potassium	**mg/L**	46.3±36.8	65.0±36.8	27.2±17.6	29.7±22.6	n/a
Calcium	**mg/L**	71.3±41.4	103.6±41.4	61.0±22.5	75.0±31.4	n/a
Magnesium	**mg/L**	132±120	198±120	73.7±53.4	86.8±72.9	n/a

*N. J. A. C. 7:9B, Surface Water Quality Standards

Table 5 and Table 6 summarize the trends found for the wet chemistry parameters, as well as anion and cation compounds. These include hardness, BOD, COD, nitrate, TSS, TDS, conductivity, salinity, chloride, sulfate, fluoride, nitrite, bromide, sodium, potassium, calcium, magnesium, pH, turbidity, phosphate, ammonia, fecal coliforms, temperature, and dissolved oxygen. The statistical test performed for each parameter assessed the R^2 value to determine if it was greater than 0.20 before concluding whether there is a significant trend of the parameter increasing or decreasing. However, for variables temperature and dissolved oxygen, the R^2 value for the overall 5-year graph will be small due to the data's dependence on the season. Therefore, for these parameters, the direction of the trend line will only be considered to decide whether the data shows an increase or decrease over time. The significant increasing trends found in the data were fecal coliform for both the river and the creek, and magnesium for the creek only. The fecal coliform trend could have increased due to aging sewage infrastructure which leads to leaks or overflow that can introduce fecal coliform into water bodies. As well, increased urbanization can lead to more runoff carrying fecal matter from streets, sewage overflows and pet water into the water. Moreover, natural leaching from magnesium-rich rocks & soils in the watershed can increase magnesium levels in the creek. Certain industrial processes may release magnesium into water bodies through wastewater & soil amendments containing magnesium can run off into the water, increasing magnesium levels.

Looking at the differences based on location, figure 2 shows the graph of the average fecal coliform amount for each season each year for both the River and the Creek. The fecal coliform data for CKC11 was not included in the fecal coliform summary graph, as for most data points, the fecal coliform at CKC11 is always too numerous to count (TNTC). This may be due to the heavy urbanization surrounding the area, potentially introducing wastewater and fecal matter into the creek. Comparing the River to the Creek data, it shows that the fecal coliform has higher concentration levels in the Creek than in the River, however as stated earlier, both locations are seeing an increase in the concentrations of fecal coliforms. Table 6 shows a statistical summary of fecal coliforms, but on a site to site basis. This allows for a more accurate representation of where exactly the higher concentrations of fecal coliforms are located. Our study shows that PH6, K14, CKC10, and CKC11 have fecal coliform concentration higher than the SWQS criteria (770 CFU/100ml). In addition, BC8 and MC 9 have fecal coliform level close to the SWQS criteria.

Table 5. The 2019-2023 average water quality trends of wet chemistry parameters for the main lower Hackensack River or its tributaries. (Green, decreasing trends; Blue, no significant difference; Red, increasing trends.)

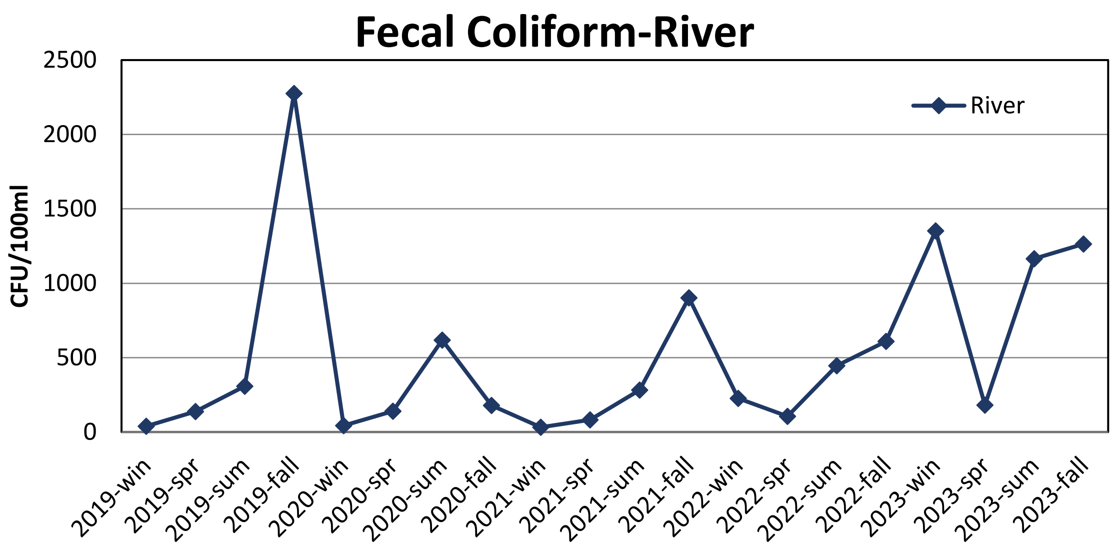
Parameters	Units	River	Creek
Hardness	mg/L	↔	↔
BOD		↔	↔
COD		↓	↓
NO_3^-		↔	↔
TSS		↔	↔
TDS		↔	↔
Conductivity	mS/cm	↔	↔
Salinity	%	↔	↔
Chloride	mg/L	↔	↔
Sulfate		↔	↔
Fluoride		↔	↔
Nitrite		↔	↑
Bromide		↔	↔
Sodium		↔	↔
Potassium		↔	↔
Calcium		↓	↓
Magnesium		↔	↑
pH		↔	↔
Turbidity	NTU	↔	↔
Phosphate	mg/L	↓	↓
NH4	mg/L	↔	↔
Fecal Coliforms	CFU/100ml	↑	↑
Temperature	°C	↔	↔
Dissolved Oxygen	mg/L	↔	↔

COD (chemical oxygen demand), calcium, and phosphate have decreasing trends at both River and Creek sites. In the case of COD, this decrease can be seen as a positive sign of better water quality, because COD measures the amount of oxygen that will be needed for the oxidation of any organic pollutants and organic matters in water. Lower COD level could indicate less organic pollution in the surface water which is beneficial to aquatic life in the ecosystem at lower Hackensack River estuary. The lower phosphate concentration in the estuary will significantly decrease the likelihood of harmful algae blooms (HABs), greatly improving the safety of nearby recreational activities.

Table 6. The 2019-2023 average water quality trends of total metals (TM) and dissolved metals (DM) parameters for the main lower Hackensack River or its tributaries. (Green, decreasing trends; Blue, no significant difference; Red, increasing trends.)

Total Metals	**River**	**Creek**
Cadmium	ND	ND
Chromium	↔	↓
Copper	↔	↓
Iron	↔	↓
Lead	↔	↓
Manganese	↔	↔
Nickel	↔	↔
Zinc	↔	↔
Dissolved Metals	**River**	**Creek**
Cadmium	ND	ND
Chromium	↔	↔
Copper	↔	↓
Iron	↓	↔
Lead	ND	↓
Manganese	↔	↔
Nickel	↔	↔
Zinc	↔	↔

Temperature variations were examined individually for each season. During the winter season, the Creek exhibited a noteworthy increase, whereas the River showed a slight increase in temperature. In the spring season, both the River and Creek displayed no significant changes. Moving to the summer season, the Creek's temperature experienced a slight decrease, contrasting with the River, which remained stable. Lastly, during the fall season, the Creek's and River's temperature remained unchanged. Dissolved oxygen levels for the four seasons over the five years were also summarized. In the winter season, both the Creek and River have slightly decreased dissolved oxygen levels, but the decreasing trend is not significant. For the spring season, there were no significant changes in either the River or Creek. In the summer season, the River experienced a considerable increase, while the Creek did not show a significant change. Finally, during the fall season, the DO levels in the River increased, and the Creek's DO levels remained unchanged. In general, the trends in temperature and dissolved oxygen changes for most seasons were similar between the River and Creek.



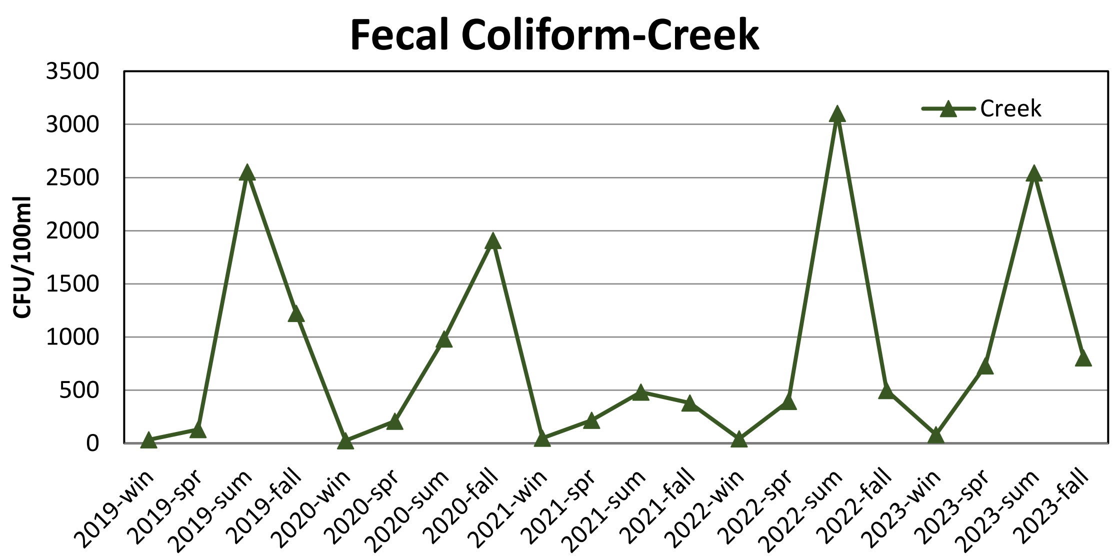


Figure 2. The 2019-2023 average fecal coliforms for the main lower Hackensack River or its tributaries.

Table 7. A statistical summary of fecal coliforms on each site from 2019-2023. Units are in CFU/100ml. The Surface Water Quality Standard for fecal coliforms is 770 CFU/100ml. Values for CKC11 are too large to make accurate calculations.

Sites	Mean	Min.	Max.	Standard Deviation	Count
HR1	383	40	1500	400	20
HR2	556	10	2000	592	20
HR3	467	5	1750	513	20
HR4	98	2	640	146	20
HR5	65	0	500	111	20
PH6	1363	20	4350	1498	20
SMC7	65	2	240	66	20
BC8	768	10	4000	1270	20
MC9	739	8	2940	894	20
CKC10	2003	8	13333	3198	20
CKC11	TNTC	TNTC	TNTC	-	20
OPC12	316	9	1415	407	20
K13	133	5	510	154	20
K14	1595	0	8000	2600	20

4. Conclusion

According to water quality data collected between 2019 and 2023, there have been no significant changes in the factors influencing the water quality of the Hackensack River and its connected creeks. All water quality parameters meet the SWQS standards, except for fecal coliform. In 2023, the average fecal coliform concentration in the creeks was 1039±1534 CFU/100ml and 991±1542 CFU/100ml in the River, which is higher than the SWQS criterion of 770 CFU/100ml for saline water. Additionally, the intrusion of seawater may contribute to increased salinity and dissolved solids levels in the lower Hackensack River, which could harm the aquatic ecosystem. To keep monitoring and evaluating these sites, the MRRI Lab will continue to collect water quality data throughout each season annually. This ongoing effort aims to detect any changes and evaluate their environmental impacts.

5. Acknowledgments

This study was supported by the Meadowlands Research and Restoration Institute (MRRI), the New Jersey Sports and Exposition Authority (NJSEA). Dr Francisco Artigas leaded and advised this project. Cheryl Yao conducted the sample analysis, data analysis and summary. Joseph Grzyb conducted the field sampling support, sample analysis and data management. Chris Evangelista maintained the data sharing network. Inputs from Mihir Jariwala, Yuleisy Rodriguez Mieses, Brian Wlodawski, Ildiko Pechmann, and Sandy Speers are also appreciated.