Comparison of 1990 and 2020 Water Quality Data for the Grand River, Michigan

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Abstract

The Grand River Expedition, launched by Verlen Kruger (Figure 2) in 1990, documented Grand River water quality. The 2020 expedition was postponed due to COVID-19, which required changes to our sampling plan. Discrete water samples were collected at 1990 sampling locations. Discrete water samples were analyzed for: *E. coli*, chloride, nitrate, ammonia, total phosphate, and orthophosphate. Additional data were collected using an In-situ Aqua Troll 500 Sonde, including high resolution temperature, dissolved oxygen (DO), pH, salinity, conductivity, total dissolved solids (TDS), and oxidation reduction potential (ORP) data. *Preliminary comparison of 1990 and 2020 water quality data shows that DO and total phosphate concentrations remained essentially unchanged while pH, temperature, TDS, chloride, nitrate, ammonia and E. coli concentrations decreased* (Figure 5). Temperature in the upper reaches of the Grand River in 2020 decreased by 1°C, while the lower reaches increased by 3°C. Average temperatures for the entire Grand River decreased (0.24°C). Average total phosphate levels, although largely unchanged between 1990 and 2020, significant decreases were observed in some reaches. *E. coli* reductions were notable in 2020 data (93.8%) compared to the 1990 data, particularly downstream of concentrated urban areas such as Grand Rapids. 2020 nitrate concentrations also exhibited a reduction (75.2%), while maintaining a similar trend to the 1990 nitrate levels. Compilation and analysis of high-resolution Sonde data is ongoing and will likely yield additional insights and explanations for observed water quality changes.

Sampling Plan Post COVID-19

Sampling Locations	Sample Type	Parameters	Methods
1990 Sampling Sites	Discrete	*E. coli* , Nitrate, orthophosphate, total Phosphate, chloride	IDEXX Quanti-Tray 2000®; Photometer with self-filling Vacu-vials; AWRI Ion chromatogaph
	Time-averaged (~ 10 minute avg.)	Temperature, pH, conductivity, ORP, TDS, Turbidity, Dissolved Oxygen, salinity	In-situ Aqual Troll 500 multi-parameter Sonde
Selected River Reaches	Continuous (2 sec. intervals)	Temperature, pH, conductivity, ORP, TDS, Turbidity, Dissolved Oxygen, salinity	In-situ Aqual Troll 500 multi-parameter Sonde
	Discrete samples	*E. coli* , Nitrate, orthophosphate, total Phosphate, chloride	IDEXX Quanti-Tray 2000®; Photometer with self-filling Vacu-vials; AWRI Ion chromatogaph

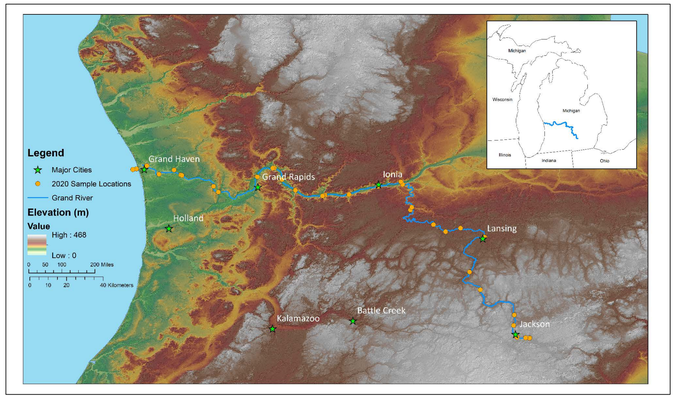


Figure 1. Map of the Grand River with major cities and sample locations.

Previous Sampling Efforts

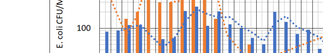
- Water quality parameters (pH, temperature, dissolved oxygen (DO), chloride, phosphate, nitrate, TDS, *E. coli)* were collected at **35 sites** along the 1990 GRE route (Figure 1). These parameters were used to calculate a **Water Quality Index (WQI) value** for each site.
  - **"Excellent water quality" - 0 sites or 0%**
  - **"Good water quality" - 5 sites or 14%**
  - **"Medium water quality" - 12 sites or 34%**
  - **"Bad water quality" - 14 sites or 40%**
  - **"Very bad water quality" - 4 sites or 11%**

Figure 2. Verlen Kruger statue in Portland, Michigan.

Methods

Continuous Sampling

- In-situ Aqua TROLL 500 Multiparameter Sonde (shown below).



- Mounted ~15-20 cm below water surface.
- Recorded data every 2 seconds.
- Measured: temperature, pH, ORP, TDS, turbidity, DO, salinity.

Discrete Sampling

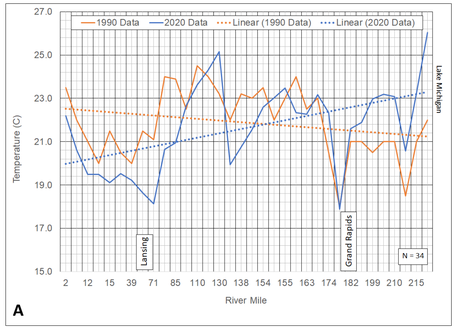
- 35 sample sites replicated from the 1990 GRE.
- Parameters measured: nitrate, orthophosphate, total phosphate, chloride, *E.coli.*
- *E.coli* samples were stored appropriately and analyzed at GVSU.
- Duplicate samples were taken at each site.

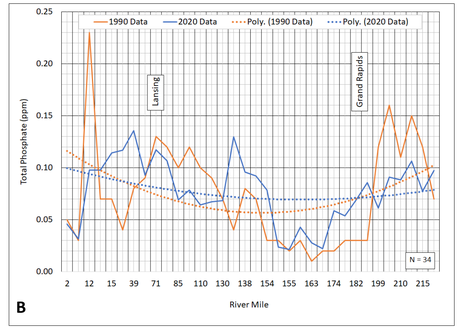
Discrete Analysis

- Duplicate samples were taken to get comparable data sets.
  - AWRI analysis
  - V-2000 Photometer (Figure 3)

Figure 3. V-2000 Photometer instrument.

1990 and 2020 Preliminary Water Quality Comparison Results





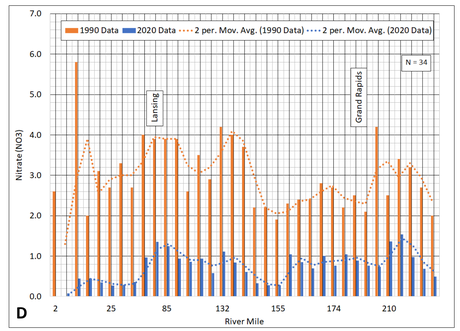


Figure 4 (A-D). 1990 and 2020 water quality comparisons along the Grand River.

Sample Set[1]	pH	Temp C	DO	Cl-	T-PO4	NO3-N	NH3-N	TDS	E_Coli MPN
Units	pH units	degrees C	ppm	ppm	ppm	ppm	ppm	ppm	MPN[2]
1990	8.26	21.88	9.27	45.01	0.08	3.05	0.09	479.85	1626.47
2020	8.16	21.64	9.33	30.06	0.08	0.75	0.06	384.97	101.21
Change	-0.098	-0.241	0.060	-14.956	0.002	-2.291	-0.026	-94.888	-1525.265
% Change	-1.2%	-1.1%	0.7%	-33.2%	2.6%	-75.2%	-30.0%	-19.8%	-93.8%

[1] Most Probable Number (MPN)

[2] Samples include 34 samples from the Grand River (Lake Michigan is excluded)

1990 and 2020 Preliminary Water Quality Comparison

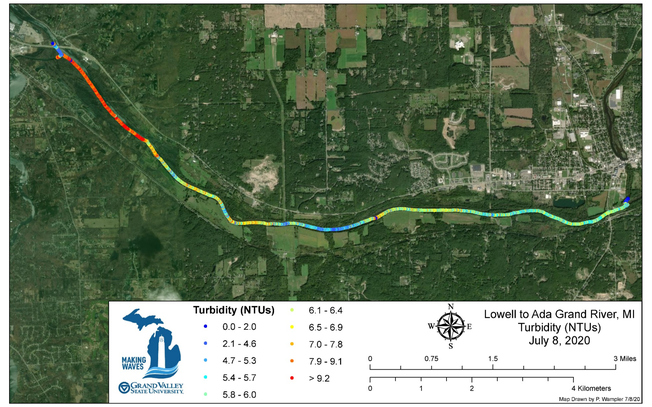


Figure 5. Continuous turbidity data from Lowell to Ada, MI (9-mile reach).

- Land use practices along the Grand River appear to be impacting observed turbidity (e.g. farmland and livestock grazing)
- Approximately 15% of the Grand River was covered using continuous sampling methods and is currently being compiled and analyzed

Conclusions and Future Research

- Over a thirty-year period, water quality parameters have improved in the Grand River.
- *E. coli* was significantly reduced which is likely a result of successful efforts to decrease combined sewage overflows (CSOs).
- Average nitrate, ammonia, and chloride levels have decreased while total phosphate and dissolved oxygen have remained about the same.
- Observed reductions in total phosphate in the lower river are potentially due to an increase in phosphate regulations.
- Increased urbanization may explain the approximate 3°C increase in temperature from the headwaters to the mouth of the Grand River.
- Analysis of continuous data will likely reveal additional insights into the sources of observed water quality changes.

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References

1.Carter, Doug, 2010, Final Report - Grand River Expedition 2010: Lower Grand River Organizations of Watersheds, http://mgrow.org/wp-content/uploads/GRE2010-Final-report.pdf.
2. Michigan Department of Environmental Quality, 2017, Water quality and pollution control in Michigan integrated report: Surface Water Assessment Section Water Resource Division, https://www.michigan.gov/documents/deq/wrd-swas-ir2016-report_541402_7.pdf.
3. Table D-1 Expedition 1990 Sample Results (p.49-50)-unpublished data
4. Dolan, D., Yui, A., and Geist, R., 1981, Evaluation of river load estimation methods for total phosphorus: Journal of Great Lakes Research, Elsevier, v. 7, p. 207-214, https://doi.org/10.1016/S0380-1330(81)72047-1.
5. https://www.mgrow.org/grand-river-expedition.