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# Eliminating the "barrier" to estuary education: Connecting students to their estuary by studying the effect of stream barrier and water quality on American eel populations

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**Abstract**

The decision to install or remove a stream barrier can have many consequences. Water quality, habitat conductivity, and flood control issues can be degraded or improved by the presence or absence of stream barriers. The objective of this work was to bring students into this decision-making process by showing them how to measure water quality parameters before/after a stream barrier using wireless hand-held probes and to compare that field data to portions of streams with no barriers. Minisceongo Creek (West Haverstraw) and Furnace Brook (Croton-on-Hudson) were the target tributaries, located directly across from each other on the West and East Banks of the Hudson River. Furnace Brook has several stream barriers just upstream of a fyke net for determining American eel counts. Local middle school students and teachers (155) were trained in how to use water quality probes and then they participated in a virtual field trip and lessons learned workshop in June 2020. Six water quality datasets measuring water temperature, salinity,

dissolved oxygen, turbidity, depth, barometric pressure and nitrate were collected in 2020: Spring data sets (2 tributaries, above/below stream barriers) and Fall 2020 (above/below 2 barriers in Furnace Brook only, nitrate probe, no eel data). Preliminary analysis of the 2020 data has shown that nitrate (mV) levels are lower on the downstream side of the stream barriers, and dissolved oxygen (mg/L) levels are higher below the stream barriers. Additional analyses of these datasets are ongoing, along with correlating eel data with water quality from previous years.

**Three Summary Points of Interest**

- Water Quality Trends surrounding three Stream Barriers on Hudson River Tributaries were studied
- Science Transfer of Water Quality conditions in Hudson River tributaries to 155 local middle school students and teachers
- Lessons Learned workshop lead by Environmental Engineering Graduate Research Students with the local middle schoolers

**Keywords**
Science Transfer, Outreach, Water Quality, Stream Barriers, Stewardship, Furnace Brook, Minisceongo Creek

**Upcoming events**

1.Collaborating with Hendrick Hudson High School: Implementing the lessons developed in this grant within a High School elective class called Environmental Solutions (half year science elective for upperclassmen). Classroom demonstrations of water probes and field trips are planned for Spring 2021.

2. Installing continuously monitoring water probes on stream barriers in Furnace Brook for Spring 2021 and Fall 2021.

Eliminating the “barrier” to estuary education: Connecting students to their estuary by studying the effect of stream barrier and water quality on American eel populations

## Introduction

The primary objective of this project was to observe and analyze water quality surrounding stream barriers on Hudson River tributaries while fostering collaborative learning with local middle school students. This project provided a means whereby youth living in communities adjacent to the Hudson River Estuary can connect with physical and biological components of their local stream/wetland to foster appreciation, stewardship, and scientific curiosity of this critical ecosystem. Additionally, Environmental Engineering graduate students analyzed data from probes that recorded 5 water quality parameters every 15 minutes for 3 months in the Spring and Fall 2020.

## Background information, literature review and basis for the study

Manhattan College received a grant from NYSDEC Hudson River Estuary program in 2017, which supplied the bulk of the funding for continuously monitoring water probes. The probes were placed at multiple locations on Furnace Brook and on Tibbetts Brook, Bronx, NY. The grant also fostered relationships with Peekskill, Hendrick Hudson, Greenbrook School Districts, and the American Association of University Women, where environmental engineering graduate students and professors would run classroom activities with hand held probes and field trips. Post field trip surveys indicated an increase in estuary knowledge after the activities. Minisceongo and Blind Brook tributaries were also monitored. This study focused on the effect of 3 stream barriers on water quality, and added nitrate monitoring to the data collection. Additionally, the effect of stream barriers and water quality on available eel count data was explored. The grant continued to engage the local school districts in the classroom, field trips and lessons learned workshops.

## Methods

This grant activities focused on stream barriers, with two specific tasks: Outreach and Water Quality Monitoring. *Task 1- Outreach:* In February 2020, the PIs and two graduate students conducted classroom activities in two school districts where students were taught about the Hudson River Estuary water quality, and stream barriers. First, students were given a brief lecture where they learned about the Hudson River Estuary and water quality. Students participated in a class discussion of how different water quality parameters including temperature, dissolved oxygen (DO), turbidity, conductivity, and pH might affect the estuary and the ecosystem. Students also learned how different stream barriers such as culverts and dams might affect water quality. Next, students were given worksheets and worked in groups to use the hand-held wireless probes (dissolved oxygen probe shown in Figure 1; Figures 2 and 3 show students using the probes and tablets) and smart tablets to measure the water quality parameters in a sample.


**Figure 1. Dissolved oxygen handheld probe (PASCO).**

**Figure 2. Students learning to use hand-held probes and smart tablets.**

**Figure 3. Students learning to use the handheld probes with smart devices.**

Students recorded the data and then filtered their sample through a column containing different media such as sand, gravel, and carbon. Filtering the sample simulated how estuary water might be filtered in a wetland. Students then

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repeated the water quality measurements after filtering their sample. Finally, the class reconvened and the graduate students led a discussion on how the water quality parameters changed before and after filtration. Students also were given the opportunity to talk with the graduate students about environmental engineering and college science and engineering classes. Between the two school districts, 155 students participated in these classroom activities.

After the classroom visits, students would expand their estuary knowledge of water quality and environmental engineering by visiting their estuary, collecting water samples, and using the same hand held probes to measure the different environmental parameters. This field trip unfortunately had to be cancelled due to Covid-19. The PIs instead filmed the field trip activities that the students would have conducted: collecting and analyzing water samples above and below a stream barrier and discussing the effects of culverts and dams in the estuary. The video was uploaded to YouTube and the school teachers shared the video with their students so they could watch the video and participate in "collecting" the water quality data. Figure 4 show stills from the virtual field trip video. This video is available to the public at: https://www.youtube.com/watch?v=zZL7t3g53k8


**Figure 4. Field trip video showing water quality parameter measurement and sample collection.**

After the students watched the field video, the PIs worked with the classroom teachers to recruit students to participate in a virtual lessons learned workshop via Google Meet where students would share what they had learned from the classroom visits and the field trip video. This workshop was moderated by a Manhattan College graduate student, the PIs, and one of the school teachers. The students were instructed to review a slide show before the workshop that showed data collected during the virtual field trip. During the workshop, the graduate student asked questions and recorded student answers during the Google Meet. Figure 5 shows screenshots from the workshop.

*Task 2- Water Quality around Stream Barriers:* In-Situ AquaTroll 600 Multiparameter Sondes were installed between 2/23/20 - 3/4/20 on Furnace Brook (at eel net, above/below Maiden Lane Dam) and on Minisceongo Creek (at eel net, and above/below weir near outlet to Hudson). The sondes were fitted with new nitrate probes, so that temperature, salinity (conductivity), turbidity, dissolved oxygen, water depth (also barometric pressure), and nitrate was read and recorded every 15 minutes. For Fall 2020, the sondes were reinstalled above/below two dams on Furnace Brook (Maiden Lane Dam and Lower Furnace Brook Dam) for September-November 2020. The statistical significance of above/below stream barriers were calculated and the data sets were plotted using actual (every 15 minutes) values, 7-day averages and 3-day average. The 24-hour average data sets were most useful in seeing trends while eliminating noise. The appendix contains tables that summarize the 24-hour average data sets above/below stream barriers for Spring and Fall 2020, along with a few sample plots of this technique.

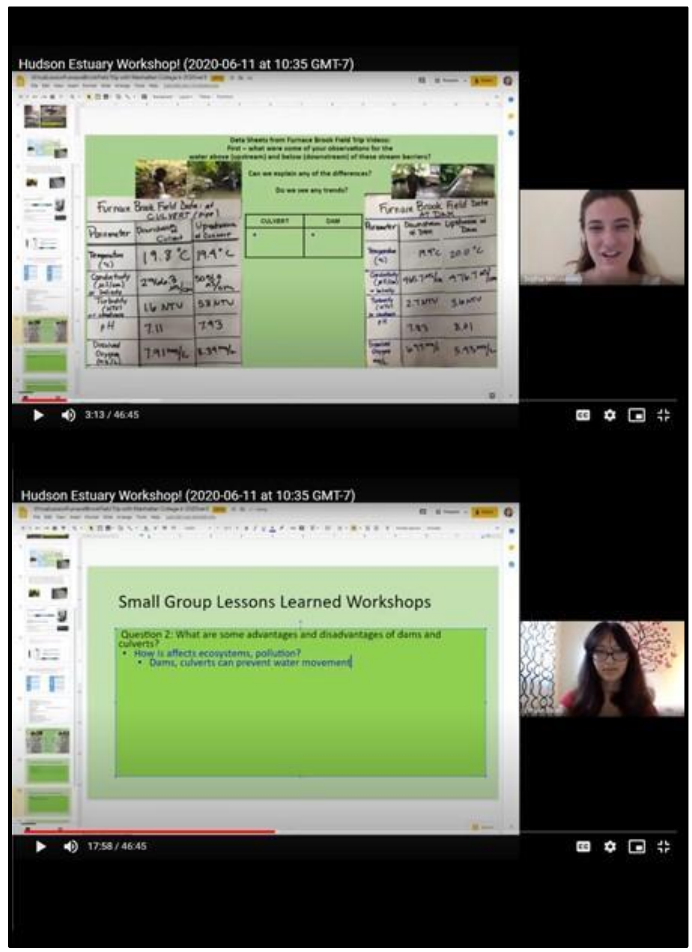


**Figure 5. Screenshots from virtual lessons learned workshop.**

**Determining statistical relationships between** juvenile eel data to water quality data was not possible for the Spring 2020 data because the eel collection program was interrupted on March 16 due to COVID 19. Research is ongoing for the 2019 2019 eel counts and water quality dataset.

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## Results & Discussion

The campaign to remove stream barriers has gained momentum in the scientific community in the last few decades, but the debate over the positive and negative effects of stream barriers on our water courses may not be well known to the general public, politicians/decision makers, or even middle and high school science teachers. This project informed 155 local students and teachers about water quality and the presence of stream barriers in their Hudson River tributaries. Students and teachers participated in a lessons learned workshop where they shared their reflections on water quality and stream barriers so that the community residents within the watershed of these streams that have barriers can make more informed decisions.

Exploratory analysis of patterns between water quality and stream barriers was initiated in this grant. The summary of all 7 Water quality parameters are included as Tables A1-A5 in the appendix. Four data sets from 2020 compared above/below stream barrier water quality: Maiden Lane Dam Spring and Fall, Minisceongo Creek Weir Spring 2020 and Lower Furnace Brook Dam Fall 2020. All data sets consistently showed the below (or downstream) nitrate (measured in mV*) values to be lower than above (or upstream) of the dam or weir. Three of these four data sets showed higher DO below the stream barrier or higher variability of DO above the dam. This would indicate that aquatic habitats might be poorer above the dam in terms of DO levels. The one data set that did not show higher DO below the stream barrier was Minisceongo creek, That probe, located below the stream barrier experiences a diurnal tide between 2.5 - 4 feet, and is within 500 ft from the creek’s out on the Hudson River. This large tidal prism likely influences the dissolved oxygen values there more than the presence of the weir barrier in the stream.

*The probes initially measure Nitrate in mV and then reports in both mV and concentration (mg/L) after initial calibration. The calibrations from the spring season used 3-point calibration using manufactured solutions (14, 140 and 1400 mg/L). However measured results never went above 13 mg/L. The probes may have been calibrated to a larger range than was needed. It may be more accurate to identify trends in mV rather than mg/L of NItrate, and the trends should be similar.

Figure A2 shows that the nitrate concentration above and below the dam for Fall 2020 at the Maiden Lane Dam were very similar. Nitrate concentration increased over the entire period at both locations. The nitrate concentration both above and below the dam also increased with increasing dissolved oxygen (DO) (Figure A4) as would be expected. There is a significant decrease in DO about October 26 both above and below the dam. The nitrate concentration below the dam is more affected by the decrease in DO than above the dam. The increase in nitrate concentration over this period is most likely the result of nitrification of ammonia (conversion of ammonia to nitrate). Both the DO concentration and temperature would favor nitrification. The lower nitrate concentrations coupled with the lower DO concentrations in September may indicate that some of the nitrate was denitrified (conversion of nitrate to nitrogen gas). Further studies are necessary to understand the variations in nitrate. Animal waste is most likely the main source of ammonia. Unfortunately, ammonia concentration is not measured. However, it would be important to monitor ammonia for any future research project. Another possible source of inorganic nitrogen is atmospheric deposition. An analysis of rainfall data might give some understanding of this.

The average number of glass eels in Furnace Brook from 2018 to 2020 is shown in Table A6 in the Appendix, along with the dates for collection. 2019 showed a statistically significantly lower average number of eels compared to 2018. Research is ongoing to explore whether the 2019 low eel counts were an anomaly or impacted by changes in environmental conditions (e.g., temperature, dissolved oxygen). The average number of glass eels in Minisceongo Creek from 2018 to 2020 is shown in Table A7 along with the dates for collection. There was statistically significant lower average number of glass eels in 2019 compared to 2019. Again, 2020 data was not analyzed for statistical significance due to COVID-19 interrupted data collection.

**Policy Implications**

This research should help the Town of Cortlandt and other Hudson River Valley municipalities make more informed decisions regarding the Hudson River tributaries in their towns, specifically involving allocating funds to remove stream barriers to restore ecosystem services if their intended function of the barriers are no longer needed. Outreach programs like this should educate and motivate residents to be involved with the decisions regarding the health of tributaries that flow through their communities.

**Outreach Comments**

On August 12, 2020 grant team members joined the discussion “Furnace Brook Dam Removal” organized by Scott Cuppett of NYSDEC and about 10-20 researchers, where researchers shared their current studies involving Furnace Brook and Dam Removal. After this discussion the grant team decided to install the water probes above/below the 2 dams on Furnace Brook for the Fall 2020 season to support the data collection efforts and decision making for the tributary. Coordination took place with the Riverkeeper for this effort. The grant team also participated in the "Regional Barrier Removal Working Group for the Hudson River" on October 14, organized by Megan Lung (NYSDEC). Other parties that were pulled into discussions for this project were the GIS program at Manhattan College, the Marketing department for Manhattan College and Briarcliff and Ossining High Schools (in addition to Peekskill and Hendrick Hudson High Schools who were already collaborators on this grant).

## Student Training

February 26-27, 2020: Manhattan College graduate students and professors were guests in ten 7$^{th}$ grade science classes (135 students) from Blue Mountain Middle School, and the 20 students in the Peekskill Middle School Environmental Club. Students had hands-on training using water quality probes to assess the health of an estuarine water body (probes measured temperature, Dissolved Oxygen, pH, turbidity and salinity). The Manhattan College Environmental Engineering graduate student supported by this project was trained in statistical data analysis and technical laboratory techniques. The graduate student made up calibration solutions for probes, used Hatch Nutrient Kits to test water samples, and compare to probe readings.

## Publications/Presentations

Effect of Stream Barriers on Water Quality and Juvenile American Eel Populations in a Brackish Tidal Wetland on the Hudson River, NY , by Misiakiewicz S., Donohue-Couch, K., Wilson, J.M., Brown, J. Proceedings from the Environmental Water Resource Institute Conference, May 2021 (anticipated)

Virtual Field Trip: June 2021, posted on youtube https://www.youtube.com/watch?v=zZL7t3g53k8

Ng, M., Wilson, J.M., Donohue-Couch, K., Brown, J., Mount, S. "Evaluating water quality data and juvenile eel populations in a brackish tidal wetland on the Hudson River, NY". Research in the Reserve Conference: Studying Ecosystems of the Tidal Hudson, Staatsburg, NY, March 2020.

## Acknowledgements

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## Appendix
## Summary of Observations: Using Daily Average Plots

Below Table A1: Spring 2020 Furnace Brook: Maiden Land Dam (probes above and below dam) not tidal

| **Parameter** | **Trends above/below barrier: February 26 - May 12, 2020** |
|---|---|
| Temperature | Gradual increase in temperature |
| Salinity/Conductivity | For both above and below dam, overall decrease but with a peak around mid-March; Above Dam had significantly higher values for salinity/conductivity compared to below dam. |
| Turbidity | Lower dam high turbidity in early May, whereas above dam had a peak in turbidity in late February |
| Dissolved Oxygen | RDO upper dam had much variability compared to lower dam, with both having an overall decreasing trend |
| Barometric Pressure | Peak in mid-march and Lowest pressure in mid-April |
| Depth of Water | High depth early May for both above and below dam; Below Dam has higher overall water depth compared to Above Dam. |
| Nitrate | Above/below dam Nitrate (in mV) differences grow as Spring goes on. Below Dam has larger drops in Nitrate levels, where Above Dam has some recovery from decreasing Nitrate levels. |

Below Table A2: Spring 2020 Furnace Brook: Under Cortland St Bridge, at mouth to Hudson R (at eel collection), tidal

| **Parameter** | **Trends, March 2020 (next to eel net): February 26 - May 12, 2020** |
|---|---|
| Temperature | Overall Temperature increasing, with peak temperature in early May |
| Salinity/Conductivity | Two specific peaks with one being in mid-March, and the next being in mid-April, almost a month apart. Most likely reflects tidal activity. |
| Turbidity | Peak in early April, with an overall increasing trend into April |
| Dissolved Oxygen | Decreases with time; peaked in late February |
| Barometric Pressure | A lot of variability reflecting precipitation. Lowest pressure recorded in early April. Overall decreasing trend. |
| Depth of Water | Depth has an inverse relationship with barometric pressure, with less variability. |
| Nitrate | Some variability, but overall decrease within peak in Late February of 140mV, and minimum in May of approximately 110 mV |

Below Table A3: Spring 2020 Minisceongo Creek: Above weir (at eel collection net) and Below (tidal portion of creek)

| **Parameter** | **Trends above/below barrier: March 4 to May 9, 2020** |
|---|---|
| Temperature | Overall Temperature increasing, with peak temperature in early May |
| Salinity/Conductivity | Below Dam has more significant differences between minimum and maximum salinity/conductivity, with steep peaks in early March, and early April. Above Dam had more variability, with an overall decreasing trend. |
| Turbidity | Below Dam significant peak in Mid-march, also reflected above dam. However Above Dam has more variability. |
| Dissolved Oxygen | Above and Below Dam reflect each other with a slow decreasing trend for both, within the same range. |
| Barometric Pressure | Lowest pressure recorded mid-April, overall decrease both Above and Below Dam |
| Depth of Water | Much variability, with increasing depth for Above and Below Dam. Below Dam has higher levels of depth compared to above dam. |
| Nitrate | Decreasing trend for both above and below dam, with Above Dam having a lower range of readings |

Below Table A4: Fall 2020 Furnace Brook: Maiden Land Dam (probes above and below dam) not tidal

| **Parameter** | **Trends above/below barrier: Sept 9-Nov 1, 2020** |
|---|---|
| Temperature | Gradual decrease in temperature, with some seasonal variation |
| Salinity/Conductivity | General decrease, with a steep decrease in late September |
| Turbidity | Above Dam has high turbidity in mid-late September, eventually decreasing over time. Below dam had a spike in late October |
| Dissolved Oxygen | Higher concentrations of dissolved oxygen Below Dam, with peaks occurring for both Above and Below in late October |
| Barometric Pressure | Lowest Pressure in late September |
| Depth of Water | Above dam depth was lower in depth, but reflected the same trends as Below Dam |
| Nitrate | Nitrate levels lower Below Dam. An overall decrease for both above and below dam |

Below Table A5: Fall 2020 Furnace Brook: Lower Furnace Brook Dam (probes above and below dam) not tidal

| **Parameter** | **Trends above/below barrier: Oct 3 - Nov 1, 2020** |
|---|---|
| Temperature | Peak in temperature mid-October, despite the overall decreasing trend |
| Salinity/Conductivity | Below Dam had higher levels of salinity/conductivity than Above Dam |
| Turbidity | Steep increase Above Dam in late October; Below Dam had more variation, with a peak in mid-October |
| Dissolved Oxygen | Variation throughout for both Above and Below Dam |
| Barometric Pressure | Lowest pressure recorded in early October. |
| Depth of Water | Below Dam had higher depth levels, and greater variation. Both Above and Below Dam had a peak depth on same day in late October |
| Nitrate* calibrated to 4 mg/l | Mid-October saw a peak in Nitrate levels for above and below Dam. Below Dam had lower concentrations overall |

Below Table A6:. Eel counts from 2018 - 2020 in Furnace Brook.

| Year | Dates | Average number of eels |
|---|---|---|
| 2018 | 02/24 - 05/19 | 61 |
| 2019 | 03/01 - 05/15 | 2 |
| 2020*Sampling season cut short due to COVID-19 | 02/20 - 03/24 | 71 |

Below Table A7. Eel counts from 2018 - 2020 in Minisceongo Creek.

| Year | Dates | Average number of eels |
|---|---|---|
| 2018 | 03/05 - 05/17 | 766 |
| 2019 | 03/07 - 05/13 | 151 |
| 2020*Sampling season cut short due to COVID-19. | 03/02 - 03/16 | 9 |

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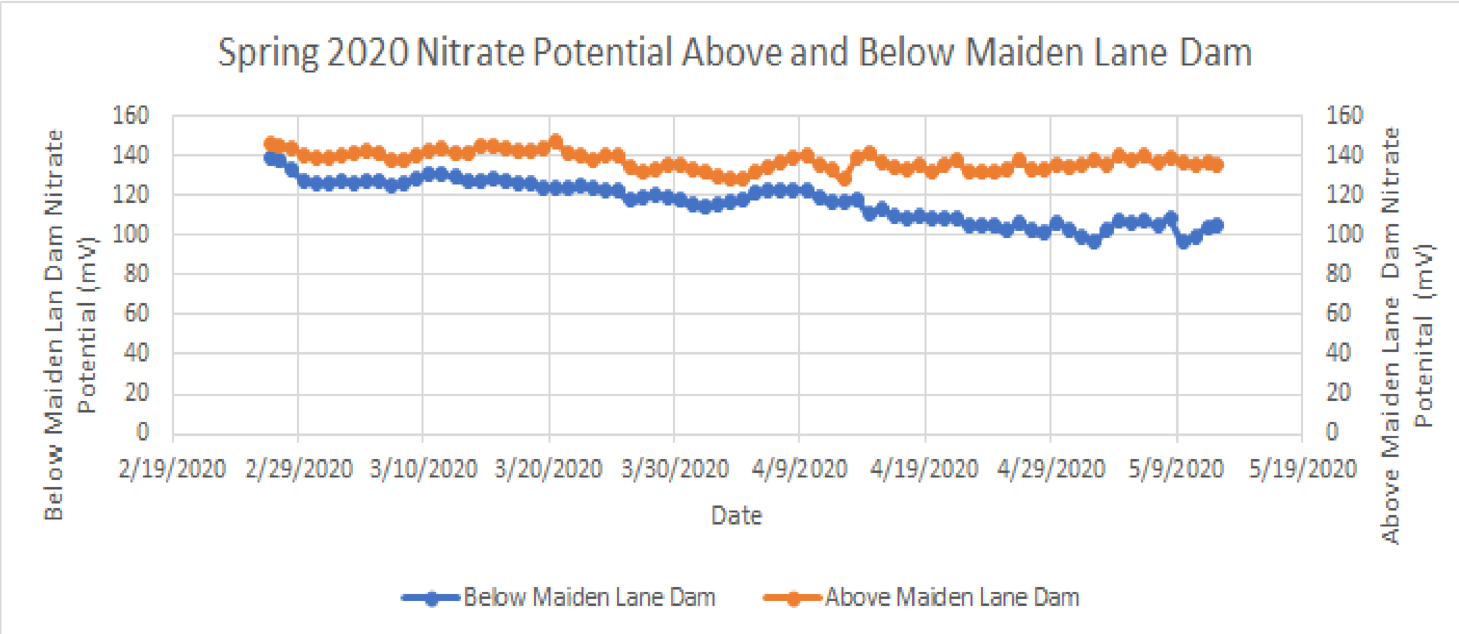
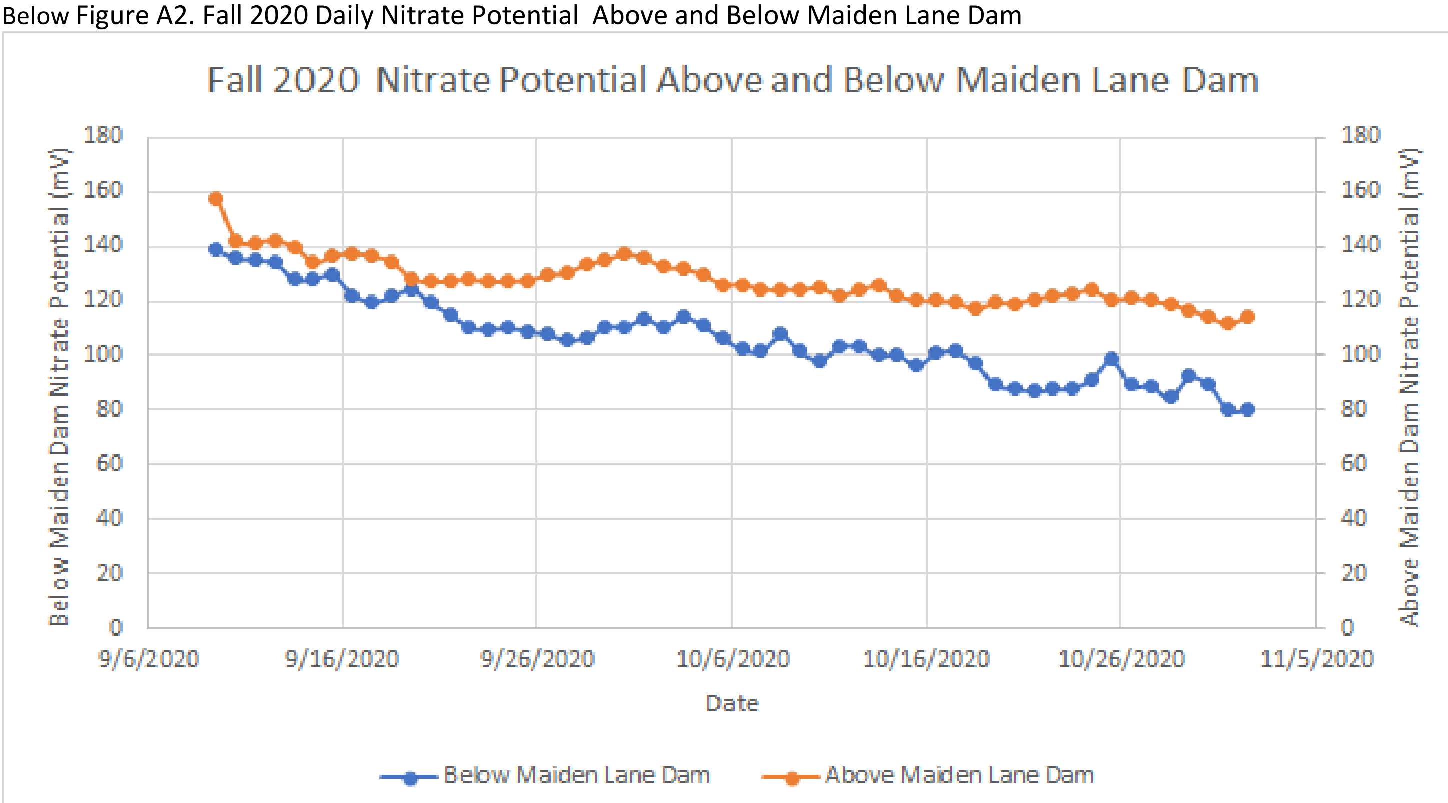
Below Figure A1. Spring 2020 Daily Nitrate Potential Above and Below Maiden Lane Dam




Below Figure A2. Fall 2020 Daily Nitrate Potential Above and Below Maiden Lane Dam

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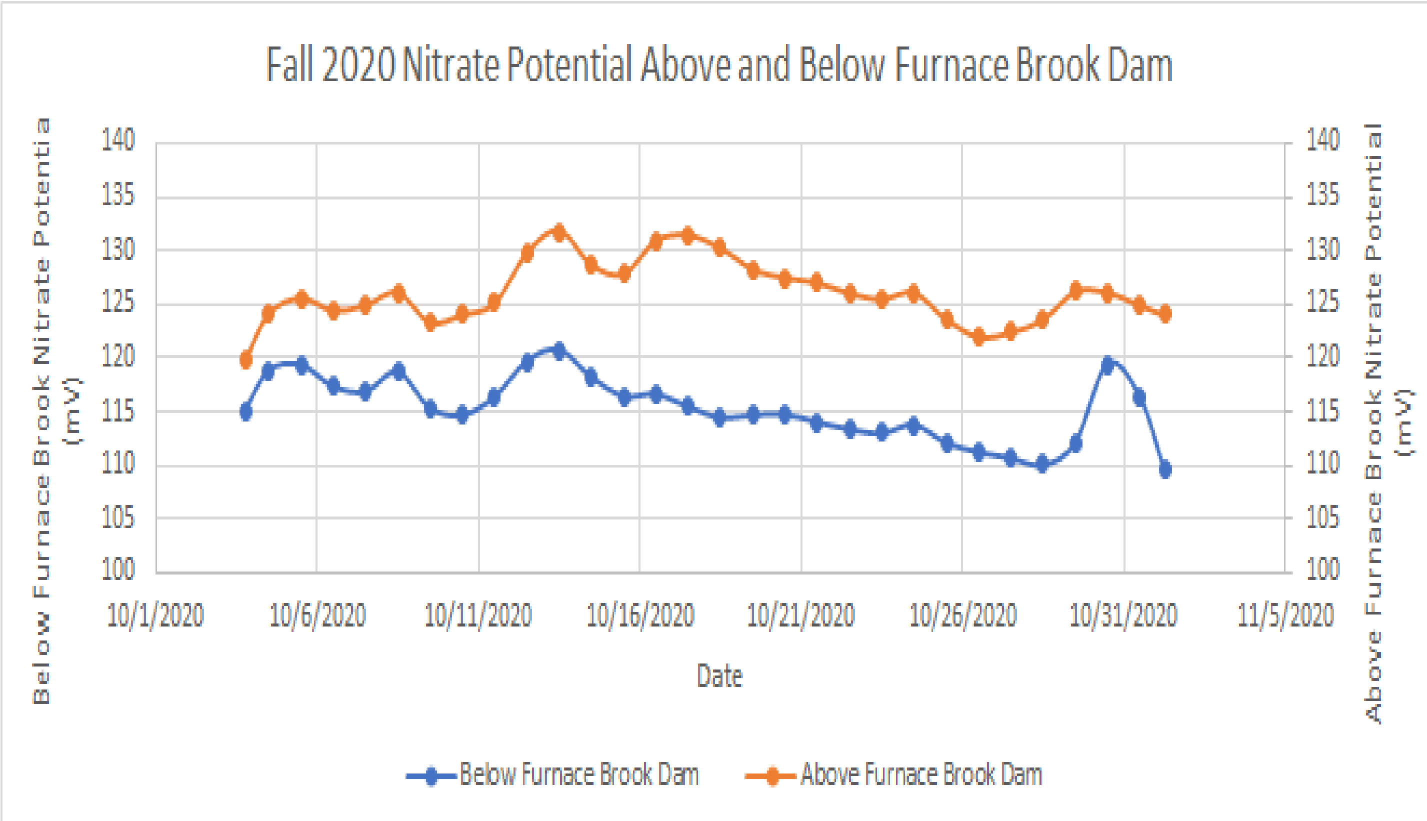
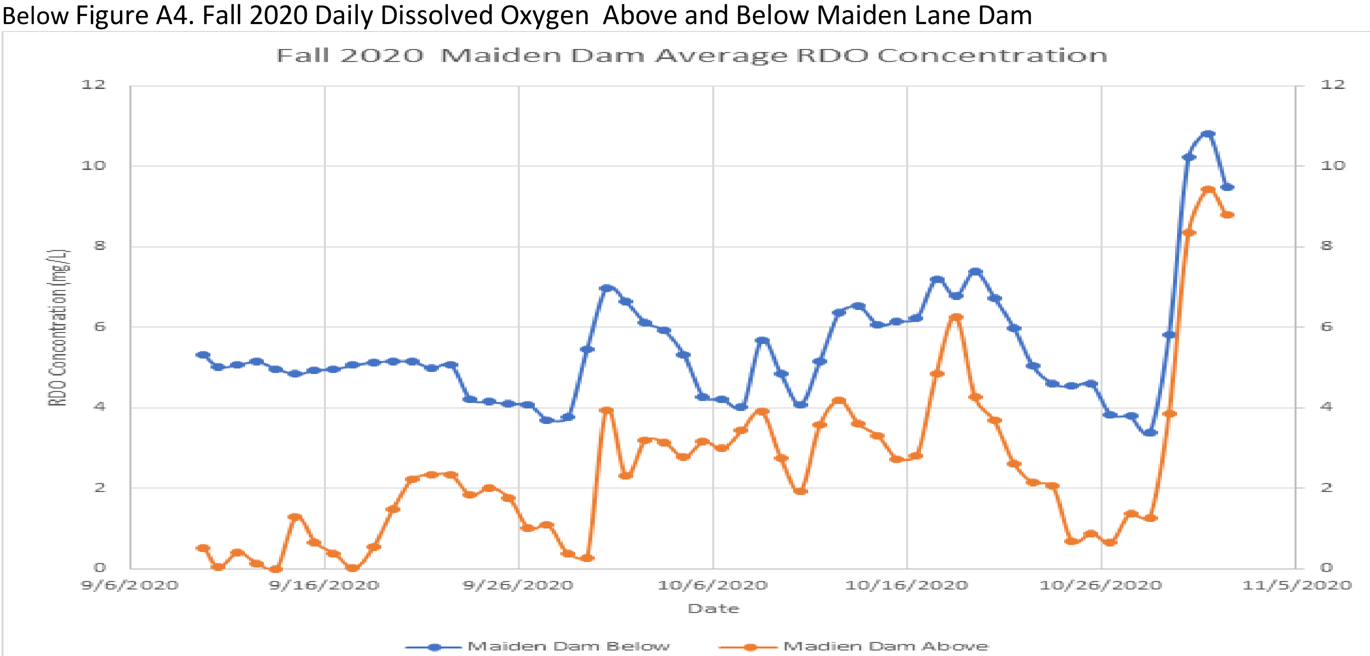
Below Figure A3. Fall 2020 Daily Nitrate Potential Above and Below Lower Furnace Brook Dam




Below Figure A4. Fall 2020 Daily Dissolved Oxygen Above and Below Maiden Lane Dam

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