**Abstract**

 The effect of manmade structures on the environment is heavily researched and frequently construction codes are ratified to ensure no negative environmental impact is being made. The water quality and quantity of streams that run throughout residential areas and communities must be monitored to ensure the safety of the water provided and to lessen flooding potential. Dry Run Creek in Cedar Falls, Iowa travels from a rural area into the residential areas of Cedar Falls and has been channelized and surround on its banks by business and homes. The overpass located on University Avenue is a manmade structure that has direct contact with the stream and affects the passage of water from the rural area into the main residential region of the city. The overpass does increase certain parameters of water quality like dissolved oxygen, temperature, velocity, and discharge, though not in such great amounts to deem the overpass as environmentally detrimental. The cement of the controlled banks and bed of the stream directly under the overpass change water quality parameters slightly. However, the rock debris placed throughout the channel under the overpass does more to reduce organic and inorganic material in the water providing for cleaner water downstream.

**Introduction**

 University Avenue, near Tremont Street and the Cedar Falls Lutheran Home, runs directly across Dry Run Creek providing wide stable banks and a rocky bed to a portion of the stream. To determine if this manmade structure, an overpass, affects aspects of stream water quality and discharge nine water quality parameters were tested. Locations upstream and downstream from the overpass, and directly beneath the overpass were determined and tested on the dates of October 24th, 26th, 28th, and 31st and November 2nd and 4th at eight o’clock in the morning. Temperatures varied from 21 -50 degrees Fahrenheit throughout those six days and there were three episodes of rain fall, two on October 23rd and 30th of about 0.07 and 0.24 inches and a larger rainfall of 0.52 inches on November 2nd. The nine parameters tested were velocity, discharge, turbidity, chloride, temperature, pH, total dissolved solids, dissolved oxygen, and total suspended solid. Field tests were conducted with identical methods each day and laboratory tests were consistent in time and measurement. Determining the effect of the overpass on Dry Run Creek will be important in potentially ratifying future building codes in association with streams quality and improving already constructed overpasses that may be harming the stream quality or worsening conditions for residents downstream. Overpasses are essential in providing transportation routes but they must provide a positive or no environmental impact.

**Previous Research**

 The concept of manmade structures effecting streams has been previously researched by several scientists in the past. In a book, by William V. Kennedy, *Road Engineering for Development*, he researches the impact of road overpasses on water quality especially the increase and runoff and sediment load. He found roads caused a reduction in water storage capacity, increased the likelihood of flooding, caused physical damage to aquatic organisms, and decreased the amount of sunlight. Another book by Alexandrine Estébe, Jean-Marie Mouchel, and Daniel R. Thévenot entitled *Urban Runoff Impacts on Particulate Metal Concentrations* found that areas of increased human activity from roads and bridges increases metals and sediment load, harming the environment downstream. The Iowa Department of Natural Resources released a study on watershed monitoring and assessment which yielded average Iowa values for the month of October and November in the parameters of temperature, total dissolved solids, total suspended solids, and turbidity. These results can be compared with data found directly associated with overpasses and the effect of the overpass can be inferred from the difference.

**Location and Site Description**

 The overpass is located on University Avenue near Tremont Street, east of the University of Northern Iowa Campus and the Cedar Falls Lutheran Home (Appendix 1, Figure 1.) Three stream areas were analyzed for water quality and discharge, one located upstream from the overpass (Appendix 1 Figure 2,) one directly underneath the overpass (Appendix 1 Figure 3,) and one downstream from the over pass (Appendix 1 Figure 4.) Both the upstream and downstream locations were located roughly 100 feet from the overpass. The stream tested is a branch of Dry Run Creek flowing from a rural to urban setting, flowing primarily northeast. The upstream location contained large quantities of organic material in the form of plant debris and animal feathers. Several fallen trees lie across from stream bank to stream bank and the banks are composed of sand and mud. The upstream portion of the testing area is also significantly deeper, with a mud and sand bed. The portion tested directly underneath the overpass was the widest of the testing areas, and the shallowest. The organic debris from upstream is often caught in the rocky bed, composed of cobble and bolder sized rocks. The banks were stabilized by concrete, creating a permanent stream width. As the water level dropped the center of the stream dried up and the bed was exposed. Velocity is also fastest beneath the overpass due to the channelization of the stream. Downstream the water began to deepen as the bed and banks returned to their natural mud and sand composition. The bank walls are steeper and there are less organic materials and tree branches present. The stream again narrowed to its upstream width, and the velocity decreased, though remained faster than upstream.

**Methods**

 Nine water quality and discharge parameters were tested on the three stream areas over a period of two weeks, and six testing days. The stream was tested for velocity, discharge, turbidity, chloride, temperature, pH, total dissolved solids, dissolved oxygen, and total suspended solids. Tests were performed in the field and in the laboratory. Testing was consistent in time, location, and amount at each of the three locations on each of the six days. Weather and precipitation was taken into account when testing and results were recorded on a premade table. An effluent pipe was also noted and tested during four of the six testing days for the same parameters, excluding velocity and discharge, determining its effects on the stream, (Appendix 1 Figure 5.) All laboratory and field tools were provided by the Hydrology and Hydrogeology Laboratory in the Earth Science Department at the University of Northern Iowa in Cedar Falls, Iowa. To increase accuracy the same probes and meters were used each testing day.

*Velocity and Discharge*

Velocity and discharge were recorded by first stretching a tape measure, across the width of the stream to determine bank width. This then acted as a marking point to calculate velocity and measure depth at the same point on the stream throughout the testing days. Upstream data was gathered at lengths 4, 5, and 6 on the tape measure with an average bank width of 8 meters. Under the overpass data was collected at lengths 2, 6, and 11 with an average bank width of 12 meters and downstream data was collected at lengths 2, 4, and 6 with an average bank width of 8 meters. Towards the end of the testing period data could no longer be tested at length 6 due to the decrease in water level and the exposure of the stream bed. Discharge and velocity calculations for that length during those testing days was recorded as zero and did not contribute to the total discharge and average velocity. Depth was determined at these predetermined lengths by lowering a meter stick vertically into the water and recording the depth. Velocity was recorded by placing a leaf at the end of a meter stick and lowering it into the water at a predetermined depth. Once the leaf began to float freely off the meter stick and begin floating downstream a cell phone stop watch was used to record the time it took to float from one end of the meter stick to the other. The data was recorded and returned to the lab for conversion and calculation. First all data was converted into meters then velocity was calculated by dividing the total meters found on a meter stick by the time in seconds it took the leaf to float that distance of the meter stick. This number was record with the rest of the data. Discharge was then calculated by multiplying the length, depth, and velocity for each of the three stream sections at each of the three testing zones. Thus the upstream section had three sections and three discharges, along with the under and downstream locations. These discharges were then summed in each section to calculate a total discharge for each stream section and averaged to calculate the average discharge for each stream section. This was repeated throughout the six testing days at the same location following the same procedure.

*Turbidity*

 *T*his parameter of the stream was measured by using the La Motte 2020i portable turbidity meter. Consistent testing was performed by first filling the plastic container with a stream sample then transporting a portion of the water into the glass turbidity vile. The glass vial was then placed into the meter and the arrow on the vile was aligned with the the arrow on the meter. The lid was then shut and the command “read” was selected. After several seconds a value appeared, measured in NTU’s, which was recorded for each sample site.

*Chloride*

 *C*hloride is another reliable water quality parameter to test because it is not broken down by bacteria. Average chloride levels in Iowa are between 16-29 ppm. Salt enters the aquatic environment by way of roads, waste, and personal applications. The addition of ions can also have an effect on the pH levels in the stream, to be discussed in greater detail later. If an excess amount of chloride is not addressed, organisms will begin to suffer and the diversity of the stream will decrease. Chloride levels were measured in the stream by using chloride titrators. These titrators were provided by the IOWATER program. The lower end of the strips was inserted into the sample of water and until the yellow band at strip turned black. The final value was determined by measuring how far the white strip saturates up the orange unit band and reading the corresponding number unit.

*Temperature*

Temperature of the stream was measured at each of the three sample locations by utilizing the Hanna Electrical Conductivity/Total Dissolved Solids/Degree Celsius/Degree Fahrenheit meter. In the lower right hand corner of the stream the temperature in degrees Celsius is constantly being recorded. Accuracy was increased by testing the water immediately after it had been removed from the stream. This was an extra measure to decrease additional interaction between the stream water sample and the ambient air after removal from the stream.

*pH*

PH was measured by inserting the Ex Stik by EXTECH Instruments pH meter into our samples collected from each of the three testing areas on site. Water was collected from the same general area in each testing location each week and placed into a clear plastic container. The meter was turned on and the given data value was recorded.

*Total Dissolved Solids*

Total Dissolved Solids levels were recorded by inserting the Hanna Electrical Conductivity/Total Dissolved Solids/Degree Celsius/Degree Fahrenheit meter into sample water at each of the three testing locations. The water was collected into a plastic container and the meter was allotted time to accurately measure the amount of dissolved solids in the sample. After completion, a measurement was provided on the meter screen which was recorded in the field log.

*Dissolved Oxygen*

Dissolved oxygen content of the stream was calculated by using the HACH HQ 30d Flexi Dissolved Oxygen meter. This parameter was tested by obtaining water from the specific sampling area in a plastic container and inserting the probe into the container. After placing the probe the meter was allowed to read and a status bar tracked the process of measurement. When completed the resulting dissolved oxygen calculation was displayed in mg/L. The sample container used had to be stout and wide to accommodate for the probes larger diameter. For increased accuracy this parameter was tested directly after temperature to eliminate excess exposure between the sample and the ambient air which could alter the temperature thusly effecting the dissolved oxygen measurement.

*Total Suspended Solids*

Total suspended solid was calculated in the hydrology laboratory in Latham hall at the University of Northern Iowa. Water samples were collected at each of the three sites from the same location on each testing day, and water was collected from the drain and tested on four of the testing days. The samples were then returned to the laboratory and filter paper from Fisher Scientific was pre-weighed using a Fisher Scientific Fisher EMP XE Series Model 100 A scale and placed on the water filtration device from Gast Manufacturing, IWC, and Marathon Electric distributed by Fisher Scientific. Six hundred milliliters of sample water was then filtered through the vacuum and the filter was removed and placed in the oven to dry overnight. The filters were dried for approximately 24-36 hours at a temperature of 25 degrees Celsius. After the filters were dried they were placed back on the scale and the weight of filter paper plus dried solids were recorded. Suspended solids were calculated by subtracting the weight of the filter paper and the weight of the filter paper plus dried solids. This number was then divided by the total volume of water in liters and resulted in a total suspended solid answer. This process was repeated for each of the six testing days at each of the three testing sites and the drain.

**Data**

*Velocity*

Variation in the velocity of the upstream area was very great as depth changed and debris blocked flow throughout the testing period. The average value upstream was measured around 0.059 m/s, with a spike on day three. The velocity under the overpass averaged around 0.196 m/s and a trend displayed a decrease in velocity as water depth dropped throughout the six testing days. The highest velocity value under the overpass was observed on day one. Downstream, the average velocity was 0.091 m/s and the highest recorded velocity was measured again on day one. Downstream data also displays a decrease in velocity throughout the testing period, Appendix 2 Table 1.

*Discharge*

Two factors need to be considered while measuring and calculating the discharge of a stream, velocity and depth. The depth of the stream ranged tremendously throughout the two week testing period: upstream depths yielded 0.76-0.66 inches, under overpass depths yielded 0.167-0.07 inches, and downstream depth yielded 0.3-0.125 inches. The average discharge value for the upstream was 0.137 m3/s and the average total discharged was 0.443m3/s. Under the overpass the average discharge was 0.142m3/s and the average total discharge was 0.426 m3/s. The average discharge for the downstream area was 0.103m3/s and the average total discharge was 0.309m3/s. The highest values for the upstream data were on testing day one and six. For the underpass discharge and the downstream discharge, the highest levels occurred on the testing day one as well. The average discharge levels for the upstream and under overpass locations were very close, and then decreased as water flowed downstream, Appendix 2 Table 1.

*Turbidity*

The turbidity value for the upstream testing area averaged to be 4.32 NTU with a peak value on testing day five. There was variability of the under overpass and downstream data with peaks occurring on day five also, but previously on day three as well. Under the overpass, the average value was measured to be 2.31 NTU and the downstream average value was 2.82 NTU, Appendix 2 Table 2.

*Chloride*

The upstream chloride value had an average of 1.49 units or 36 ppm and there was a very slight downward trend throughout the testing period. Referring to the data tables, Appendix 2 table 2, it is evident that day two and four had the highest measurements of Chloride, high levels remained consisted across all sampling areas on those days. Under the overpass, the average chloride level was 1.45 units or about 36 ppm. The downstream values had a very slight downward trend, across the testing periods, similar to the upstream with average chloride levels of 1.41 units or 33 ppm.

*Temperature*

As for temperature, there was a downward trend at all of the areas sampled throughout the two week testing process. Peak values were observed on days two and four for each testing location. Upstream, the average temperature was 9.45 degrees Celsius. Under the overpass, the average temperature was 9.08 degrees Celsius. The downstream average temperature was measured to be 8.97 degrees Celsius.

*pH*

The pH values varied from day to day especially through the first four days. It was the same for all three areas of sampling. Upstream, there was an average of 8.16. Under the overpass, the average was 8.15 and the downstream average pH was 1.17. The values were slightly basic and are close to the average for Iowa though they are slightly lower, Appendix 2 Table 2.

*Total Dissolved Solids*

There is a good amount of variation in total dissolved solid sampling throughout the testing period. Day two experienced a spike for each of the areas we sampled, Appendix 2 Table 2. The upstream average was 441.6 ppm, under the overpass the average was 435.8 ppm, and the downstream average was 431.5 ppm. All values trend downward throughout the testing period. As the water moves downstream, the TDS seems to be naturally filtering out. All these values were much higher than Iowa’s average.

*Dissolved Oxygen*

The average Dissolved Oxygen level for the upstream area was 9.165 mg/L. Under the overpass, the average value was measured to be 9.208 mg/L. The data trends for Dissolved Oxygen are almost identical for the upstream and under overpass locations. Downstream, the average Dissolved Oxygen level was 9.472 mg/L and an upward data trend was observed throughout the two week testing period. The Dissolved Oxygen values were increasing as the water moved downstream, Appendix 2 Table 2.

*Total Suspended Solids*

There was a great deal of variation among the TSS values. The upstream values averaged 8.28 mg/L, the peak observed on day four. Under the overpass, the value was 5.97 mg/L with a slight upward trend throughout the testing days. The peak value was observed on day three. The most variation occurred in the downstream data, and a trend reveals downward concentrations throughout the testing period. The average value downstream was 4.08mg/L with the peak again on day three, Appendix 2 Table 4.

*Effluent Pipe*

 The effluent pipe located upstream from the overpass was analyzed to see if it was contributing in any way to the water quality of the under overpass and downstream testing locations. The underpass and the downstream levels should be higher in any of the nine parameters than the upstream level to note any effect. The parameter values for the effluent pipe were as follows: Turbidity 0.47 NTU, Chloride 2.05 units or 52 ppm, Temperature 13.725 degrees Celsius, pH 8.252, Total Dissolved Solids 478.75 ppm, Dissolved Oxygen 9.693 mg/L, and Total Suspended Solids 1.67 mg/L, Appendix 2 Table 5.

**Analysis**

*Velocity*

Stream velocity is influenced by depth, width, and material in the water. An increase in velocity was noted as the water traveled from the upstream location to the downstream location due in large part from the decrease in depth and channelization of the overpass. The banks of the area directly under the overpass are composed of unwavering cement walls. The stream is unable to erode the walls and have a depth variation because the bed and banks are controlled. By observing the comparison graph found in Appendix 3 Graph 1, it can be noted that the velocity in a controlled channelized location is significantly higher than in a natural stream setting and has a resulting higher velocity in the downstream portion of the stream.

*Discharge*

Discharge is affected by velocity and depth. The depth varied greatly throughout the testing period as water levels dropped with temperature levels. Velocity was seen to increase under the overpass and then decrease slowly as water flowed back into a natural channel situation, found at the downstream location. This influenced the change in discharge throughout the stream as well, discharge was highest under the overpass where velocity was high and the two sides of the stream along the cement banks were deep. The discharge upstream was higher than the discharge downstream since depth upstream was significantly higher. Referring to the graph Appendix 3 Graph 2 total and average discharges for each stream section can be compared and it is evident that the under overpass and upstream discharges are very similar as upstream depth is extremely high and under overpass velocity is extremely high.

*Turbidity*

Turbidity levels were highest in the upstream stream section where several organic material and debris was present in the water. As the water flowed downstream through the under overpass location several rocks acted as a filtration system resulting in the lowest turbidity levels found here. The effluent pipe found directly above the overpass had the lowest turbidity which was evident of the crystal clear water flowing from the pipe; the pipe also acts as a filtration device preventing cloudiness in the water. As the water flowed from the overpass to the downstream location organic materials and debris reentered the water from the falling leaves of the above trees and turbidity levels rose again, but remained less than upstream levels. The overall turbidity levels for each of the three stream testing locations were well below the average for Iowa which is 14 NTU, comparisons can be seen at Appendix 3 Graph 3.

*Chloride*

Overall, chloride levels went down slightly from sample site to sample site as the water moved downstream. This could be attributed to the natural filtration of the water. As the water passed through the rocks of the overpass chloride was collected and purer water resulted downstream. The highest levels of chloride were found in the effluent pipe, which was water directly taken from the surface of roads. Roads naturally have a higher salt concentration from winter ice prevention and car traffic. The values at each of the stream sections are significantly higher than the average value for Iowa, Appendix 3 Graph 4.

*pH*

PH levels have a delicate balance in stream systems. PH is naturally influenced by rain water, soil, and bedrock content. Average pH levels in Iowa are more basic at 8.2 for rivers because of Iowa’s limestone bedrock. The values found at Dry Run Creek were slightly basic but extremely close to the Iowa average, though slightly lower. The pH levels between testing locations was not great enough to make a differentiation between upstream and downstream. The pH of the drain pipe contributed the highest concentrations, due to the influence of the road debris, though this level was still extremely close to the averages for the rest of the stream. The graph shows that there was really no pattern as the water moved downstream, Appendix 3 Graph 5.

*Temperature*

The temperature level drops as the water flows from the upstream site to the downstream site. This can attributed to the fact that the overpass is blocking sunlight from warming the water as it flows beneath and the banks and bed composed of cement are naturally colder than banks and beds made of sand and mud. The water from the effluent pipe was significantly warmer than the normal stream water due to its flow through a closed pipe buried beneath the surface shielding it from ambient air conditions. These temperature values are lower than the average Iowa temperatures found across the state for the months of October and November, Appendix 3 Graph 6.

*Total Dissolved Solids*

Total Dissolved Solids is the measure of dissolved organic and inorganic materials in the stream. Dissolved solids enter the water by way of agricultural runoff, leaching of soil pollution, and general erosion. Average Total Dissolved Solids levels for Iowa are around 367 ppm. This is lower than the averages results found for the three testing locations at Dry Run Creek. As the water moves downstream, the Total Dissolved Solids concentration filters out through the rocks present in the under overpass location. The water is flowing from agricultural areas upstream explaining the higher values than across Iowa. The effluent pipe had the highest concentration of total dissolved solids, which is logical considering the organic and inorganic material collected from roads and vehicles, Appendix 3 Graph 7.

*Dissolved Oxygen*

The Dissolved Oxygen values increased from the upstream to downstream testing locations. Dissolved oxygen is influenced by temperature and velocity. Since the velocity increased from upstream to downstream more oxygen was found in the turbulent water beneath the overpass. Also the temperature decreased from upstream to downstream which also would increase the levels of dissolved oxygen. Since the effluent pipe had the highest temperature the dissolved oxygen there yielded the lowest concentrations. These values were lower than the average for Iowa a further indication that Dry Run Creek is a healthy stream, Appendix 3 Graph 8.

*Total Suspended Solids*

Total suspended solids are a measure of the un-dissolved solids found within a water sample. The effluent pipe had the lowest levels of suspended solids since the water was being filtered through a pipe. As water traveled from the upstream to downstream testing locations total suspended solid concentrations decreased. This is in part due to the filtration of the rocks under the overpass and the absence of falling tree debris under the overpass. Each of these values were below the Iowa average which is 20 mg/L, evident on the comparison map found in Appendix 3 Graph 9.

**Conclusion**

 Based on the results of nine parameter tests and comparing average values to the average values of Iowa provided by the Department of Natural Resources it can be concluded that the overpass located on University Avenue does not have a negative environmental impact on Dry Run Creek. The overpass does change values from the upstream location to the downstream location, but overall they are too insignificant to cause large negative environmental impact. It is important to keep in mind that the overpass does not yet affect the amount of chloride in this part of the stream, but testing did not occur during times of salt application to prevent road freezing. In general the water speeds up and discharge increases underneath the overpass and is faster than water at the upstream location once it leaves the overpass, though these increases and decreases are not significant enough to attribute to potential flooding downstream. The temperature also drop as the water moves downstream, though no negative aquatic impact could be noted downstream, and the increase in dissolved oxygen levels resulting from this inverse relationship also did not have a notable effect on the downstream aquatic environment. The remaining parameters had concentrations too similar to note the change from upstream to downstream, and it can be determined that the construction of this overpass is not negatively impacting the steam environment and quality.

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