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Travel time study at the Wetlands Park National Preserve

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Abstract

This thesis reports on a study of the residence time of water in the Wetlands Park Nature Preserve in Henderson, Nevada. Rhodamine WT was used in order to test for the travel time of the water from the Monson Channel inflow to the Nature Preserve outflow to the Las Vegas Wash. The initial hypothesis was that the water would stay in the system for approximately 8 days. Residence time was tested using an ISCO sampling machine along with a Sequoia-Turner model 450 fluorimeter to test for the fluoresce of the dye in the water. All samples collected were taken immediately to UNLV where they were run through the fluorimeter. Precautions were taken in keeping the samples from being degraded by several factor, including temperature and sunlight. Results were input into Microsoft Excel and statistical values were calculated. The results show that there is a difference in the calculated time and the actual mean residence time. The calculated residence time was 188 hours and the actual mean residence time was 109 hours.

Introduction

This study examines the question: what is the residence time of the water that is moving the system of ponds and streams at Wetlands Park Nature Preserve? To answer the main question, we began by examining several ways to test residence time. The purpose of this paper is to report the procedures and results of the study. Dave Betley, Rosangela Brazao, and Jim Pollard developed this study; Brandon Bair, Dave Betley, and Rosangela Brazao conducted it. This study was conducted at the Clark County Wetlands Park Nature Preserve, (WPNP), a newly created wetland established in the southeast corner of the Las Vegas valley.

Creating the wetland created a new ecosystem in that area and there are several variables that need to be studied. The hydrology of the park is one of these variables, specifically the residence time of the water in the system. Hydrology is the study of how water moves through an environment. Understanding the hydrology of park will help managers manage the park. This information is vital to the management; they need to know this in order to find ways of controlling variables such as sedimentation, but more importantly what is the amount of pollutants being removed by the vegetation.

A wetland works by removing pollutants and sediment from water by slowing the flow of water coming into the system. Through the uptake of plants harmful pollutants are removed from the water, thus acting as a natural filtration system. This study provides baseline hydrologic information about the park. A baseline is the beginning point from which we can do more studies and gives us a point to compare to. The importance of this information is to allow for more testing in the future to establish things like the effects of sedimentation, vegetation, and other factors that will build up the

bottom of the ponds, which will in turn cause a change in water velocity and a decrease in volume. Pond build up would eventually cause a depletion of water turning the wetland into small meandering streams. All the above information is needed in order to establish protocols that can be used in measuring the ponds and other part of the system.

Figure 1 shows the 130-acre WPNP system. Water enters the system from the north, from the Monson Channel, and flows southeast through the five ponds before leaving the system. Within the 130-acre park, there are five ponds and several streams that serve as a filtration system for contaminants entering the system. In addition, numerous aquatic and riparian plants and animals are dependent on the wetlands to meet both nutritional and water needs. The water that finds its way into the WPNP comes from the Flamingo and Tropicana Washes.

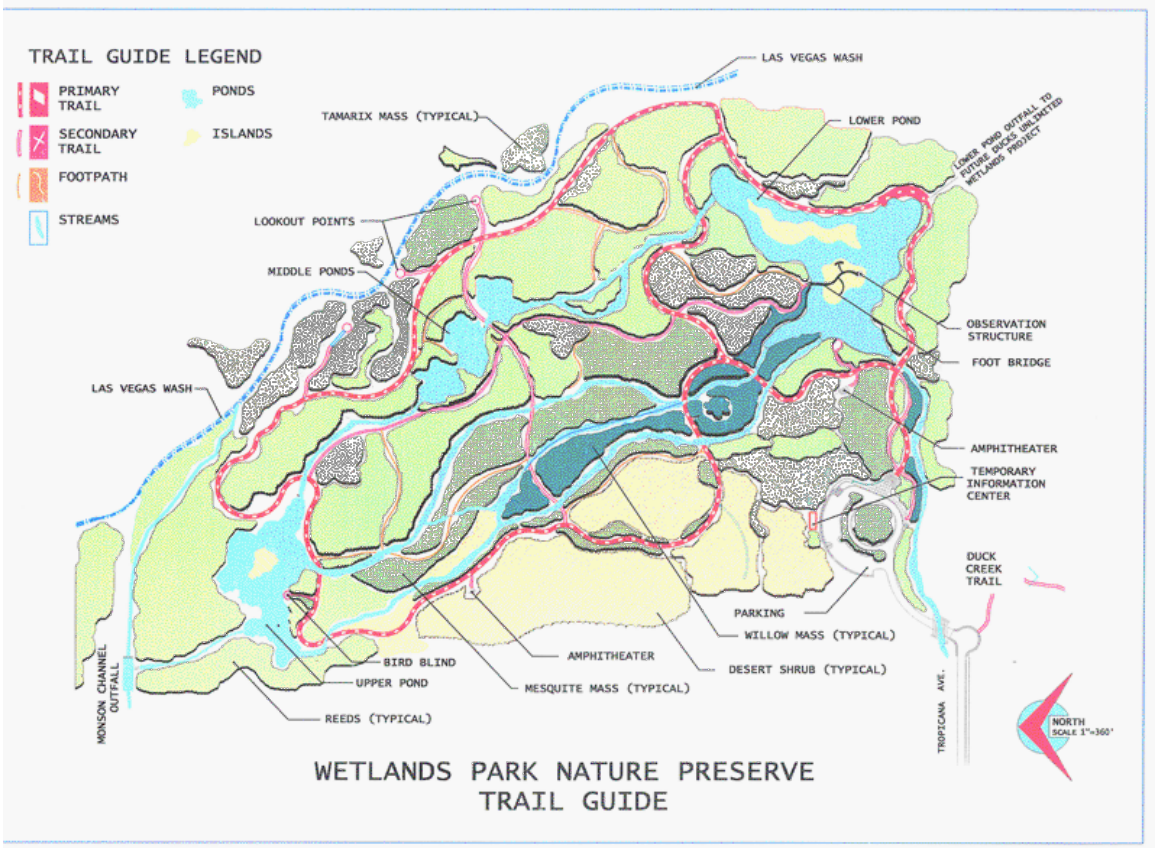

Fig. 1 Map of the Wetlands Park Nature Preserve.

The water coming into the wash is from runoff, like sprinkler water and people who wash their vehicles, among other things. All of the pollutants, including soaps, fertilizers, oils, and sediment flow into the wash and down into the WPNP via the Monson channel. After entering the pond the water moves east through the upper pond. This is a large pond consisting of an island with dense vegetation around the edges of both the outside of the pond and around the island with some vegetation growing throughout the water. It continues east over two weirs that are on the northeastern and southeastern side of the pond. A weir is a concrete channel that can be adjusted to raise and lower the pond water volume by placing wood timbers in the slot found in the middle of the weir. There is a shunt on the southeastern side of the upper pond that directs some water into a stream that goes directly to the lower pond.

From the northeastern side of the upper pond, the water moves down to the middle ponds, which are divided up into three small ponds. The upper pond of the three is the largest; it is not as densely vegetated, with some open areas on both the north and south sides. The middle of the three ponds is smaller with relatively the same amount of vegetation, except for the eastern side, which is very dense. The last of the middle ponds is the smallest but is the most densely vegetated. The pond is surrounded by substantial amount of vegetation and also throughout the water. Almost all of the vegetation in the WPNP is bulrush, which can grow up to around 9 feet with small round stems. This allows for very dense stands of vegetation. Each of the three middle ponds are controlled by weirs and connected to the next pond east from the previous pond. The water then flows through another small channel into the lower pond; this is also a large pond, similar to the upper pond. The lower pond has a point that is accessible by walking

that reaches out into the middle of the pond. The vegetation around this pond is lower than the amount found at the previous ponds. After moving through the lower pond water then flows out through a pipe that regulates the amount of water leaving the system. The outflow from the WPNP eventually runs into the Las Vegas wash and into Lake Mead. All of this information is needed to comprehend how the system can be tested in order to find out the hydrology of the park.

The first question in this study was: what is the best way to measure travel time? We investigated several methods and chose to use dye tracer that can be sampled and measured for concentrations of dye present in the water sample. A dye-tracer is a fluorescent dye put in water that when used can give off low light radiation, that can be detected by a fluorimeter. One dye that is commonly used is Rhodamine WT; it is inexpensive, easy to use and has little environmental effect due to its benign effect in water (Kilpatrick and Wilson 1989). The way in which Rhodamine WT is used is it is introduced in one large quantity upstream from the area to be sampled. The dye then diffuses into the system of water and is almost undetectable by sight. The only way in which to test the water for the dye is by looking at the fluorescence. A fluorimeter, which is a machine that measures fluorescence, is used to test for the dye. Fluorescence is low radiation (light) of lower energy (longer wavelength) given off from the dye once mixed in a solution (Cobb et. al. 1986). In order to measure the fluoremetery we must have consistent sampling. This can be done in many ways. For example, one could take a bottle and place it under water getting a sample. This would be very time consuming and therefore is not practical. We used a machines ISCO 3700 portable sampler to collect the samples of water. It is capable of sampling up to 24 times and at any interval

from one minute to hours to days, which will allow for precise sampling. We also used a fluorimeter to measure the concentration of dye.

Approach

This thesis reports on how travel time was measured, presents the results and discusses some considerations for future studies. By looking at storm data our group speculated that the water in the WPNP would take at least 8 days to travel through the five-pond system that makes up the WPNP. A dye tracer is a fluorescent dye put in water that when measured can give off low light radiation which can be detected by a machine called a Fluorimeter.

Several factors were key to the success of the project. The literature says Rhodamine WT is a good dye tracer, but that several factors can cause it to degrade. First is concentration. If there is not enough dye administered than the fluorescence may not be detectible even with a fluorimeter. Second is temperature. Fluorescence increases as temperature decreases and vice versa as temperature increases fluorescence decreases (Wilson et. al. 1988). Some other factors that might cause degradation in the dye are algae, salt compounds, and manmade pollutants (oils, dyes, detergents). Photochemical decay is another type of degradation; rhodamine WT is very susceptible to photochemical decay. In strong light, the fluorescence can decrease very rapidly. Turbidity and pH also play a role in the degradation of the dye. All of these factors have been looked at and were going to be taken into consideration.

Methods

We used CAD drawings of the ponds before they were filled to calculate the amount of dye needed to give us a collectable value, which would be anything that would give us a reading in the fluorimeter. The system was divided up so that we could test individual ponds to reduce the effects of degradation on the results.

There were samples collected at specific times of the day. Each of the samples was run through a fluorimeter to see the concentration of dye present in each sample. Each step was carefully noted, so that this project can be repeated over again. This procedure has been done for many years, by a variety of agencies. The sites where dye was added and where samples were taken are shown in Figure 6.

Dye Selection & Quantity To Be Used

The dye chosen for this study was Rhodamine WT 20% solution because of the qualities it possesses. It is inexpensive, easy to handle, has very little effect on the environment. For the lower pond NP 8 one liter of dye was administered. At site NP 3 .3 liters of solution was administered, and at NP 2 one liter of solution was administered.

Quantity of Rhodamine WT to inject in NP-2 formula.

The first thing we needed to calculate the amount of dye needed was the volume of the pond, which is 4,633 m^3. Next we needed to know the concentration of

Rhodamine WT, which is 10,000 mg/L (10 parts per thousand - ppt). Concentration is equal to mass divided by volume (C = M/V). (1ppb/L)/4632.99 $m^{3.}$

The total quantity of dye to inject at NP-1 is equal to 1L (we can use 500 mL graduated cylinders to measure with).

Field Work

In order to do the dye study there are some tasks that must be done first. To begin we need a sampling machine and the one chose was an ISCO model 3700 portable sampler. First we need to know about the capabilities of the machine so some initial tests were taken after reading the operators manual. We needed to see how long the battery would last and how accurately the machine could sample. The time intervals and water quantities the ISCO could sample had to be determined to test the florescence. Tests were run in the lab. Battery tests were later taken at the park to see if the battery would hold up in hot environmental conditions. The dye tracer study was run from May 20, 2002-June 1, 2002. Sampling was done by breaking down the WPNP into three testing sites, because of the degradation of the dye due to temperature, vegetation and other factors that were addressed earlier. The first testing site was NP 8, which is at the outflow of the lower of the three pond systems found in the park. The dye was administered approximately 40 feet from the walkway at the upper inflow to the lower pond. 1 liter of concentrated Rhodamine WT 20 % solution was administered. The ISCO sampler was set at the outflow of the lower pond and was set to sample every two hours and to collect 250ml of pond water. Samples were collected every twenty-four hours and taken to the lab for analysis. There were extra bottles so that we could have

constant sampling without having to wash the bottles out and reuse them. The dye has an affinity for the bottles and therefore could be left in the bottle for no longer than one day.

After each collection of bottles the machine was carefully put back together so that there was no misalignment that might throw off the sampling. The battery was also changed daily so that power failure would not occur. The bottles were numbered before removal in order to keep track of the samples. An ice chest was used to store the bottles in from the park to the lab to prevent temperature and sunlight degradation of the dye further. After the samples were collected and the machine was put back together we reset the time and made sure that the machine was setup for the correct sampling. A manual sample was also taken to make sure that it had not lost its calibration due to removing the lid and retrieving the bottles. Samples were taken from the time that the dye was administered to the time that the dye concentration in the water was almost zero.

For site two (NP 3), we administered 300ml of the Rhodamine WT 20% solution upstream from the three middle ponds. The ISCO sampler was set at the outflow of the third middle pond (NP 6) below and after the weir. The machine was calibrated and, sampling times were set for every hour due to the pond's small size and volume. The volume to be collected was set for 250ml. The time was set to take one sample every two hours and was collected every 24 hours.

Site three is the upper pond system (NP 2); it was set up the same as the other sites. The sampling times were set at two-hour intervals and set to collect 250 ml per sample.

How to work the ISCO Model 3700 Portable Sampler

The ISCO has numerous functions that can be used for more complex studies. For this study however, we are using it in its most basic function, which is taking only one sample, at one or two hour increments. This is a general guide for using the sampler to perform the basic skills needed to run the experiment.

1. Turn on machine with on/off key.
2. Select enter/program.
3. Select program.
4. Select time.
5. Select time for each sample.
6. Select no for multiplex samples.
7. Select sample volume (250 ml).
8. Select suction head of feet (the length of hose being used).
9. Select calibrate sample volume (yes).
10. Select sampling time.
11. Now it should be in the standby mode.
12. Run a manual sample by pressing the manual sample button
13. Remove top and see if correct volume has been collected. If not, rerun manual sample until the correct volume is obtained.
14. Put everything back together in proper alignment, there are small tabs on the machine to align with.

    Now press begin sampling.

Calibration Curve

Once these initial tests were done, the calibration curve was set up in this manner. A calibration curve is based on standards that are prepared using the maximum allowable value of concentrations and the lowest concentration value along with several other concentrations that fall on the line in between the highest and lowest points on the graph. The line is linear. In order to do a calibration curve, we first obtained one gallon of pond water. This water was taken into the lab and filtered by pouring the water into a funnel with filter paper that has a 1.2-micron porosity; this allows us to pull out any of the large particles that might give us an inaccurate reading. Next we take a 100 ml volumetric flask and add 1ml solution of the Rhodamine WT 20% to the flask. We then fill the remaining 99ml with the filtered pond water, which makes a 10 ppt solution. From the flask a 1ml of solution is drawn and put into a 100ml flask. This is then diluted by adding 99ml of filtered pond water, making the concentration 10ppm. Next add 5ml of the second diluted bottle (10ppm) is added to a 1000ml volumetric flask, and then filled with 995ml of filtered pond water. This results in a 100ppb solution, which is the highest allowable concentration, because the amount of dye was calculated to have the highest volume in water at 100ppb. After each bottle was filled, a piece of parafilm was used to seal the top. The bottle was shaken to mix the dye evenly. To establish the calibration curve we made concentrations of 1,2,3,10,20,50, and 100ppb. For the 1 ppb we added 1ml of the 100ppb solution to a 100ml flask. We then filled it up to the 100ml mark with filtered pond water. This resulted in a 1ppb solution. We then added 2ml of 100ppb to another flask followed by filling the remaining space with the filtered pond water, thus giving us a 2ppb solution. The same technique was used for the 3,10,20, and

50ppb solutions. This gave us a way to measure the samples that would be taken from the Wetlands Park.

Dilutions

1. Take 1ml of Rhodamine WT into 100 ml volumetric flask (10 ppt- parts per thousand).
2. Take 1ml of solution #1 into 100 ml volumetric flask (100ppm).
3. Take 1ml of solution #2 into 1000 ml volumetric flask (100ppb).
4. Take 1ml of solution #3 into 100 ml volumetric flask (1ppb).
5. Take 1ml of solution #3 into 100 ml volumetric flask (1ppb).
6. Take 2ml of solution #3 into 100 ml volumetric flask (2ppb).
7. Take 3ml of solution #3 into 100 ml volumetric flask (3ppb).
8. Take 10ml of solution #3 into 100 ml volumetric flask (10ppb).
9. Take 20ml of solution #3 into 100 ml volumetric flask (20ppb).
10. Take 50ml of solution #3 into 100 ml volumetric flask (50ppb).

Lab work

The setup for the lab work was as follows. First, we obtained the standards that were placed in a refrigerator and covered by tinfoil to protect the integrity of the dye. The standards were placed in order from 1 to 100ppb on the counter. Second, we needed the filtered water and the samples collected from the day. The samples were laid out in numerical order. Next, we set plastic weighing dishes in front of every sample and standard along with pipette tips. The contents of each bottle were then poured into the

weighing dish and placed in front of it in small amounts, enough so that 5ml of each solution could be placed in test tubes. Each standard was drawn and put into a test tube that was then placed in a holder in order, from the smallest to largest concentration of dye. The same was done for the samples, which were also put in order from the first sample to last. When we finished with the standard we put a piece of parafilm on the top and wrapped them up in tinfoil again, putting them back in the refrigerator. The weighing dishes and pipette tips were discarded and the bottles of samples were dumped out. Each bottle was then rinsed in water three times and then be put into a tank of soapy water to sit for a period of 12-24 hours. After sitting in the soapy water they are rinsed three more times, followed by another rinsing with de-ionized water. Note: some technical support people said to use ethanol to clean bottles; others said just regular soap is enough.

Fluorimeter

The Fluorimeter used in this study belongs to Dr. Jaci Batista in the engineering laboratory. It is a Sequoia-Turner model 450 Fluorimeter and for the purpose of this study it was used in the modes gain 1 and 5. To set up the machine it first must be turned on and warmed up for at least fifteen minutes. Once warm-up is complete, turn to gain 5 and span clockwise until it stops. Put the filtered pond water in and zero out the machine using the zeroing knob. After it has been zeroed out (when the machine reads zero for the value) remove the test tube with the filtered pond water and put in the 100ppb solution. Turn the knob counterclockwise until it stops. This is the value of fluorescence. Next you put in the test tube with 1ppb solution and record the value.

Make sure that the test tubes are clean before setting them in the machine so that it does not distort the value. Do these same steps for the 2,3, and 10ppb solutions. Now it is time to test the fluorescence of the samples. Record the time and date the sample was taken along with the value. Make sure to make two separate columns because we need to do the same testing at gain one. After completing the samples turn to gain one and get the values for 10,20,50, and 100 ppb solution. Record the data next to the gain 5 column so that this information can be put into the computer.

Procedures to Create Calibration Curve

Equipment

- Digital Fluorimeter model 450 Sequoia –Turner

Fluorimeter operation.

- Turn on power switch. Allow 15 minutes to warm-up.
- Place SC585 and NB540 filter in sample compartment.
- Place cuvette with DI water into cuvette holder.
- Set SPAN button fully clockwise and adjust ZERO knob until display indicates 000.
- Replace blank solution with sample to be measured (use the highest concentration first).
- Adjust GAIN and SPAN controls until a desired reading is obtained on the display (sets to the concentration you prepared). Don't touch ZERO knob.
- If the display goes blank, reduce GAIN until a number is displayed. If the display remains blank on the lowest setting, install aperture slide.

Reading dilutions in Fluorimeter

Calibration curve 2 to 0, 10, 20 50, and 100 ppb

- Put blank in the cuvette.
- GAIN button is on 1.
- SPAN button fully clockwise.
- Set ZERO.
- Insert higher concentration (100 ppb) and set SPAN to 100.
- Read each concentration and register the value.
- Plot a graph with the results and find $R^{2.}$

Calibration curve 1 to 0, 1, 2, 3, 10, and 20 ppb.

- Put blank in the cuvette.
- GAIN button is on 5.
- SPAN button is fully clockwise.
- Set ZERO.
- Insert higher concentration (20 ppb) and set SPAN to 200.
- Read each concentration and register the value.
- Plot a graph with the results and find $R^{2.}$

Flask #	**Concentration (ppb)**	**Reading**
1	0	0
3	1	183
4	1*	271*
5	2	258
6	3	300
7	10	522
9	20	969

Flask #	Concentration (ppb)	Reading
1	0	0
7	10	136
9	20	67
10	50	23
11	100	7

Results

The results were entered in Microsoft Excel in order to graph and interpret the data. This data can be found in Dave Betley's thesis, which, is currently being written. The data that was collected from this study is summarized in the figures and tables provided below.

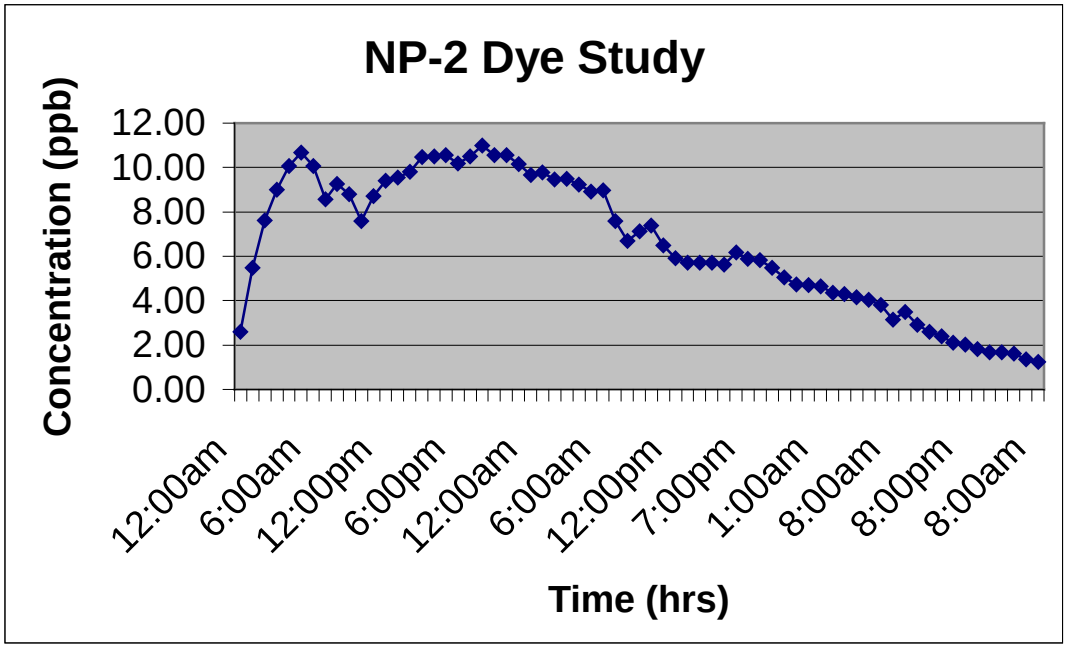

Figure 3 Residence time for NP-2, which was collected from May 28, 2002- June 1, 2002)

Table 1 Results from NP-2 travel time.

The data was graphed to visually determine the travel time. It was also used in order to calculate the theoretical residence time along with the actual mean residence time. As figure 3 indicates, there is a large difference in times between the two, which broken into day intervals would be approximately one day.

Mean HRT	Theta	29.1	hours
	Sigma^2	230.6	
	t(f)/T	0.1	
	t(p)/T	0.2	
	t(90)/t(10)	6.0	
	Sigma (theta)	0.3	
Theoretical HRT	T	50.4	Hours

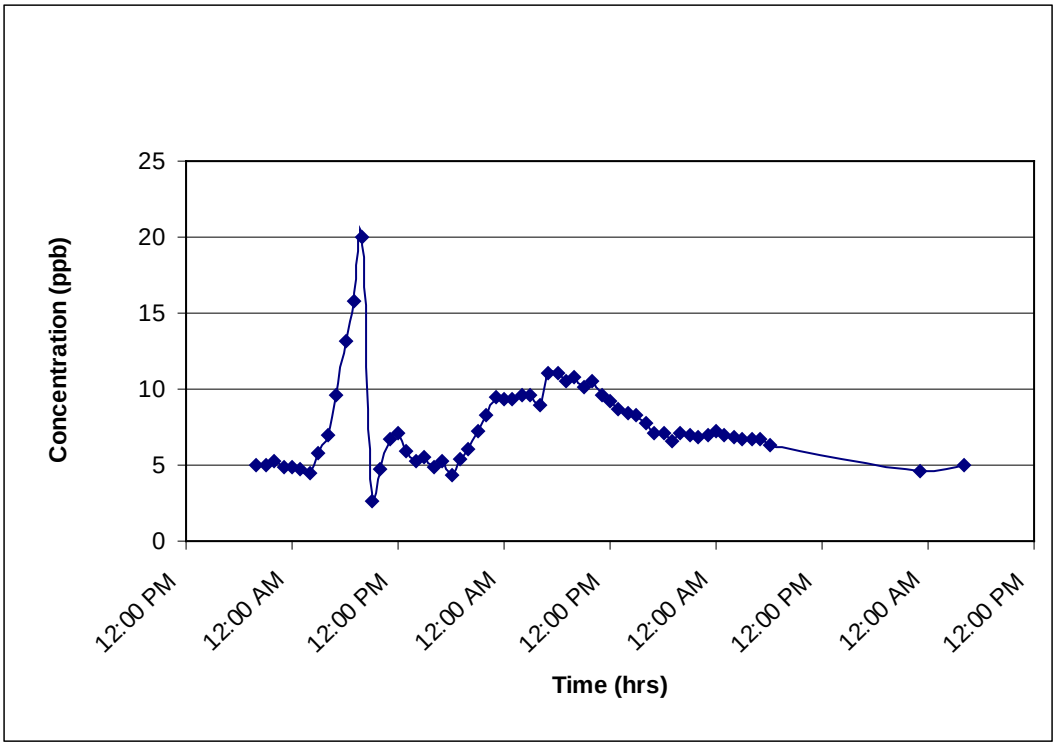

Figure 4 Residence time for NP 4-6 from May 25, 2002-May 28, 2002

Table 2 Results from travel time study of NP 3; see fig.6 for pond system classification.

Mean residence time	Theta	31.4	Hours
	Sigma^2	201.4	
	T (f)/T	0.2	
	T (p)/T	0.3	
	T (90)/t (10)	5.4	
	Sigma (theta)	0.2	
Theoretical HRT	T	38.4	Hours

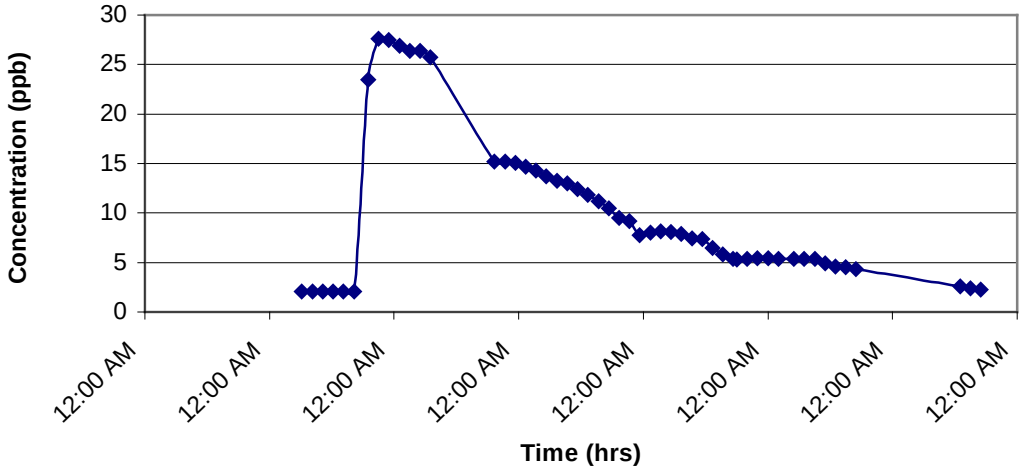

Figure 5 Rresidence time of NP 8,May 20, 2002- May 22,

Table 3 Results from travel time study of NP 8. As show there is a large difference between mean residence time and actual residence time.

Mean residence time	theta	38.2	hours
	sigma^2	548.9	
	tf/T	0.13	
	t(p)/T	0.15	
	t(90)/t(10)	5.33	
	Sigma^2/theta^2	0.38	
Theoretical HTR	T=	98.88	Hours

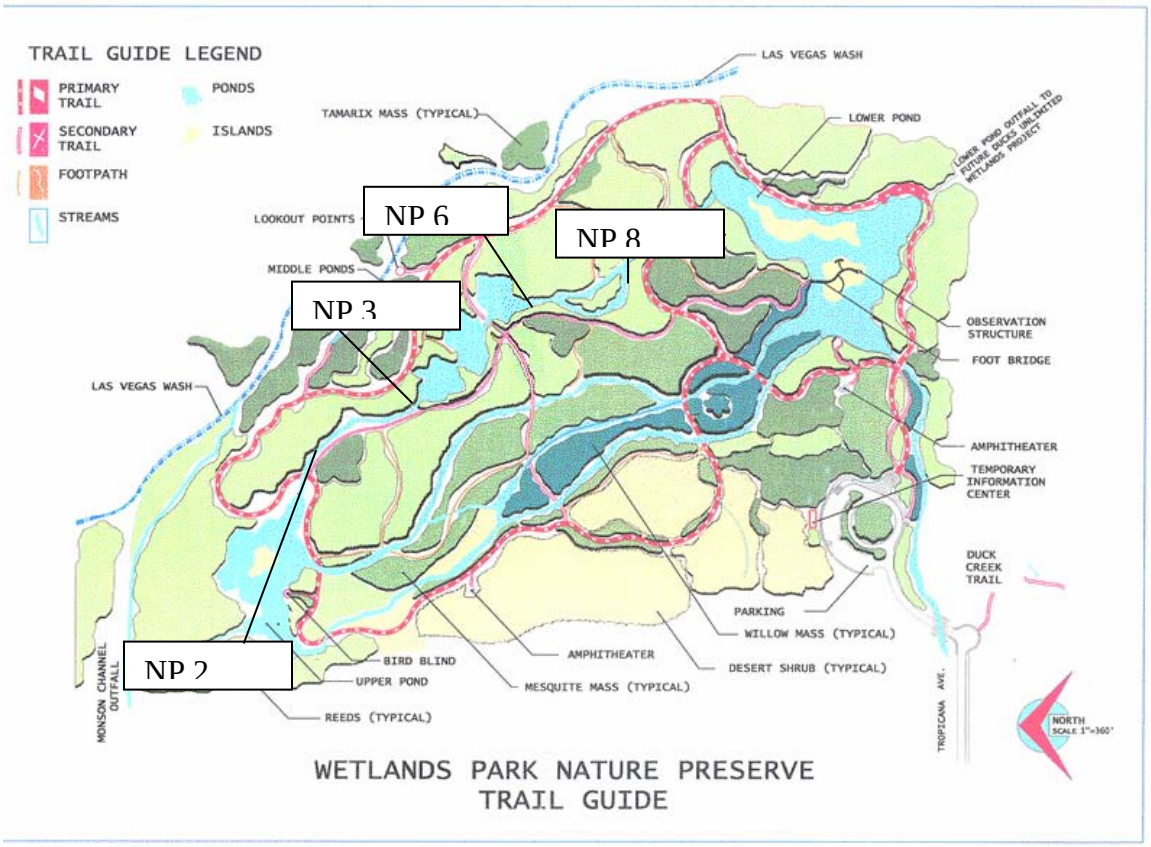

Figure 6 Map of the ponds and the numbering used in order to number the pond systems.

Table 4 is a summary table showing the theoretical vs. actual residence times with a separate column for difference between the two values.

	Theoretical mean	Actual mean	Difference	Difference in Days
NP 2	50.4 hours	29.1 hours	21.3 hours	.9
NP 4-6	38.4 hours	31.4 hours	7 hours	.3
NP 8	98.88 hours	38.2 hours	60.68 hours	2.5
Total	187.68 hours	108.7 hours	88.98 hours	3.7

Discussion

My hypothesis was proved incorrect, in that it took only 109hours (4 ½ days) for the water to run through the ponds instead of the 188 hours (8 days) we predicted. This could have been because the conductivity data used to calculate our hypothesis might have been collected at a different time of year than the study was conducted. There are also questions about the validity of our study. This study was performed in the summer time when evaporation is at its highest point. This could have had an effect on the study by limiting the amount of water that entered the system. This study was also only done

one time so there could be a variance in the residence time due to yearly fluctuation of water flow that moves through the WPNP. Another question to ask is, would the conductivity data used for this study have affected our hypothesis? I believe it does due to the fact that the data used was from storm data collected after a large rainstorm, which could stir up the water increasing turbidity. The best way to test this hypothesis would be to find turbidity samples collected from normal flows.

For a future study it might be better to do this study in the winter time when the vegetation is dormant, the temperatures are lower and some of the other factors that degrade are not going to reduce its fluorescence. That way one could test the whole system in order to get better results. If one were to do it the same way it would be better to do it in another season to see if there are a lot of variances between the two studies, and if there were, then I would suspect that the data collected in the study was invalid, due to the degradation of the dye. This might have shown a peak time by degrading the dye, which might have shown a different result.

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