

A Study of the Impact of the Hoosac Water Quality District

Wastewater Treatment Plant on the Hoosic River

An Environmental Studies 102 Final Project

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May 11, 1990

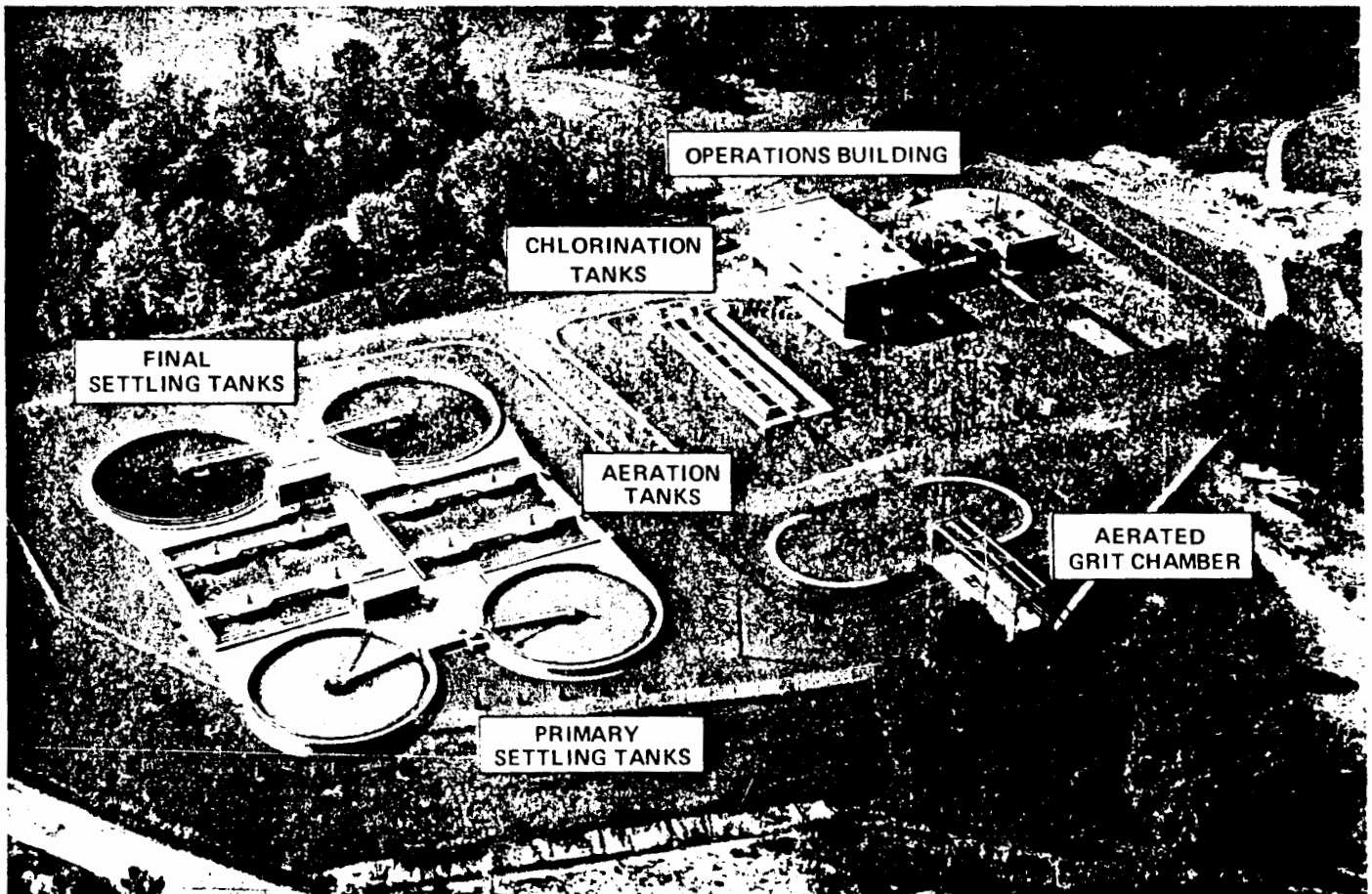
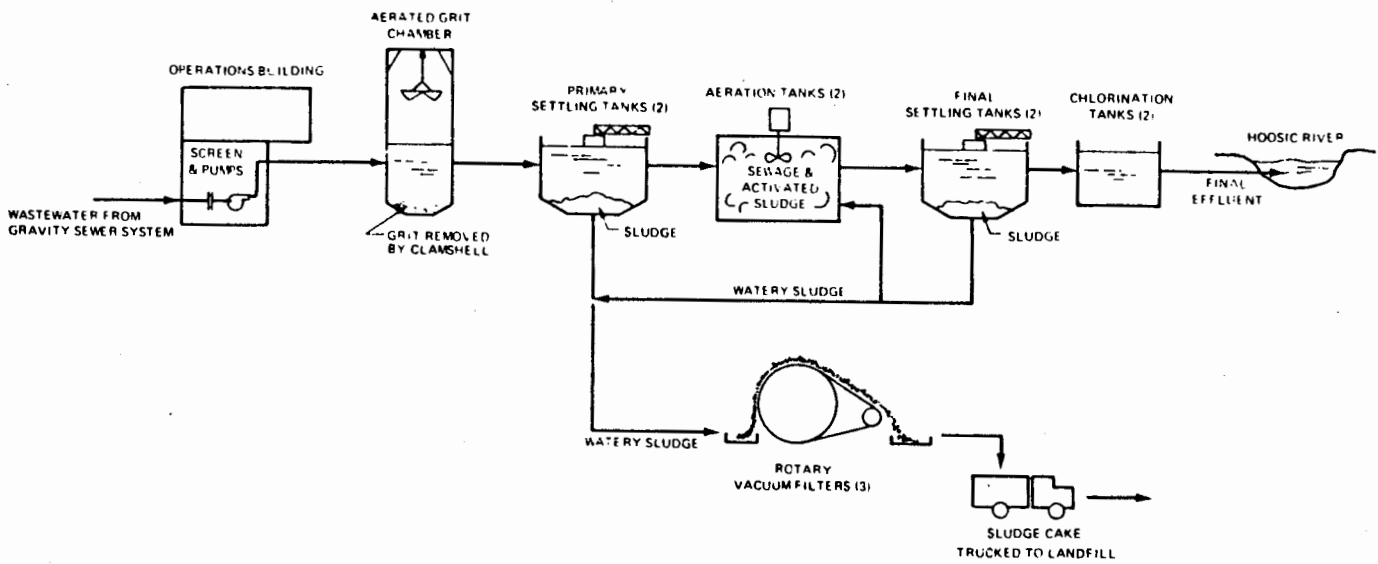
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I: Introduction and Description of Treatment Plant

This study focuses on the impact of the treated sewage effluent released by the Hoosac Water Quality District's (HWQD) facility into the Hoosic River. The HWQD facility was constructed in two phases, reaching completion in 1977. It is a secondary treatment facility which removes over 90% of the major pollutants found in sewage. This plant replaced the old primary treatment plants in Williamstown and North Adams which only removed 50% of the pollutants. This plant was constructed in an effort to improve water quality in the Hoosic River.¹

The plant collects wastewater from the sanitary sewers in North Adams and Williamstown. The sewage flows by gravity through the sewers to the plant. As it enters the plant it is screened to remove large particles, and then pumped to the grit chamber. In the grit chamber it is aerated to keep the organic matter suspended while the larger particles settle out. It is into this tank that the "honey trucks" dump septic tank wastes. The sewage is directed from here to the primary settling tanks where most of the solids settle out forming sludge while scum floats to the surface. The scum is skimmed off and processed with the sludge. The liquid effluent is sent to the aeration tanks where there is enough oxygen present to facilitate bacterial growth. These bacteria decompose the organic matter in the effluent. The effluent then goes to the final settling tank where any sludge left settles out. This clarified effluent flows to the chlorination tanks where hypochlorous compounds are added to kill the bacteria. Finally, this disinfected effluent is released into the river. The sludge is vacuumed dry and transported to a landfill.²



II: Data Gathering Methods

It is the chlorinated effluent that is the subject of this study because it is what is released into the Hoosic River. The secondary treatment process does a good job of removing organic matter, but it does nothing to remove ions, metals, or other inorganic compounds. In order to determine whether the effluent is polluting the river or whether something upstream is the cause of pollution, water samples were taken upstream, in the effluent, and downstream of the effluent release.

On the following two pages, Map 1 shows the position where the samples were taken with respect to the sewage treatment plant and Map 2 is a blowup of the area. (Map 3 at the end shows the position of the plant with respect to Williamstown.) The samples were taken by wading out into the river in hip waders and then reaching out with a six foot pole with a coffee can on the end. I wedged my sample bottle into the coffee can and submerged it two to three feet under the water.

I wanted two samples upstream from different areas so that I could be sure I was getting a random, accurate sample. By taking two samples and getting similar results I could be sure I had accurate results, whereas if I only took one sample I couldn't be sure there wasn't something influencing that sample. My two samples could corroborate each other. I took two samples from the effluent for the same reason; corroboration of results. When I took samples from downstream I wanted to see how the pollutants dispersed as the effluent became diluted by the river. My first sample was only 50 feet down and my second sample was 100 feet beyond that. These samples were close enough to the outlet that they were still probably influenced by the effluent. My final sample was taken 500 feet down from the outlet after a bend in the river and should be representative of the overall downstream chemical composition of the river.

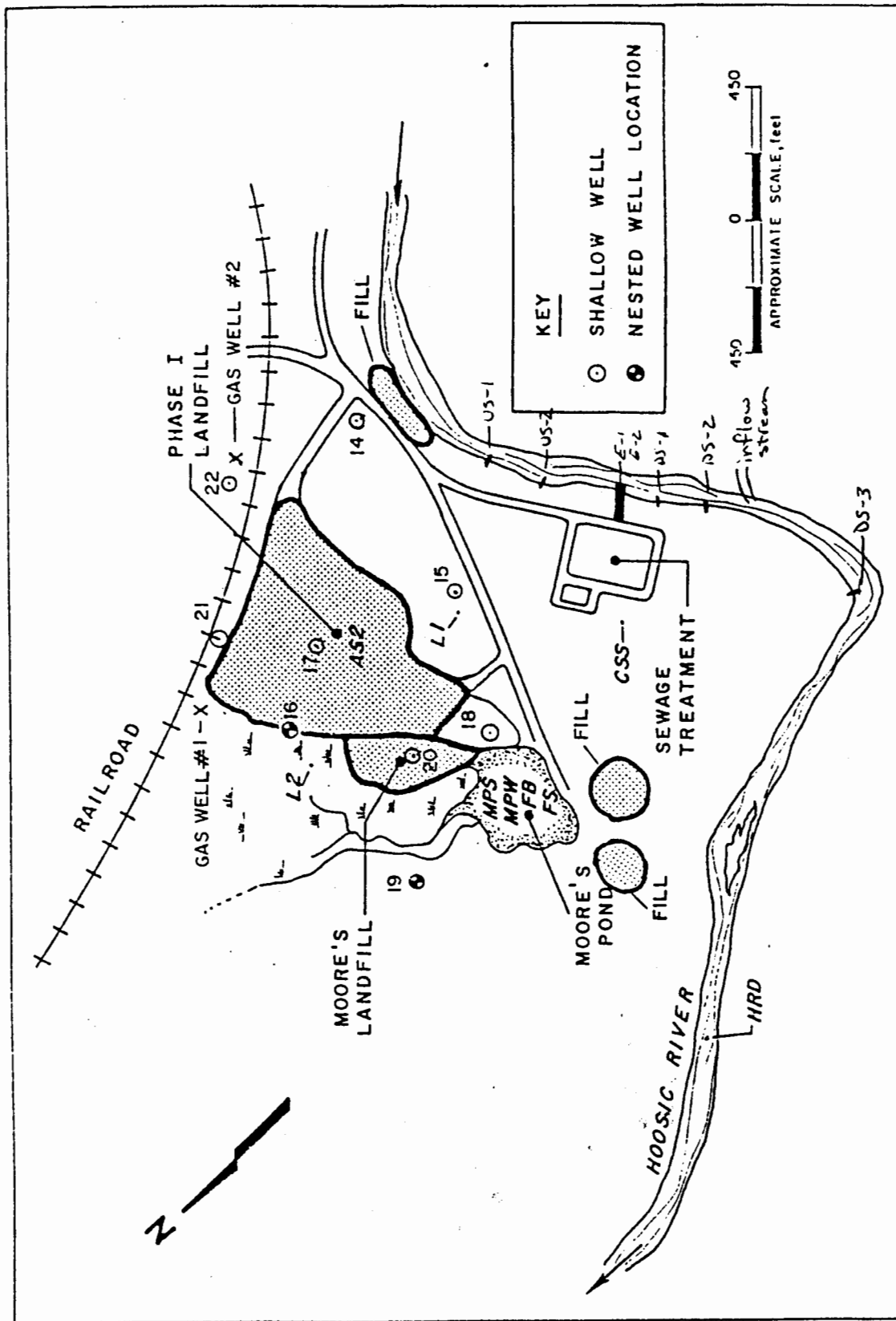


Figure 5-1. Phase I Landfill Site Map

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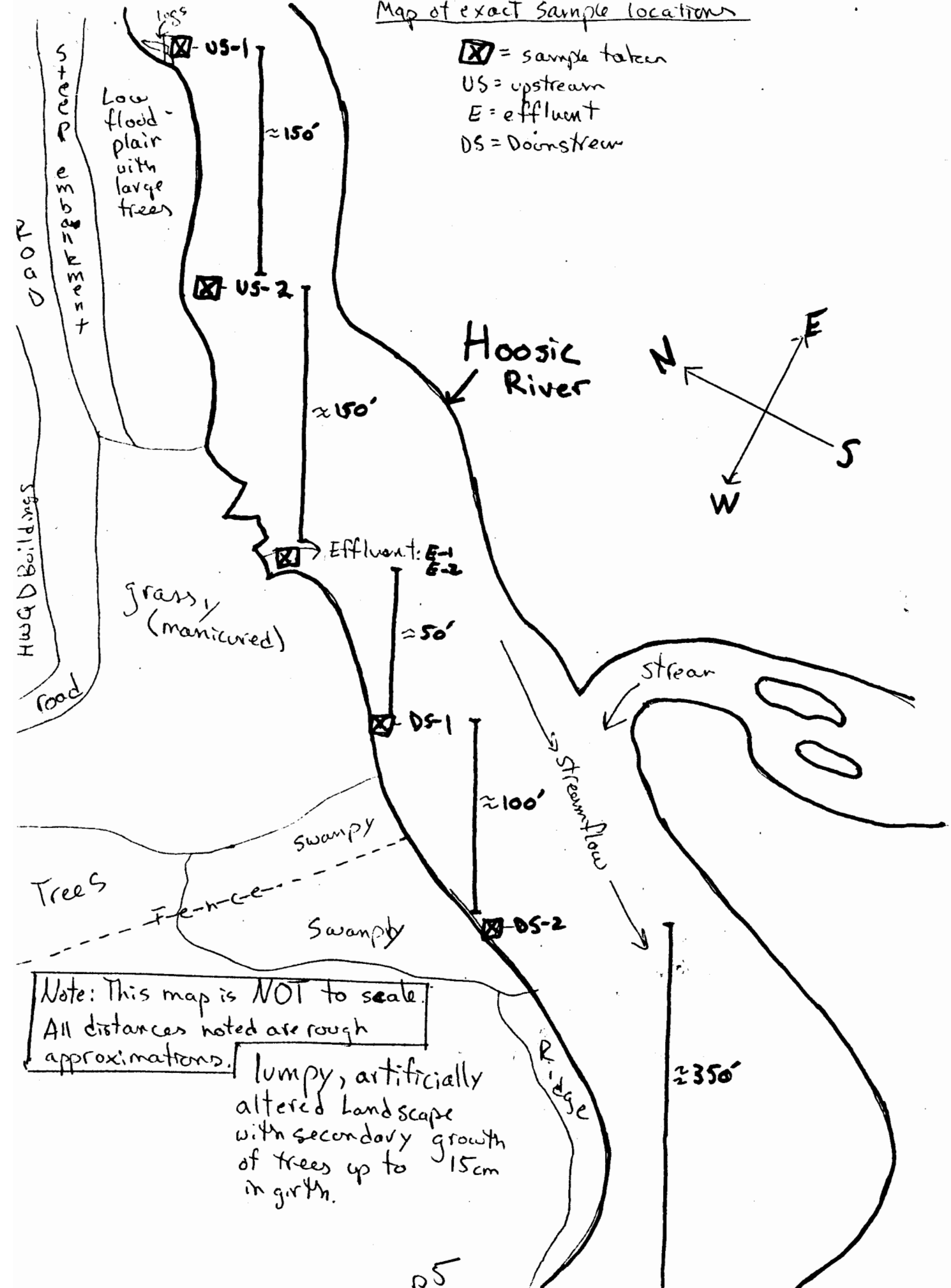
Map of exact Sample locations

☒ = sample taken

US = upstream

E = effluent

DS = Downstream



Note: This map is NOT to scale.
All distances noted are rough approximations.

lumpy, artificially altered landscape with secondary growth of trees up to 15cm in girth.

III: Testing Methods

My data came from two different places. The first source of data was tests I ran myself. I tested my seven samples for chloride, sulfate, nitrate, and fluoride on a Dionex Ion Chromatograph; and calcium, magnesium, potassium, sodium, and chromium on a Perkin-Elmer Atomic Absorption Spectrometer. I tested pH on the pH meter in 165 Bronfman and I tested ANC with a Hach Titrator. The second source of data was tests run by the HWQD. They test for chlorination, pH, coliform bacteria and fecal coliform bacteria.

On the following pages I've presented my data and then the plant's data.

Envi

Tue, May 8, 1990 2:00 PM

	Sample	FI	Nitrate	Chloride	Sulfate	Magnesium	Calcium
1	US-1	---	2.90	8.2	9.9	4.9	20.1
2	US-2	0.01	2.87	7.4	9.7	4.8	19.2
3	E-1	---	7.07	47.2	25.8	11.2	36.0
4	E-2	---	7.01	50.2	27.9	12.0	38.6
5	DS-1	---	4.25	20.5	14.9	6.9	25.0
6	DS-2	---	4.60	21.4	15.1	7.2	26.7
7	DS-3	0.02	3.62	18.4	12.5	6.0	22.9

	Sample	Sodium	Potassium	pH	ANC
1	US-1	5.3	0.71	7.75	48
2	US-2	5.0	0.68	7.75	54
3	E-1	peg(>30)	2.54	7.53	110
4	E-2	peg(>30)	2.72	7.72	110
5	DS-1	18.1	1.20	7.79	52
6	DS-2	18.5	1.22	7.71	64
7	DS-3	12.0	0.94	7.56	60

Bacteria2

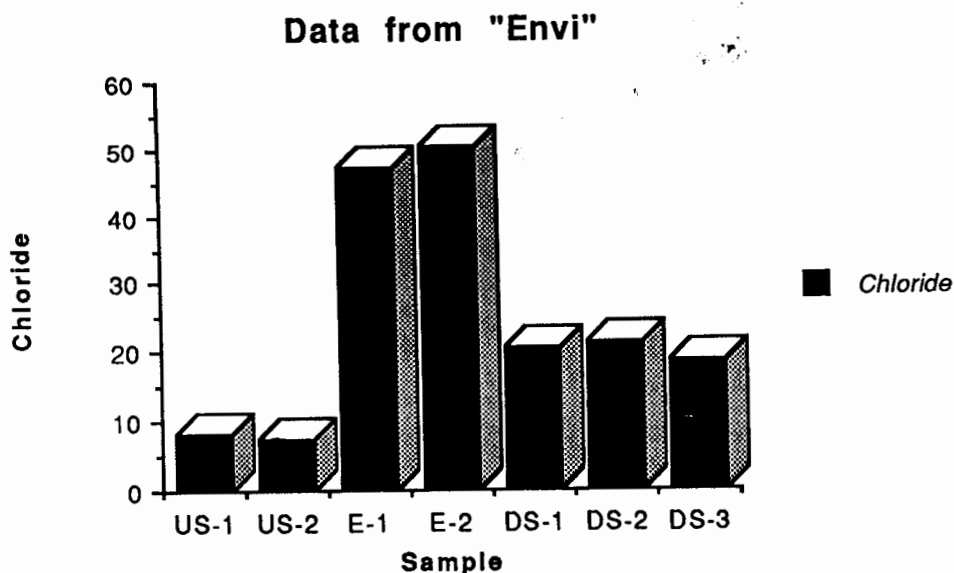
Sat, May 5, 1990 3:02 PM

Location	4/3	4/10	4/17	4/24	5/1
1 <u>Tot-coliform</u>					
2 Upstream	1400	1000	1000	500	100
3 Effluent	150	2600	2700	7400	10400
4 Downstream	900	1700		4300	7700
5 <u>Fec-coliform</u>					
6 Upstream	180	60	100	0	10
7 Effluent	0	1	3	750	790
8 Downstream	30	0		350	420

	Date	Chlorination	Time	pH
1	4/1		---	7.400
2	4/2	0.110	12:45pm	7.000
3	4/3	0.510	11:10am	7.300
4	4/4	0.310	2:55pm	6.900
5	4/5	0.310	2:30pm	7.200
6	4/6	0.410	2:40pm	7.000
7	4/7	0.310	7:40am	7.400
8	4/8	0.310	7:45am	8.200
9	4/9	0.310	1:50pm	7.200
10	4/10	0.310	11:05am	7.200
11	4/11	0.110	3:10pm	7.100
12	4/12	0.000	3:10pm	7.200
13	4/13	0.310	2:40pm	7.100
14	4/14		---	7.300
15	4/15		---	7.200
16	4/16		---	7.400
17	4/17	0.310	11:00am	7.200
18	4/18		---	
19	4/19	0.110	2:00pm	7.400
20	4/20	0.010	1:55pm	7.300
21	4/21	0.030	---	7.200
22	4/22	0.100	---	7.300
23	4/23	0.210	1:30pm	7.100
24	4/24	0.110	12:45pm	7.100
25	4/25	0.210	9:40am	7.200
26	4/26	0.310	11:00am	7.400
27	4/27	0.310	1:21pm	7.000
28	4/28	0.010	7:40am	7.100
29	4/29	0.010	7:45am	7.200
30	4/30	0.110	10:20am	7.300
31	5/1	0.110	1:05pm	7.200
32	5/2	0.510	9:45am	7.300
33	5/3	0.110	9:40am	7.600

IV: Data Analysis of Ion Results

The first ion tested for was chloride. As expected, the chloride levels in the effluent were much higher than the levels in the water upstream. This makes sense because the HWQD is adding hypochlorous compounds to kill the bacteria. Chlorine is very reactive and readily gains an electron to become the chloride ion that we detected. Although not noted in the data, E-2 had a small chloride peak just before the main one. This is most likely due to a hypochlorous compound that was added to kill the bacteria that had not yet degraded into chloride ion. It is notable that the levels of chloride downstream of the plant are significantly higher than the levels upstream. Even though the level is higher, it is still low enough so that it does not pose a threat to the health of the plants and animals. According to the water quality criteria for domestic water supplies, the highest permissible chloride level is 250 mg/L, but the desirable level is below 25 mg/L.³ As the graph shows, the highest effluent level reached 50.2 mg/L and the highest downstream level was 21.4 mg/L. It seems clear that the chloride levels, while not desirous where the effluent comes out, soon become diluted to the point where they are not a threat to the plant and animal life in the Hoosic river. This level should, however, be monitored because certain plants are adversely affected by chloride levels greater than 20 mg/L.



The next ions seen on the ion chromatograph were the nitrates. There was a similar trend here in that the level of nitrates in the effluent was greater than that upstream. These higher levels persisted in the water downstream. The higher levels in the treated effluent can be accounted for because of the organic matter in the sewage. This organic matter is nutrient and nitrate rich. As the bacteria decompose the organic matter they take a good deal of the nitrates with them. The treatment process, however, only removes about 90% of the organic matter. Also, as the plant bacteria data shows, not all of the bacteria are killed and so the nitrates that they have in them show up in the data. Even though the effluent levels are high in nitrate, they are still within the water quality criteria for domestic water supplies. The highest permissible level of nitrates is 10 mg/L, but ideally they should be virtually absent.⁴ Our highest effluent level was 7.07 mg/L. These relatively high nitrate levels would have no ill effects on the river ecosystem; all that they will do is provide more nutrients for the bacteria and plants.

The ion chromatograph also tested for sulfate ions. As with the previous ions, the levels in the effluent were higher than those upstream and these elevated levels continued downstream. The high sulfate levels in the effluent probably come from acidic precipitation that falls on the ground during rainstorms and flows through the storm sewers to the sewage treatment plant. These sulfates remain in solution and don't settle out in the sludge like the nitrates. This tends to concentrate them so that their levels are higher when they are released into the river. Even though the levels are elevated, the water quality criteria for domestic water supplies states that sulfate levels must be below 250 mg/L, and should ideally be below 50 mg/L.⁵ The highest level in the effluent was 27.9 mg/L and the highest level downstream was 15.1

mg/L. Clearly, sulfate levels are well below dangerous levels for the organisms in the river.

The ion chromatograph gave results for fluorides as well, but they were below testable levels in five of the seven samples. None were present in the effluent samples so there is no basis to think that the plant is releasing them into the river.

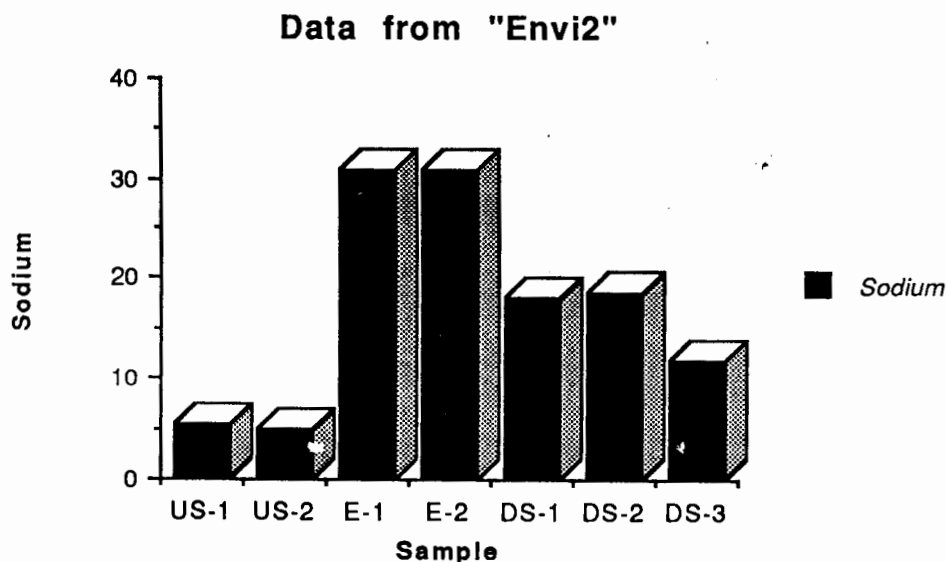
The atomic absorption spectrometer gave results for a number of cations. The first cation tested for was magnesium. The results contained the same trend as the anions in that the effluent had a higher concentration than the upstream samples and this level stayed slightly elevated downstream. The downstream levels in this case however, were almost back down to the upstream levels; 6.0 mg/L as opposed to 4.9 mg/L. Also, the overall level of magnesium was relatively low. Our Bridges Pond average magnesium value was 13.01 mg/L, while the highest effluent value was 12.0 mg/L. It is not surprising to see magnesium in the water because it is one of the most common elements in the earth's crust. The water could easily have picked it up as it ran over the soil. It is extremely unlikely that the magnesium levels will have any ill effects on the biota of the river.

The calcium levels had higher concentrations upstream and downstream than any other ions. Calcium showed the same trend as the others with the effluent being highest in concentration, but like magnesium, the calcium was diluted almost back to the upstream values as it travelled downstream. The reason the levels are so high is that there is a great deal of carbonate rock in the mountains surrounding this valley. As the water falls and runs down the mountains it dissolves some of the calcium carbonate. This water then flows into the Hoosic River. Williamstown's drinking water also has high levels of calcium because the deep, confined aquifer's recharge zone is up on Pine

Cobble. The water runs over calcium carbonate as it travels down to the aquifer. Once the people use this water it is discharged into the sewers and goes to the sewage treatment plant. I could find no standards as to what were acceptable levels of calcium in drinking water supplies, but our pond average in Bridges Pond was 25.42 mg/L. The highest effluent level was 38.6 mg/L. This does not seem to be high enough to pose a threat to the organisms or plant life of the river, especially considering that calcium is a naturally occurring ion in the water in this area.

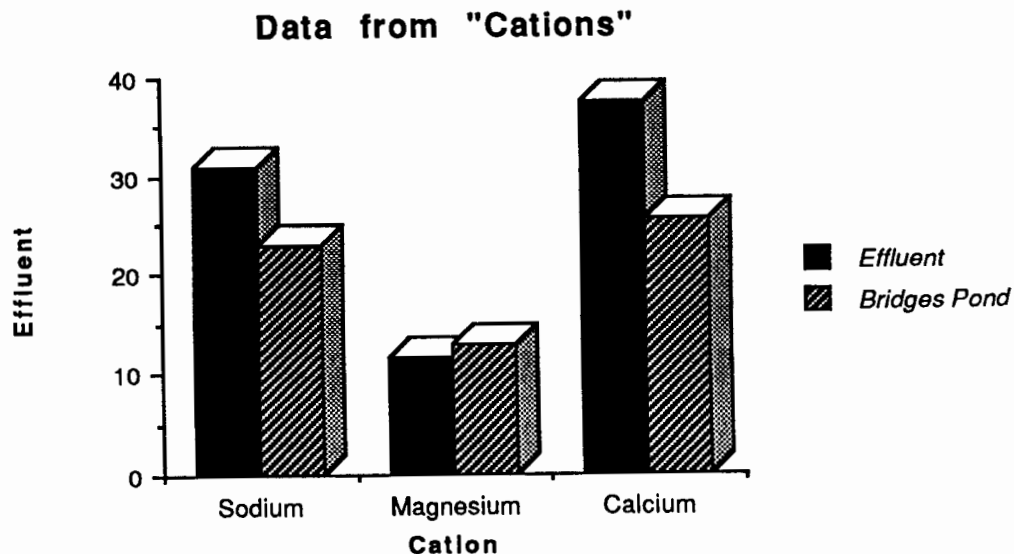
The sodium levels in the samples were quite elevated as well. As can be seen clearly on the graph below, the levels upstream are much less than the effluent or the levels downstream, indicating that the effluent is having an effect on the overall sodium level in the Hoosic River. This high level in the effluent is most likely due to runoff of NaCl from the roads into the storm sewers. Even though road salt has not been applied for several months, this seems the most likely cause. This would also corroborate the high levels of chloride in the effluent. Even though these levels are high, they still are low enough not to pose a threat to the biota of the river.

Sodium vs. Location



The last ion tested for was potassium. Its concentrations were by far the lowest of any ion tested. For this ion there were no domestic water quality standards or data to compare with, but, seeing as the concentration of potassium got back below 1 mg/L downstream of the plant, I can't see that it would have any negative effects on organisms in the river.

The following graph compares the cation concentrations from Bridges Pond with those from the sewage effluent.

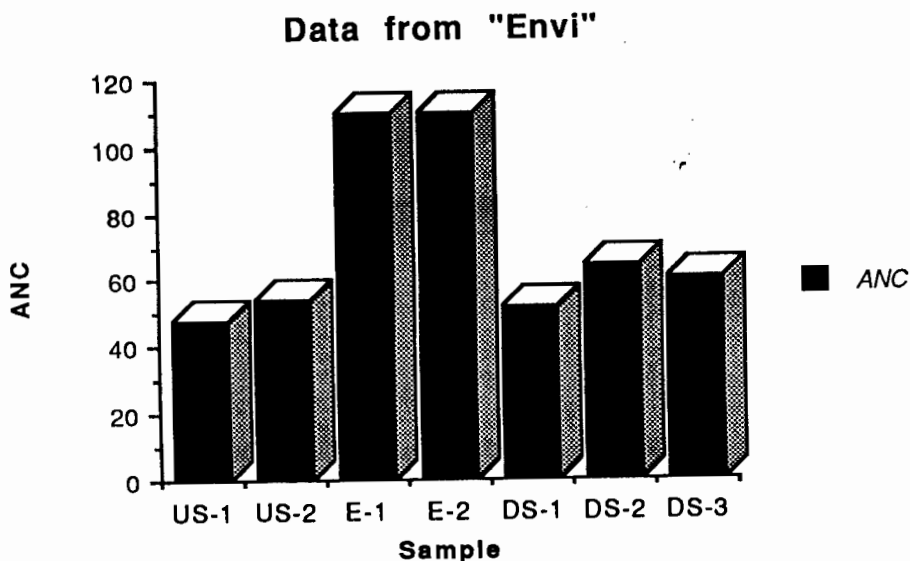


V: Data Analysis of pH and ANC

The pH measurements I took were quite consistent and did not show any trends. All the pH's were between 7.5 and 7.8. The data from the sewage treatment plant indicates that the pH of the sewage effluent was between 7.0 and 7.6 on all but two of the thirty three days tested. My samples were taken on April 7, around 2:30 in the afternoon. The pH's of the two effluent samples I took were 7.5 and 7.7. On the same day the plant tested at 7:40am and got a

pH of 7.4. These pH's are not that different and during the seven hours between their test and mine they may have altered some of the chemicals they added and/or the water in the system at that time might just have had a higher pH. The values I received, however, are consistent with the general pH's the plant has recorded.

The ANC data was gathered with a Hach Titrator of 1.6 N sulfuric acid. As the graph below demonstrates, there was a trend in the data that was very similar to that of the ion concentrations. The effluent had a very high ANC and as a result the downstream water had a higher ANC than the upstream water. This high ANC probably comes from two areas. First, the water has come off the mountains and contains dissolved calcium carbonate. This is the salt of carbonic acid, a weak acid. The carbonate ions act as a natural buffer by bonding to hydronium ions in the water to form undissociated carbonic acid. The second source of buffering capacity could be the chemicals they add. The hypochlorous compounds they add may also be the salts of weak acids. They would then, like the carbonate ions, bind to hydronium ions that enter the water. This increased buffering capacity would have no ill effects on the river ecosystem, in fact, it would be helpful to the ecosystem because biota only function within a narrow range of pH, and this would help to prevent any change.

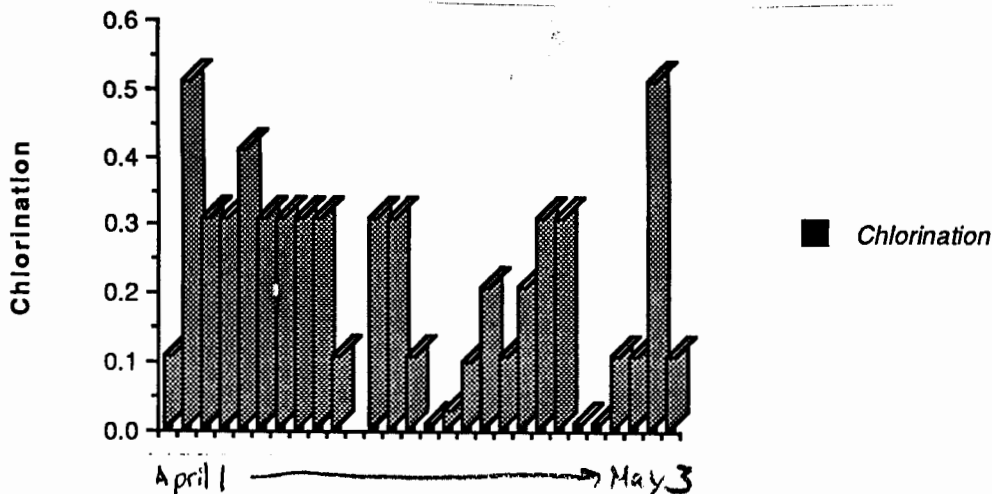


hypochlorous compounds are also strong oxidants as well as buffers. This oxidizing ability is not good for the ecosystem.

VI: Data Analysis of Chlorination

In order to kill the bacteria that have been decomposing the organic matter in the waste, the sewage treatment plant adds hypochlorous compounds. *specifically?* They test the final effluent every day to be sure that the dissolved chlorine levels are low enough so that they do not harm the biota of the water they are released into. There is a key difference between this test and the test the ion chromatograph (IC) does. This test determines the concentration of dissolved chlorine molecules (Cl_2 or HOCl), while the IC tests for the concentration of chloride ions (Cl^-). Chloride ions are not as harmful because they are not very reactive. They have gained a single electron in their outermost shell, filling it up and making it stable. The chlorine molecules, however, still need one electron in their outermost shell to make them stable. Hypochlorous compounds do not usually kill bacteria in this manner, but cross the cell membrane and disable enzymes. When a large number of chlorine atoms do this to a bacteria or other microorganism it generally kills them. This is beneficial when trying to kill the fecal coliform bacteria, but can be harmful when it kills other bacteria and microorganisms in the Hoosic river. As can be seen on the graph of total coliform bacteria for 4/3/90, the level of bacteria upstream of the sewage treatment plant is higher than the level below the plant. This means that the chlorine released by the plant is killing the bacteria that were already in the water. If it is killing them it is certainly killing other organisms as well. *Note: Bacteria graph on next page.*

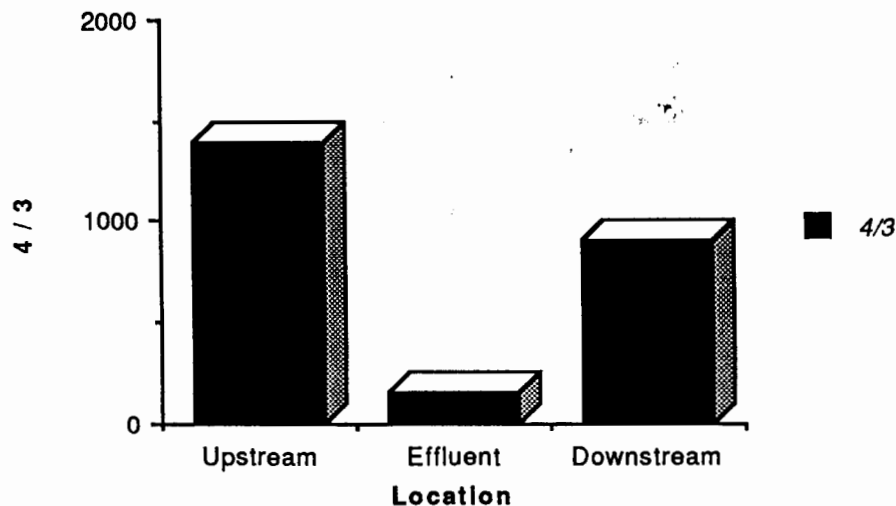
It would be nice to see this graph superimposed on a day-to-day bacterial graph what about the peak on 4/24?



In order to keep from killing the organisms in the river, the plant is supposed to keep the chlorine levels below 0.5. Out of the thirty three days tested, only two of them had levels greater than 0.5, and these were both 0.51. What worried me was the opposite extreme. Some days had only 0.11 and some days were 0.01 or 0.00. It seems that this may not be enough to kill the dangerous bacteria that are in the sewage. Another thing that bothers me is that they only chlorinate the effluent from April through October. They say that from November through March the water is cold enough that it kills the bacteria. It seems that the water may be cold enough to kill them most of that time, but there have to be periods in November and March, or recently even in February, when the temperature is in the sixties or seventies. What is to prevent these bacteria from infecting fish and other larger vertebrates downstream? During this November to March period the plant also does not test for bacteria. This is scary because they have no way of knowing what the bacteria levels they are releasing into the river are. One would assume that they would be much higher because they are not killing them with the chlorination. It would seem to be common sense that you test for bacteria during the time that you aren't killing them."

See
HOCWA
data.
They did
a Jan. test

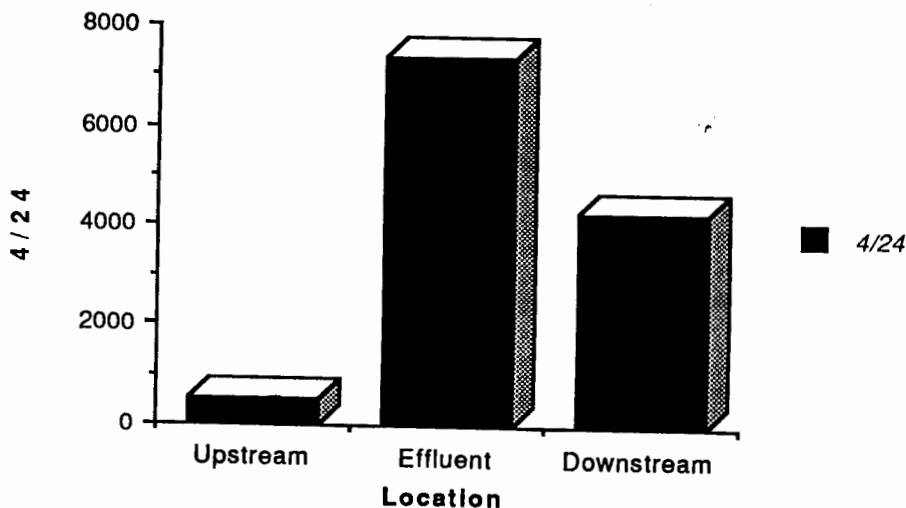
Data from "Bacteria2"

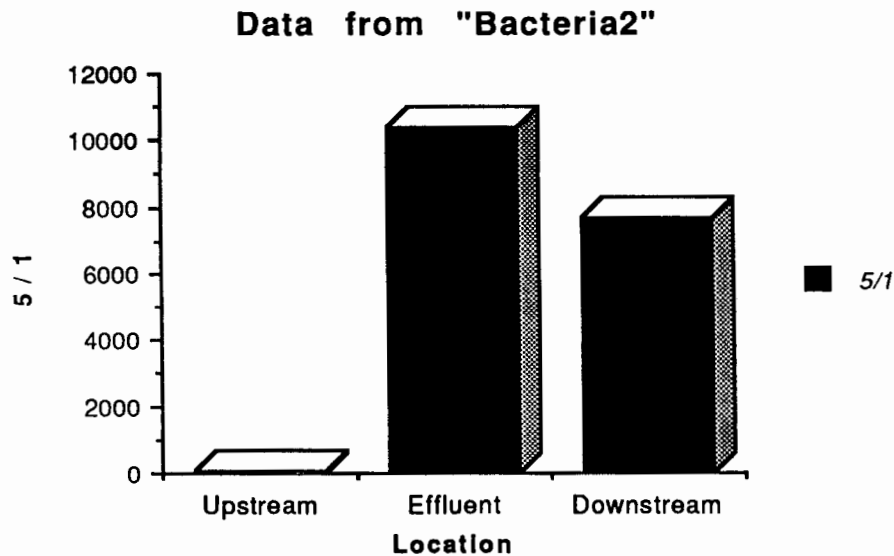


VII: Data Analysis of Bacteria

Because I knew that the plant tested for bacteria and because there was a lack of sterile bottles, I did not test for coliform or fecal coliform bacteria. The plant tests for both total coliform and fecal coliform bacteria once a week. They test the effluent itself, upstream of the effluent release point and downstream of the effluent release point. As the graph from 4/3/90 (shown above) demonstrates, the bacteria released into the Hoosic from the effluent can at times be quite low and safe. During normal operations this is usually the case. The effluent spends a long enough time in the chlorination tanks to kill most of the bacteria. At times, however, when there is a large amount of water coming into the plant, such as after a storm, the effluent cannot spend a long enough time in the chlorination tanks. This means that not all of the bacteria get killed and those that live get dumped into the Hoosic. The last two testing dates show that large amounts of total coliform bacteria and fecal coliform bacteria were released into the Hoosic and raised the downstream levels of these bacteria as well. Shown here are the total coliform bacteria graphs for 4/24/90 and 5/1/90. (The fecal coliform graphs corroborate this data and can be seen in Appendix A.)

Data from "Bacteria2"





According to the Surface Water Criteria for Public Water Supplies, the maximum permissible level of total coliform bacteria is 10,000 and the maximum permissible level of fecal coliform is 2,000. The old maximum level for total coliform bacteria was 5,000, but newer data suggests that the level should be 10,000. (All per 100ml) The desirable levels, however, are below 100 for total coliform and below 20 for fecal coliform.⁷ In all tests, the plant released more than the desirable amount of total coliform bacteria and on two of the five dates the plant released more than the desirable amount of fecal coliform bacteria. Only on one date however, did the plant release more than the permissible amount of total coliform bacteria and it never released more than the permissible amount of fecal coliform bacteria. The E.P.A. has its own standards which the sewage treatment plant must meet as well. *where??*

Coliform and fecal coliform bacteria are tested for because they are good indicators of the sanitary quality of water. If there is a high level of

coliform bacteria, especially fecal coliform, then there is a high disease-producing potential in the water. There are probably also pathogens in the water that were contributed by feces.^a The analysis here is that if the chlorine didn't have time to kill the coliform bacteria, then it didn't have time to kill the pathogenic bacteria either. When these bacteria enter the water they have the potential to harm or kill many larger organisms, up to and including humans.

VIII: Heavy Metals

The only test for heavy metals that was attempted was for chromium. The graphite furnace on the atomic absorption spectrometer had been acting up and it was difficult for us to get accurate readings. I was only able to run two samples and they came out at 1-2 ppb. This is within the error of the machine (especially with the way it was acting) and was well below any hazardous levels. Since the tanning industry has stopped around Williamstown, there are no local sources for chromium anyway. Chromium is also one of the least toxic heavy metals because when it alters a protein, it is broken down with that *Cr is an element + cannot be broken down further* protein and excreted. It is almost never found to accumulate in mammalian bodies because stomach acid reduces Cr^{6+} to Cr^{3+} which has a gastrointestinal absorption of less than 1%.^a

I wish that I could have tested for cadmium and lead because according to a Geology 103 lab, the sewage effluent was high in these two metals. The cadmium most likely comes from photoprocessing chemicals. The photo developing *} Where?* labs in North Adams dump their used solutions down the drain and they flow to the sewage treatment plant. None of the processes at the plant remove cadmium and so it is released into the river. Cadmium is also found in batteries, as a

stabilizer in plastics and in certain pigments, but it is not likely to find its way into the sewers from these sources. The cadmium stays in the water as free Cd^{2+} or binds to organic matter in the water. Some of this organic matter settles out in the sludge, but sewage effluent also binds cadmium well.

Cadmium builds up in the food chain as it is ingested by algae, freshwater invertebrates, and then fish. If people ingest the fish or ingest cadmium from other sources it builds up in us as well. Eating the fish is not as large a threat to humans as it would seem, however, because the cadmium builds up in the organs rather than the muscle or fat tissues. In plants, cadmium can inhibit growth and photosynthesis. In invertebrates high levels of cadmium can be toxic, but increased levels of calcium, sodium, chloride and buffering capacity help these invertebrates to survive. In humans, accumulation of cadmium can cause birth defects, kidney damage, lung damage, and has been linked to cancer.¹⁰

The lead in the sewage effluent is probably due to old lead sewer or water(?) pipes or solder on newer pipes. As the water travels through these pipes it dissolves some lead ions and carries them to the sewage treatment plant. Lead is also used in ammunition, pigments, and as an antiknock agent in gasoline, but these are not sources that would release lead into the sewer system. Most lead binds to colloids which means that it should settle out with the sludge, but not all of the organic matter is screened out. Some reaches the river and could be polluting it. Lead is readily accumulated in aquatic plants, but is not extremely toxic. Not much is known about how lead alone, without other accompanying metals, harms aquatic plants. There is almost no accumulation of lead in invertebrates, except in the most polluted cases. At extremely high levels, however, lead can be acutely toxic to these invertebrates. Like invertebrates, fish do not accumulate lead in large

airborne lead from old gas got into the water supply → gasoline

old dead can batteries → + old dead can batteries

amounts unless the water is extremely polluted. At these high levels it can cause fish eggs to be more sensitive to environmental changes, it can decrease hemoglobin levels, it can cause scoliosis in second generation fish, and it can inhibit certain enzymes. In humans, lead is deposited like calcium in our bones. Most human lead intake is through respiration, not ingestion of contaminated water or fish. In humans it can cause birth defects, destroy enzymes, cause kidney problems and lead to nervous system disorders.¹¹

I was unable to test for these metals so I cannot be sure whether they represent a hazard to humans or the aquatic life in the Hoosic River. Further testing will be required before any judgement can be made. I would be inclined to say, however, that levels of heavy metals are probably going to be higher in the Hoosic River due to industrial dumping and industrial landfill leakage in North Adams, and leachate from the Cole Field landfill, rather than anything people are going to dump into the sewers. If there is a threat to the aquatic life, it is probably not from the sewage treatment plant, but from other sources.

Disregard Blank Space

IX: Comparison to HOORWA Data

HOORWA is a local group of concerned citizens that test the Hoosic River as well as several other local rivers on a regular basis to assess the water quality. The data presented below was gathered on May 20, 1989. The anions were tested for on the same ion chromatograph that my samples were tested. They tested for Coliform bacteria in a manner similar to how the sewage treatment plant tests.

Site	Town	Fluoride	Chloride	Nitrate	Sulfate	TotCol10
1 Avg	Ches/Lnsbro	0.45	16.76	0.52	7.56	36.66
2 Avg	Adams	0.00	16.63	2.06	9.03	2266.66
3 Avg	North Adams	0.00	18.36	2.26	11.13	564.00
4 Avg	Stam/Ciksbrg	0.00	13.20	2.24	5.13	210.00
5 Avg	Wmstn/Pownal	0.00	17.44	3.95	12.64	3622.00 ¹²

These sites are listed from upstream to downstream. All of the sites, with the possible exception of 5 (Wmstown/Pownal), are upstream of the Williamstown sewage treatment plant. There is also a sewage treatment plant in Adams and the high coliform bacteria levels there and in Williamstown are probably because of the sewage treatment plants and would indicate that they are polluting the river with an excess quantity of bacteria. The data shows that the level of bacteria remains high, although not extremely dangerous, all the way from Adams to Williamstown. This would indicate that the sewage treatment ~~plant in Adams is having a permanent downstream effect on the number of~~ bacteria.

⇒ not necessarily. Leaking septic systems probably the biggest factor here.

The levels of chloride in the river seem relatively constant, but are higher than the levels I found upstream of the sewage treatment plant. I would have expected the HOORWA data to be similar to the data I collected upstream from the plant. The levels are, however, similar to the levels I found downstream of the sewage treatment plant. This could be due to the effluent from the Adams sewage treatment plant as well as industrial sources such as Pfizer. These samples were also taken almost a year before mine, so it is impossible to say whether chemicals were being released into the river then that aren't being released now.

amt of water in the river & time of year also very important. Winter/Spring \Rightarrow road salt. High Flow \Rightarrow dilution etc.

The nitrate levels, on the other hand, are very similar to the results I got. My upstream average was 2.89 mg/L and their average (excluding the Wmstown measurement) was slightly above 2 mg/L. It would be useful to know whether their Williamstown measurements were from upstream or downstream of the sewage treatment plant because their Williamstown average is very close to my downstream average; 3.95 mg/L compared to around 4.1 mg/L.

sample sites described in the reference

Again, their sulfate levels (except Williamstown) are very close to my upstream measurements, 8.5 mg/L compared to 9.8 mg/L, and their Williamstown measurement is close to my downstream average, 12.64 mg/L compared to around 13.5 mg/L. None of the ion measurements are exactly the same or extremely close, but this can be attributed to the year in between our samplings. The similarity between our data allows them to corroborate one another. It gives me more confidence that my measurements were accurate and indicative of the true river chemistry and it should do the same for them. It was also important to note that their data showed influences from the Adams and Williamstown sewage treatment plants. This supports the notion that the sewage treatment plants are having an impact on the river.

X: Possible Sources of Error

There were a number of possible source of error in my sample gathering and testing procedures. The first source of error was in the sample gathering itself. I only gathered two upstream samples, two effluent samples, and three downstream samples. This is a small enough number that I can't be sure they were random. Also, when I took my samples, the locations I chose may not have been random. I was not able to go out into the middle of the river, so all my samples were from relatively near shore. Finally, I only tested on one day and I cannot be sure that it was a random day and that the chemical constituents of the effluent don't change on other days. Looking at the sewage treatment plant's data helped me to minimize this problem.

Another source of error is contamination of my samples. I tried not to get my hands in the water as it entered the bottle, but there is no guarantee that I didn't. I used clean bottles, but I have no way of knowing how clean they were. Once I was back in the lab, it was often confusing as to what glassware was clean and what was dirty. I made sure I cleaned everything before I used it, but I was never sure that I really got it clean.

A third source of error is the delay between when I got my samples and when I ran the tests. I did the pH and ANC within a couple days of getting the sample, my initial and my first diluted IC run within a week, and my initial AA run within two weeks. My second diluted IC run, my diluted AA run, and the chromium test, however, all took place three weeks after I took my samples. I'm pretty sure that my pH, ANC, and IC results are all fine, but I'm slightly concerned with my AA results. They seem reasonable, but I can't be 100% sure of their accuracy.

*should be within 24h-
when did you filter?*

A fourth source of error concerns the refrigeration of my samples. It took

me several hours after I got my samples to get them to my refrigerator. They had to stay there for over three weeks and I had trouble with suitemates disliking the amount of room they took up in the refrigerator and removing them. On several occasions I came back to the room to find them on top of the refrigerator rather than in it. *Oops! Kick those suitemates out!*

A fifth source of error could be poor laboratory procedure and testing method. I know how to run the pH meter and add acid with the Hach Titrator, but I am by no means an expert. I could easily have forgotten to rinse the electrodes on the pH meter or forgotten something else. The IC and the AA seemed to run well and give accurate results, but after a whole day of running Hoosic River samples, I wonder how contaminated the column on the IC was and whether that could throw off some of its readings. Also, we had a great deal of trouble getting the graphite furnace on the AA to work correctly and I don't put much stock at all in the chromium data that it gave me.

Finally, I was forced to trust the data of the sewage treatment plant on chlorination, pH and bacteria. They are professionals and do this every day so I would assume they collect accurate data, but they have a vested interest in how the data comes out. If their bacteria or chlorination levels are too high they have to answer to the E.P.A. I was forced to take their data at face value.

Yes, but if they fudge their data, eventually someone will find out & they will be in even bigger trouble.

X: Conclusions

Unfortunately, I was not able to test my samples for PCB's, heavy metals, pesticides, and other organic chemicals. These can be extremely toxic and would be better factors to consider in order to determine whether the sewage effluent is acutely toxic to the biota in the river. It is unlikely, however,

But would you expect to find much of these in the water? Think about our results from the RB lab.

that these type of chemicals would be released into the sewers. They are much more likely to enter the river as leachate from a landfill, illegal dumping, or runoff from agricultural land. The only chemicals that get to the sewage treatment plant are those that are flushed down the toilet, dumped down a sink, or enter a storm sewer. Granted, many nasty things can get into the sewer this way, but one would not expect to find PCB's, heavy metals, and pesticides there.

Of all the ions I tested for, I was pleased to note that all of them were below the maximum permissible levels and most of them were below the desirable levels. Of the ions, the levels of sulfate, magnesium, calcium and potassium are clearly acceptable for the plants and animals in the river. The level of sodium was not determined exactly, but is greater than 30 mg/L. This is still within the safe range, but is getting near the level where people may be concerned. The levels of chloride and nitrate are above the desirable range, but do not pose an acute threat to plants or animals. Some species, however, have a low chloride tolerance and are adversely affected when the chloride level rises above 20 mg/L. The effluent may slightly damage some plants, but chlorine is necessary to kill the bacteria in the effluent. It is already strictly regulated by the E.P.A., and cannot be safely lowered any further.

The high nitrate level would have no adverse effects on the plants, in fact,

not really { they would use it like fertilizer. The Hoosic is moving so fast, however, that they would have a tough time extracting it from the water. The reason the maximum permissible level is 10 mg/L is because babies have a low tolerance to nitrate and it can damage their hemoglobin.¹³ I would suspect that high nitrate levels may also adversely impact the young of other mammals and possibly even invertebrates. Even though the level is slightly high, it is less than half the maximum permissible level once you get downstream of the

plant and hence, does not require any immediate action. Overall, the ion levels are not that bad and, although they should continue to be monitored, no remediation efforts are required.

Even though the ion levels may be acceptable, the bacterial levels seem out of control. When the effluent sits in the chlorination tanks a long time all of the bacteria are killed and when this effluent is released into the river it kills bacteria in the river as well. Other times, when the effluent cannot spend as much time in the chlorination tanks, lots of bacteria remain alive. These bacteria may not just be coliform bacteria, but disease causing pathogens. I realize that the plant can only handle a certain volume of wastes, but their treatment seems too haphazard. Sometimes they kill too many bacteria and sometimes they kill nowhere near enough. When they kill too many they may kill bacteria in the Hoosic that are vital to the food chain or decompose vital nutrients. When they don't kill enough, the pathogenic bacteria may infect and kill animals in the river.

The sewage treatment plant needs some sort of volume regulator to assure that they always process the waste at the exact same rate. When they have a high flow of waste they could store it somewhere and only process it at that certain rate. When they are at low flow, they could just process Hoosic river water to reach that rate. By always processing the waste at the same rate they will be able to accurately add chlorine and kill only the desired amount of bacteria. As a safety measure it would also be wise to test the effluent for bacteria during the winter when they are not chlorinating. In this case, if the levels got too high they could begin to chlorinate again. They should also have a minimum temperature at which they chlorinate. This would mean that even if it wasn't the season to chlorinate, they would have to chlorinate if the temperature got too high. Bacteria seems to be of more immediate concern than

the ionic composition of the water and some sort of regulatory action should be taken. The E.P.A. does have standards for bacteria levels, but they appear to be lax in their enforcement.

XI: New Sewage Treatment Technologies

In the U.S. each year more than 7 billion pounds of BOD is processed by sewage treatment plants. The majority of these plants are secondary treatment plants like the one in Williamstown. When regulated and run effectively they do a good job of removing the organic matter and killing the microorganisms. The problem that these plants have is treating inorganic compounds. They have no mechanism for removing inorganic cations and anions, pesticides and PCB's. These are not natural constituents of sewage and only occur when released into the sewers. This is can be a real problem in larger cities and near industrial centers.¹⁴

In order to remove these inorganic compounds, tertiary treatment is required. Physico-chemical processes can be quite effective at removing the inorganic constituents of sewage. These processes include coagulation by metallic salts or polyelectrolytes, precipitation with lime at a high pH, and activated carbon adsorption. These processes are particularly good at removing heavy metals. They can be performed most effectively in conjunction with biologic treatment. A longer residence time in the plant can also help to improve the amount of pollutants removed from the effluent. Unfortunately, these methods are expensive. I have no data as to whether this type of treatment is needed at the HWQD, and it will require detailed testing for other inorganic compounds to determine this. This process also can remove nitrates and phosphates, but my results indicate that that is not necessary.¹⁵

The chlorination process, however, may be a problem at the HWQD. As the bacterial data showed, sometimes the plant doesn't do an effective job of killing all the bacteria. Chlorine kills the bacteria because when it is in a hypochlorous form it crosses the cell membrane, and inhibits enzymatic action. Chlorine, however, is not nearly as effective at killing viruses. Also, as the bacteria data showed, sometimes the chlorine compounds released into the Hoosic end up killing the bacteria already there. Some alternatives to using hypochlorous compounds to kill bacteria are using chlorine dioxide, ozone chloramines, or to some extent the use of UV rays. Ozone and chlorine dioxide have also been shown effective at killing viruses. Ozone also has the beneficial effect of being unstable and not remaining in the water for very long. It quickly degrades into oxygen and is no longer toxic. This would mean that it wouldn't kill any organisms in the Hoosic River. This would increase the dissolved oxygen in the river which would be beneficial to the organisms that live there.¹⁶

In addition to these measures which can be added to the current system, there are new sewage treatment technologies which are totally different. Some of the more popular involve spraying the sewage effluent (after primary treatment) as irrigation water on farms or creating large plots of bacteria filled land and letting the sewage filter down through the ground to an artificial water table where it is collected. There are problems with these methods because they are not entirely safe. The effluent may have an adverse effect on the plants in the field, or it may escape from the artificial water table. Also, these technologies do not remove inorganic compounds very well. The plants pull most heavy metals and inorganic ions out, but they then become contaminated and cannot be used as a food source.¹⁷ These methods are being

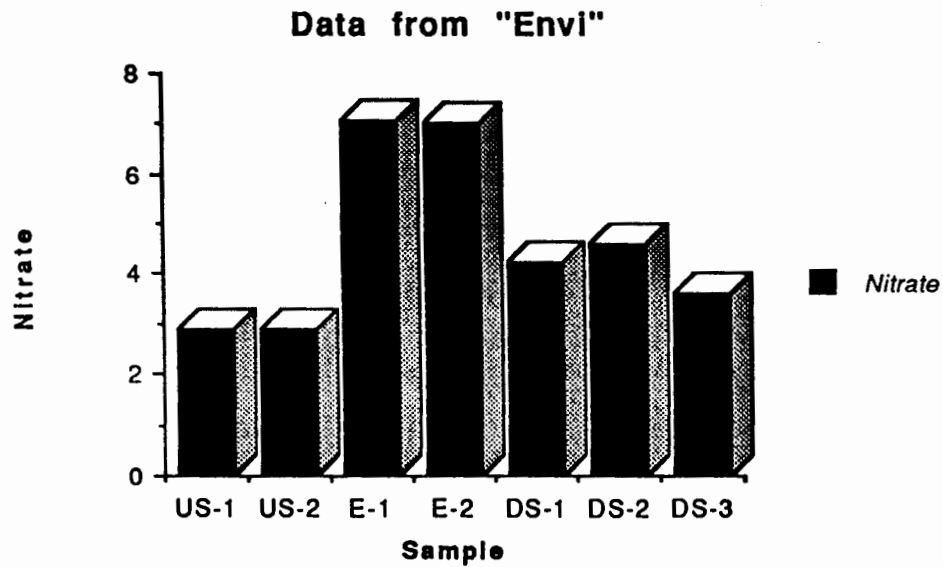
used in some areas on an experimental basis, but they don't appear to be viable options here. We already have a sewage treatment plant that is running pretty effectively.

XII: Summary

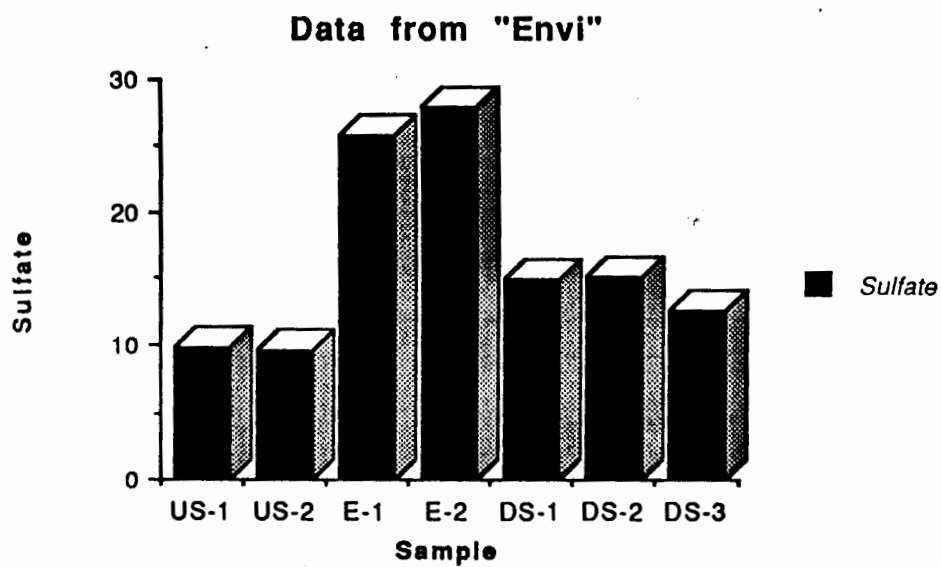
After running all the tests, visiting the plant, examining the data and comparing it to other data, I am forced to conclude that the sewage treatment plant is not doing all that bad a job. All their inorganic ion data is within acceptable levels. The only thing I worry about are their fluctuating bacteria values. Even though I didn't test for PCB's and pesticides, I don't think there is cause to worry. It is very unlikely that these will be entering the sewers. It is necessary to keep in mind that upstream there is the Adams sewage treatment plant, the Pfizer corporation, the old Sprague Electric Company, the Carol Cable Company (on the Green River), and other industries as well as at least two old landfills. These are much more likely to be dumping toxic or hazardous waste into the river because they are using petroleum products and products that contain heavy metals. It is very unlikely that these acutely toxic compounds will enter the sewers and reach the Hoosic via the sewage treatment plant. Other than helping the plant to better regulate its bacteria output, I think that people should be much more concerned with what industry is dumping into the river. It is the industry upstream of the sewage treatment plant, not the plant itself that should be monitored more closely.

Appendix A: Graphs

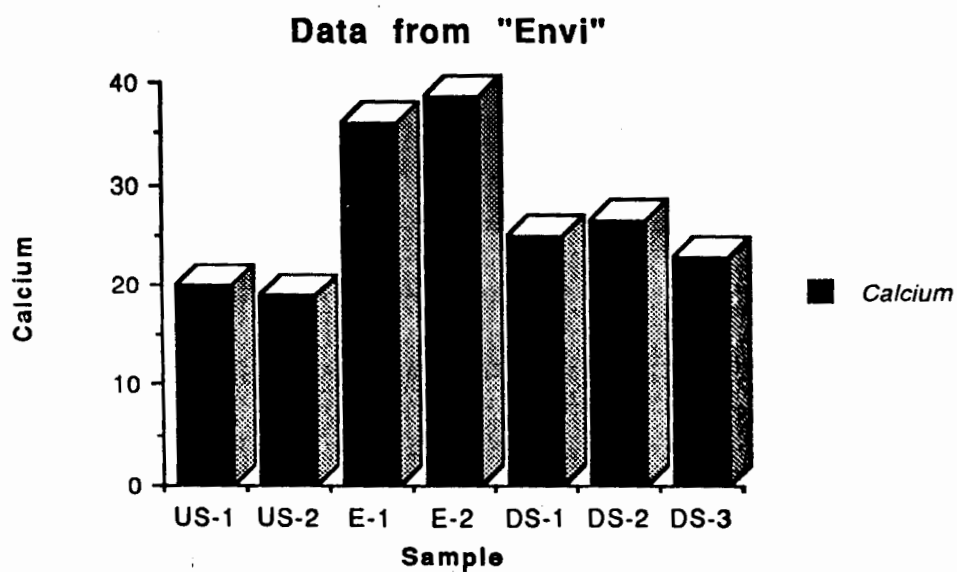
Nitrate Concentration vs. Location



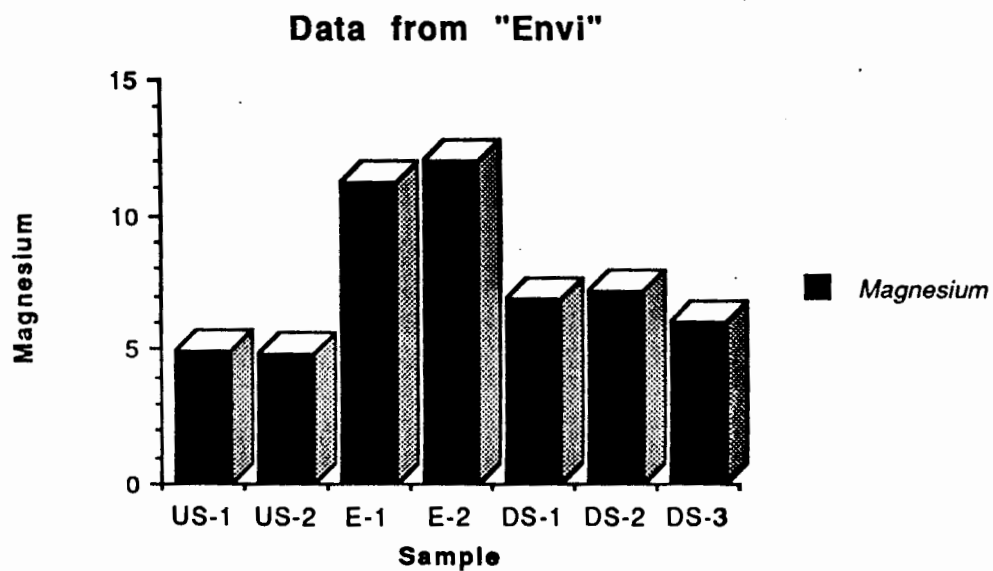
Sulfate Concentration vs. Location



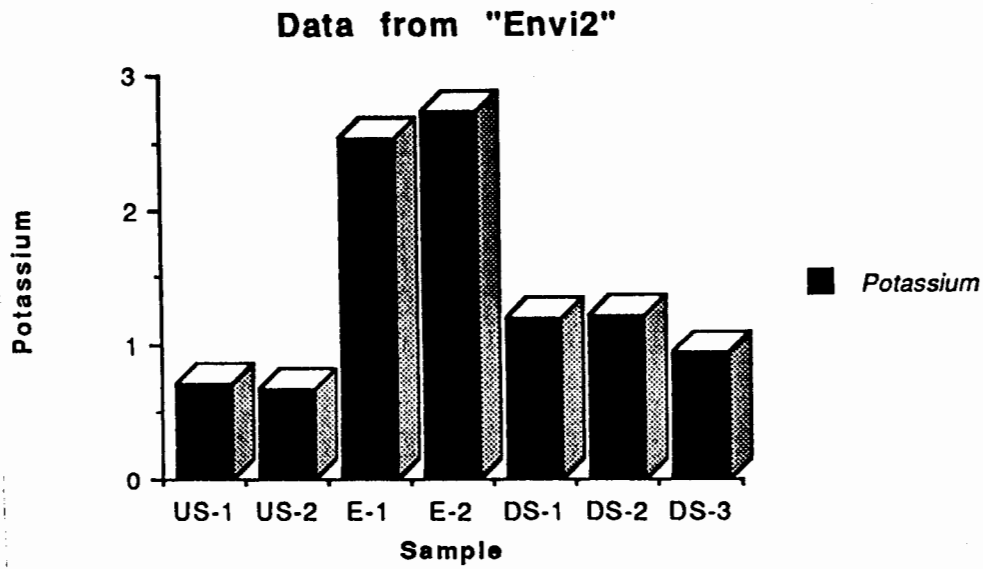
Calcium Concentration vs. Location



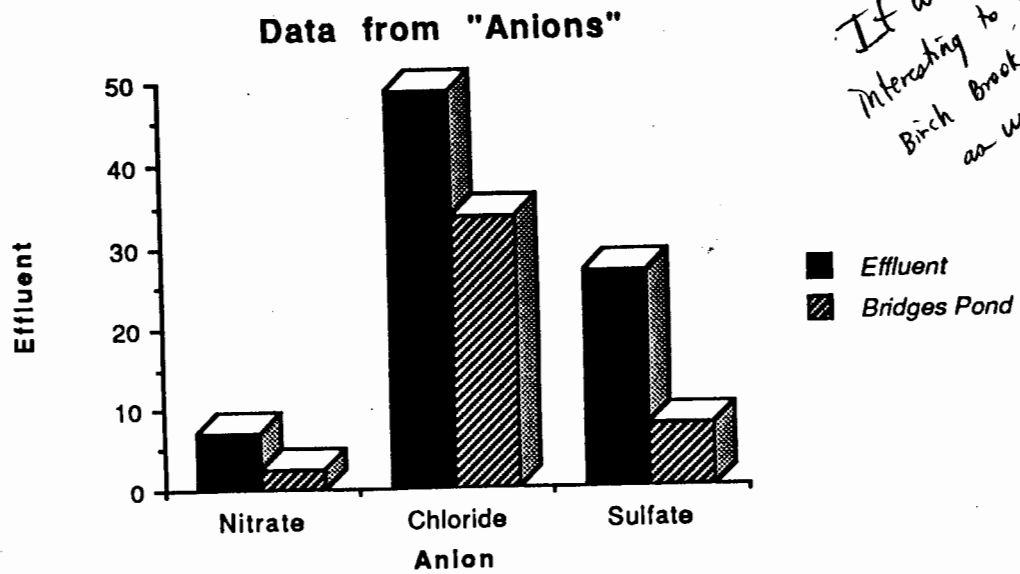
Magnesium Concentration vs. Location



Potassium Concentration vs. Location

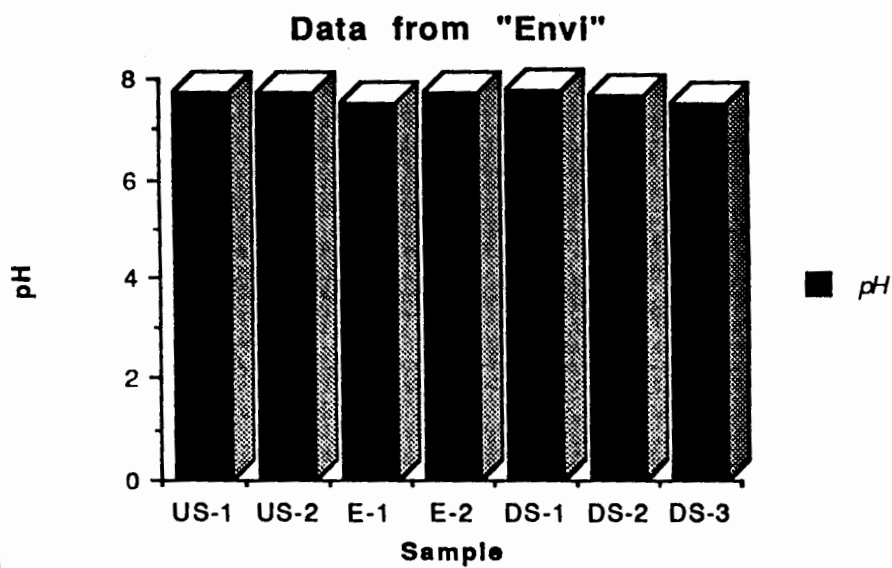


Anion Concentration Comparison

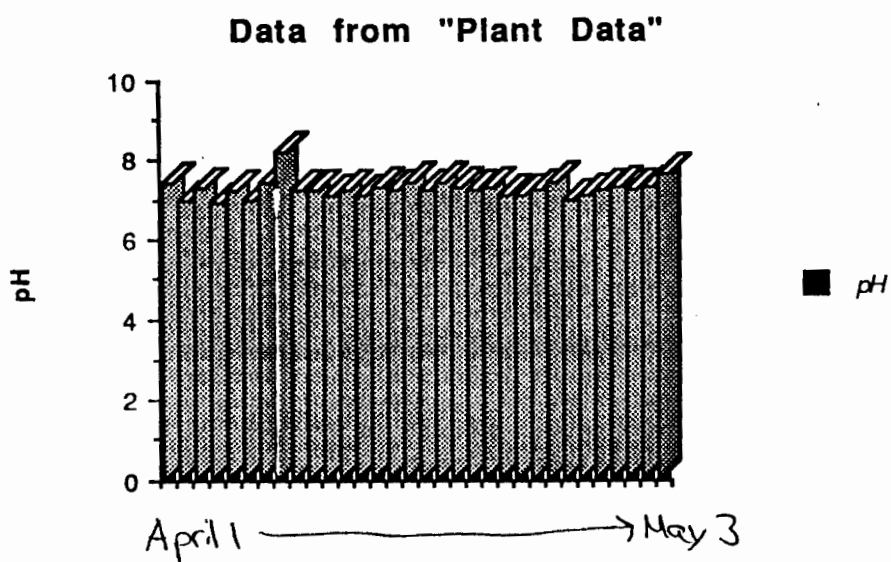


It would be interesting to have Birch Brook on here as well!

pH Data vs. Location

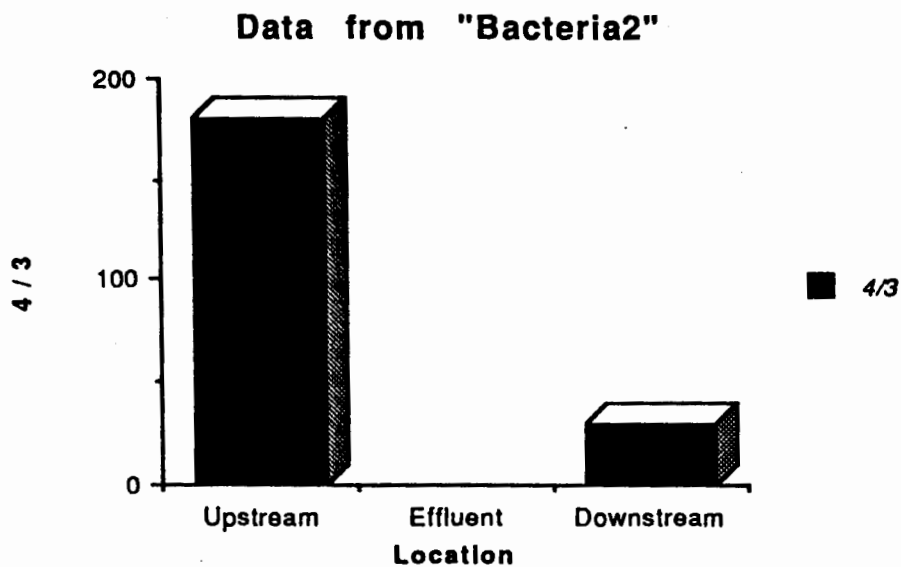


Plant pH data vs. Date

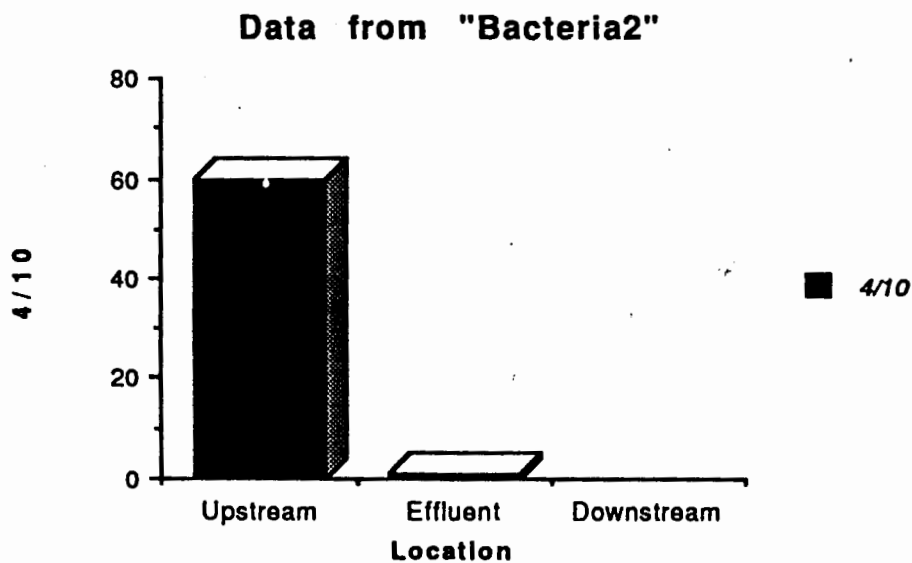


Date (each line = one day)

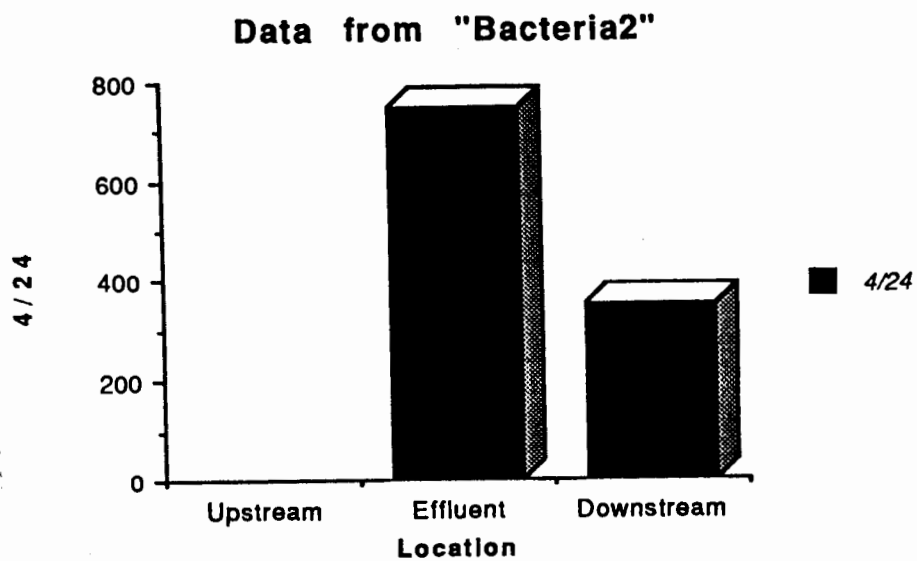
Fecal Coliform Bacteria on 4/3/90 vs. Location



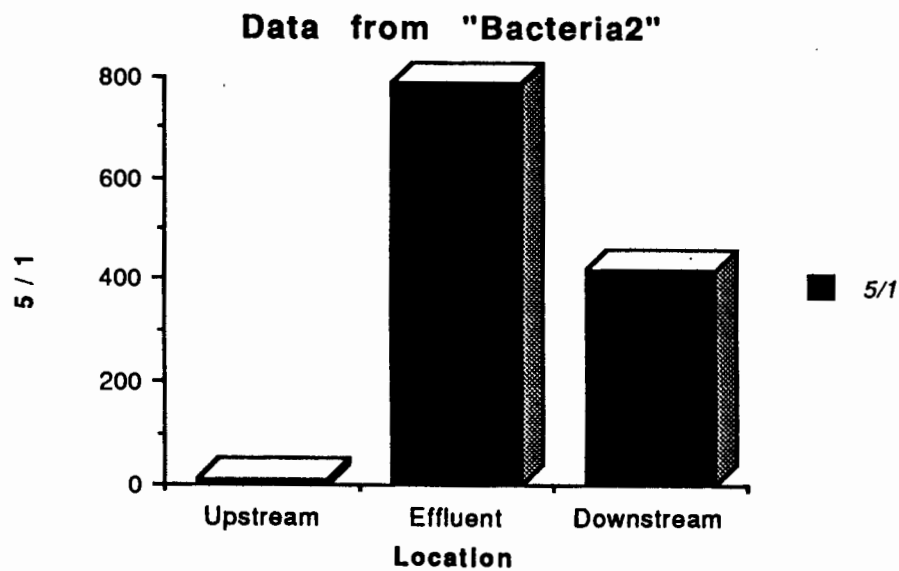
Fecal Coliform Bacteria on 4/10/90 vs. Location



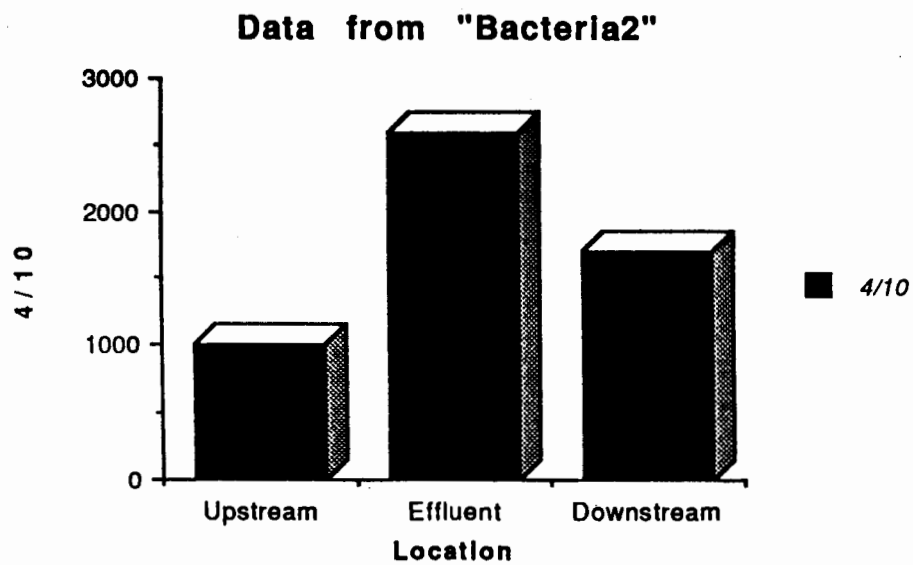
Fecal Colliform Bacteria on 4/24/90 vs. Location

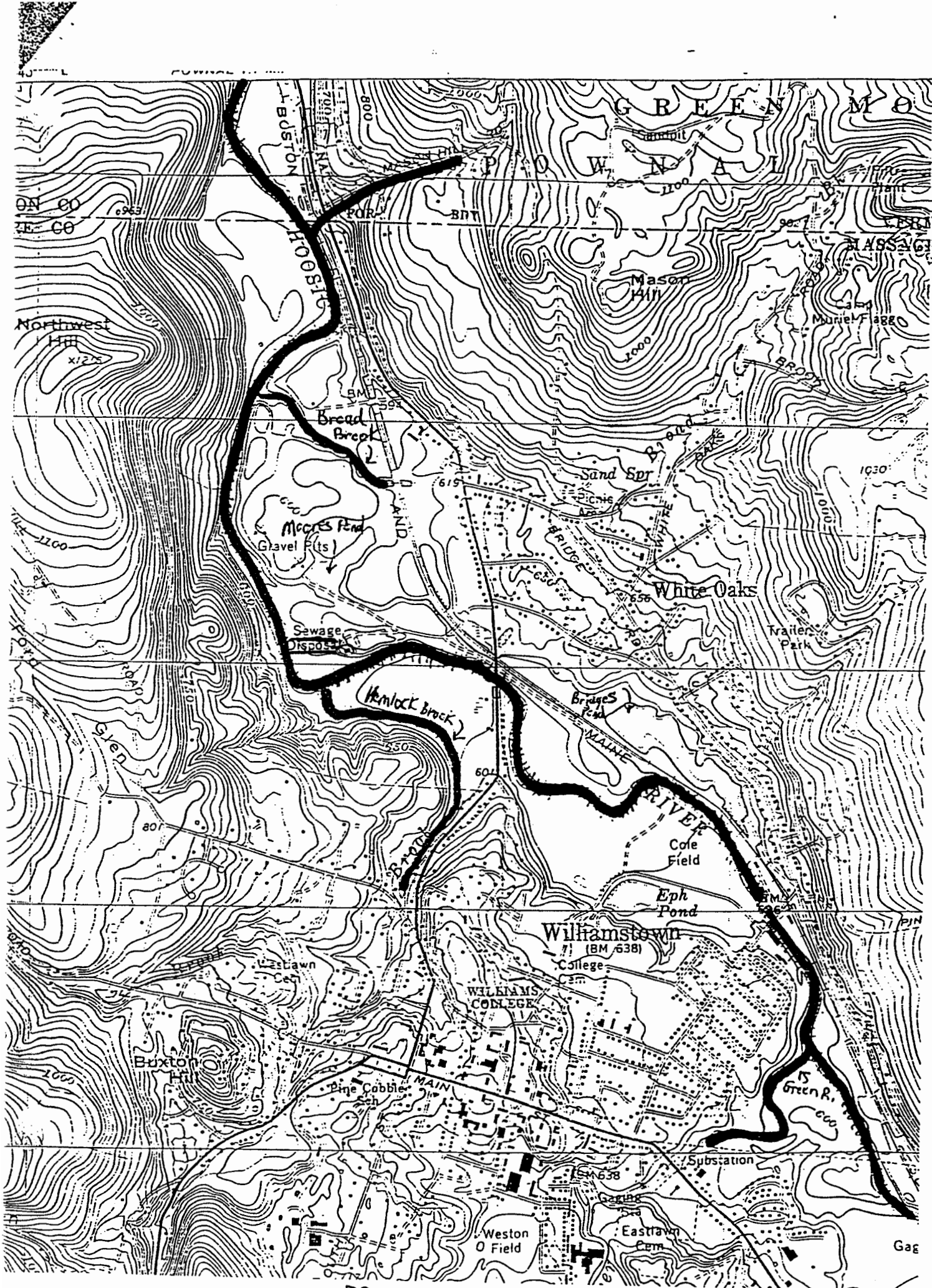


Fecal Colliform Bacteria on 5/1/90 vs. Location



Total Coliform Bacteria on 4/10/90 vs. Location





Footnotes

¹Pamphlet from the HWQD sewage treatment facility.

²Pamphlet from the HWQD sewage treatment facility.

³Water Quality Criteria, A Report of the National Technical Advisory Committee to the Secretary of the Interior, (Washington D.C.: U.S. Government Printing Office, 1968), 20.

⁴Ibid.

⁵Ibid.

⁶Personal Communication with George Helsler, operations manager at the HWQD.

⁷Water Quality Criteria, 20.

⁸Ibid., 21-22.

⁹James W. Moore and S. Ramamoorthy, Heavy Metals in Natural Waters, (New York: Springer-Verlag, 1984), 59-60.

¹⁰Ibid., 30-51.

¹¹Ibid., 100-120.

¹²HOORWA sampling report issued June 5, 1989 by Susan Kegley.

¹³HOORWA sampling report issued June 5, 1989 by Susan Kegley.

¹⁴William E. Sopper and Liou T. Kardos (eds), Recycling Treated Municipal Wastewater and Sludge through Forest and Cropland, (University Park: The Pennsylvania State University Press, 1973), 7-15.

¹⁵Control Policies for Specific Water Pollutants, (OECD: OECD Printing Office, 1982), 29-30.

¹⁶Ibid., 207-208.

¹⁷Sopper and Kardos (eds), Recycling Treated Municipal Wastewater and Sludge through Forest and Cropland, 324-330, 345-360.

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