A CHEMICAL ANALYSIS OF TWO SITES ON THE IPSWICH RIVER

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Envi. Science 102

5/11/'90

TABLE OF CONTENTS:

The Ipswich River is an extremely important river in the area that I live in. It is a mature river with many wetlands bordering along its path. It is also home to a lot of wildlife, and it flows through at least two wildlife sanctuaries: one is the Topsfield Audobon Society Wildlife Sanctuary, and the other is located near the mouth of the river at Crane's Beach in Ipswich. The latter is a vast saltwater marsh that is home to a great many deer (often too many--overpopulation is a serious problem, as well as Lyme disease associated with the deer tick) and a thriving insect population (mostly greenhead flies). However, the river has a reputation for being dirty. There is some industry along the river, many roads that cross over it and a dairy farm on its banks. In fact, it was not uncommon a few years ago to find cow manure in the river downstream from the dairy. This experiment focuses on two possible threats to the river's health: the highly controversial Rubchinuk landfill and the less widely known Bostik plant. Water samples upstream and downstream of both sites should indicate whether or not these two places are affecting the river adversely. (if we measure the right thing) Also, the values at both ends can be compared to see if a very bad polluter is located between the sites.

The site that has been under closer scrutiny of late is the Rubchinuk landfill. It has long had a reputation as a polluted area, and only recently, Peter Rubchinuk was thrown in jail (his son Carleton is still at large) for operating an illegal landfill. The irony is that Mr. Rubchinuk was found guilty and in contempt of court for refusing to pay fines levied against himself and his family. So far, there is very little conclusive evidence available about the environmental impacts of Rubchinuk's landfill. — I need a map 1.

The history of Rubchinuk's problems with the law regarding the landfill began in 1972 when the Middleton Conservation Commission sent a cease and desist order to stop using the landfill. Apparently, it violated the zoning bylaws, but it was not known then whether or not the landfill was actually polluting the nearby wetlands and river. In late 1973, the state Department of Public Health at Tewksbury cited nine health violations against the landfill, but the health hazards didn't come into the public eye until nearly two years later. On November 21, 1975, a semi-underground fire broke out in the landfill. The combined efforts of the Rubchinuks, the Middleton Fire Department and the Massachusetts National Guard required till February of the next year to put it out. The fire was the subject of an air pollution incident emergency declared by the Governor. The smoke was so bad that the high school classes (located about a half mile away) had to be canceled if the building was downwind of the blaze that day. This caused some problems with tests such as the SAT's. Apparently, the school was downwind on a day that the SAT's were supposed to be administered there. According to my sister, two people ended up passing out, and many more became ill before the test was over. This fire brought the landfill problem into the minds of many Middleton residents. No longer were the Rubchinuk landfill and the problems associated with it merely a legal matter, to be dealt with in some courtroom far removed from the actual problem. Now, the landfill had become visible thanks to the smoke given off, noxious and more blatantly threatening to the health of the residents and surrounding environment.

what burned?

However, very little progress was made in closing the landfill, despite the flow of court orders pertaining to this problem. Four years later, the landfill was back in full operation with the fire mostly forgotten by the general populace. Neighbors reported seeing anywhere from 30 to 100 trucks each day dumping construction debris and other fill at the site. Many of these trucks arrived in the early hours of the morning, making their arrival suspicious enough for the selectmen of the town to authorize police officers to inspect any trucks entering the landfill. After three months, the program failed due to a lack of funds to pay the extra police officer to sit in one place all day. However, a surprise inspection of the landfill by the DEQE revealed illegal dumping at the site. Finally, after years of ignoring court orders and not paying his bills, Peter Rubchinuk was thrown in jail for civil contempt of court on March 22, 1990. The town is now looking to finally put a cap on the landfill and close it down for good. In the meantime, some experimentation could provide information pertaining to how and to what extent the landfill is affecting the environment, and what measures could be taken to prevent any more damage. are there suspicions of anything besides demolition debris?

In order to test whether or not a pathway exists for chemicals in the landfill to reach the Ipswich River, I had to take samples upstream and downstream of the landfill. The first group of samples was taken March 28 of this year. The upstream samples proved to be very easy to obtain; the public swimming hole is only a few hundred feet from the Rubchinuk's property. One was taken before Thunder Bridge, and one was taken after to determine the possible effects of road salt on the results. However, the downstream samples provided more of a challenge. I didn't have a canoe at the time, and the unpopulated left bank of the river faded into wetlands that were impassable just before I got downstream of the right area. Then, I went around to the right bank and tried honesty as the best way to convince the homeowners to let me walk through their property to get to the sampling site. This failed miserably, and having already given myself away, it was too late to resort to sneakiness. I settled for a site much further downstream, near the high school. I took a second batch of samples on April 12, and this time managed to find an accessible sampling site that was much closer to the actual landfill. When I got the samples back to Williams and ran them on the ion chromatograph, they all peaked. After a 1:10 dilution, only one of the downstream samples taken at the Rubchinuk site peaked, but all three of the samples taken at the Bostik plant peaked. These were diluted 1:20. The atomic absorption spectrophotometer was less finicky, and allowed all but one of my samples to get by with a 1:10 dilution. The ions tested for were chloride, sulfate, sodium and potassium.

Chloride concentration is a very good test to perform on water samples because the chloride anion often shows up in detectable amounts, and it provides a good tracer ion to find out where water is coming from. This can help to ascertain if there is a pathway for more harmful elements to enter the water. Chloride is abundant in nature, and it is highly soluble in water. The ionic form should not be confused with the elemental form of chlorine gas. Chlorine gas is a strong oxidizer and is used as a disinfectant and a biocide. Chloride ion is almost completely innocuous and unreactive. Chloride ions can come from natural sources like rocks, or from the salt put on the roads for deicing. Chloride concentrations are generally lower than sulfate in most surface streams. Exceptions occur most often when some man-made effect enters into the system. My results show chloride concentrations that are generally two to four times higher than my sulfate values. This is a good indication that some source of chloride is tainting the Ipswich River. The samples taken in March show higher chloride to sulfate ratios than do the samples taken in April. This would suggest that at least some of the chloride ion concentration is due to salting of the roads. The spring thaw allows large amounts of salts into the water, but these taper off as they are leached out of the soil and washed downstream.

Another ion that is affected by the salting of roads is the sodium ion. It may also be liberated from silicate-mineral structures, and once loose, it will stay in solution very well due to a high degree of solvation and a small atomic size. Right below sodium on the periodic table is potassium. This is an essential element for both animals and plants (the sodium-potassium pump, which allows animal nerve cells to carry impulses, depends on this element). Since it is less abundant than sodium, it is more difficult for organisms to get the requisite amount. Potassium exhibits a strong tendency to be incorporated into certain clay minerals. Thus, the concentration might be expected to decrease if no new supply was bolstering the concentrations. Also, cations in general tend to be attracted to organic sediment, which is found in abundance in the Ipswich River. The organic sediments often carry a negative charge, and pull cations out of solution.

These four ions were tested for using the ion chromatograph and the atomic absorption spectrophotometer. According to the newspaper articles, Rubchinuk's landfill was primarily used for the dumping of construction materials, with some hint of illegal toxic waste dumpings. These materials could contain small amounts of the ions that were tested for. More importantly, if the landfill is leaching ions into the river and surrounding wetlands, then it also has high potential to leach more harmful chemicals into the environment. Finally, the presence of sulfate ions could indicate acidic conditions since one of the causes of acid (probably minimal on this scale!) rain is sulfur dioxide put out by cars. The sulfur dioxide reacts with water and oxygen in the atmosphere to form sulfuric acid, which could lead to sulfate ions at a pH above 4 (below 4 and HSO_4^- will appear rather than SO_4^{-2}). The acidic conditions could help to dissolve and leach other metals such as iron into the water.

where are these data?

The data obtained from the samples that were collected on March 28 show one major trend across the board. The concentration of each ion in the sample before the bridge is significantly less (about 9% less for chloride) than the sample taken after the bridge (only about 50 feet further downstream). This indicates that the road over the river is contributing greatly to the concentrations of all four ions. The sample taken nearly a half mile downstream from the landfill shows concentrations for the ions that are between the two upstream values, indicating that the landfill might not be contributing as much to the ionic concentrations as was hypothesized. However, it must be remembered that the downstream sample was taken much further downstream than would be ideal. Therefore, the water had a large *more important to be diluted by flow*

#5 could be highly significant -- either the landfill is contributing a big plume or Nichols Br. is contaminated by 95 or both!

amount of time to be diluted.

The samples obtained on April 12 revealed different trends. The upstream sample was comparable to the previous samples. However, the downstream sample showed a huge jump in all ionic concentrations except for potassium. One way to explain this is that a rainfall had recently occured, and the leaching of ions out of the landfill *or wetland* was at a high point. Another factor to consider is that the second downstream sample was taken much closer to the landfill, and therefore, the sample was more concentrated. Also, during spring the river tends to expand into a large wetland/pond after the site of the second sample but before the site of the first (taken on 3/28). Perhaps this expansion diluted the first sample back to nearly normal river water concentrations, and this caused the lack of an upward trend in ionic concentration. In any case, the data from the second sampling seems to override to some extent the data from the first. The sampling methods were better the second time around, and fluctuations in the ionic concentrations could be caused by a rainfall (i.e. perhaps the landfill only leaches ions during and shortly after a rainstorm).

(depends on subsurface plumbing - what is known about hydrogeology?)

The facts about the landfill, combined with topographic information, support the hypothesis that it could leach ions into the river and surrounding wetlands. The landfill contains debris *what* that would likely have fairly high amounts of the ions in it. Also, the landfill is not yet capped or closed, which means it is very susceptible to drainage into the river during a rainstorm. The topographic map *- refer reader to it* shows that the landfill is situated on the river side of a small (approximately 40 feet high) hill. Any drainage would drain directly into the wetlands and then into the river. Finally, it should be noted the proximity of the landfill to the adjacent wetlands. According to the map, the landfill actually touches the wetlands, which is in clear violation of the Wetland Protection Act. This Act essentially states that no human interference is allowed in the vicinity of a wetland. There should also be a 100 foot buffer zone around the wetland. This somewhat limits restoration efforts in that major changes in the landscape should be kept to a minimum.

However, if the landfill were to be capped, this could prove a sufficient solution to the problem. It seems to only leach materials during precipitation, and a clay cap would prevent the water from reaching those materials. Also, if the area where the clay was to come from was chosen carefully, this technique could be performed with little damage to the nearby wetlands. Finally, a layer of topsoil stabilized by vegetation over the cap would make the site more aesthetically pleasing, as well as more resistant to erosion.

The Bostik plant posed a different kind of problem. There was no direct evidence of any dumping in the river around the plant. There were rumors that the plant had once been a heavy polluter, but had since cleaned up its act. The plant makes industrial adhesives, such as the kinds of glues used to bond running sneakers together. Also, they used to have a machine used to clean off their trucks (see illustration). The tests were for the same ions as at the landfill, and they were designed to see if the plant puts out ions or washes them off of the trucks in large enough amounts to affect the river.

A brief visual inspection of the river yielded a few things. The water was a golden brown/yellow color, which is not unusual for the

Ipswich River. Also, the tiny shrimp that live in it at some parts of the year were present. However, on the negative side, the water had a good deal of foam on the surface. I wondered if this might be soap from the truck wash, or whether it was indicative of organic solvents (such as are used to keep glue liquid). Since the cost and complication of testing blindly for an unknown organic solvent precluded testing this hypothesis, I stuck to the ionic concentrations. good judgement!

The most immediately striking observation that I made was that the anion concentrations dipped down whereas the cation concentrations had a peak in the middle. The middle sampling site was after the waterfall and was slightly removed from the main stream. A small stream flowed off to the side and connected into the big stream later after passing near to the plant. The middle sample was taken at a juncture between the two streams. This data would indicate that the plant might be releasing some cations but not anions. there would always balance However, I'm not sure why a glue factory would be releasing slightly elevated sodium and potassium levels without a concurrent increase in anionic concentrations. Other than this observation, the data doesn't reveal too much. For one thing, only one group of samples was obtained, and one of these was lost when my roommate turned his refridgerator down to freeze his pizza. Instead, it froze (fortunately) only one of my samples, which cracked the bottle. With only three data points, trends were hard to ascertain.

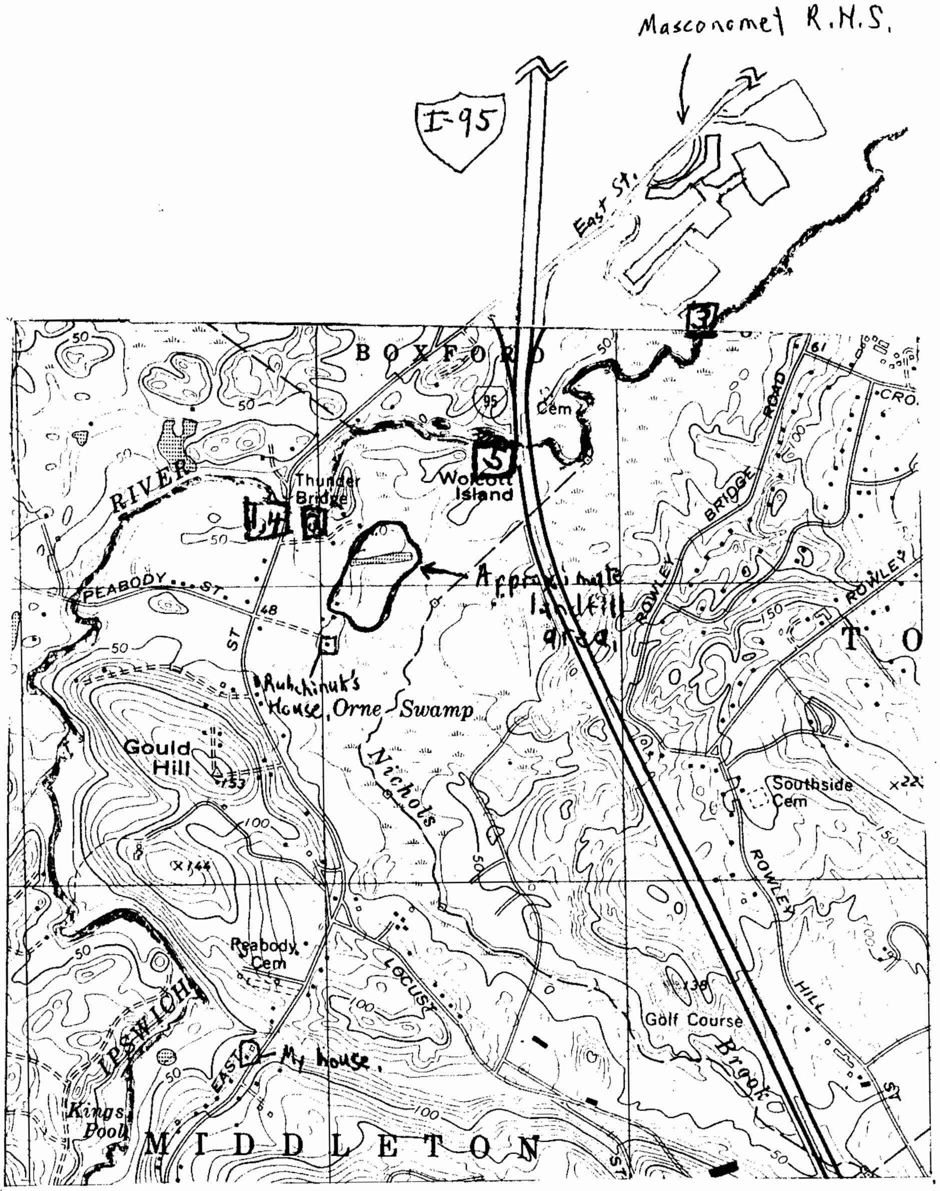
However, one thing the data ~~is~~ are quite useful for is expanding the technique used on a small scale around specific locations to include a large segment of the river. Basically, the Bostik samples become an indicator of upstream samples, while the Rubchinuk samples represent the downstream. This is only a very general indication of how the river changes as it moves downstream. It should be noted that the two locations are separated by about 5-7 miles, and that there is the Richardson's Dairy Farm on the banks of the river, as well as the Middleton Town Dump, which is apart from the river, but still a possible threat through groundwater contamination. Surprisingly enough, even with all the roads that cross over the river and the various potential sources of pollution that line the river, the concentrations of the four ions under scrutiny all drop slightly. This is likely due to a fair amount of tributaries coming in that are very low in ionic concentrations. These dilute the main river a good deal. Also, it's quite possible that the Bostik water was dirty both upstream and down, but that this was a localized effect. (middle sample is odd... looks like a local anomaly!)

The sources of error in a field experiment like this are many. In obtaining the samples, great care must be taken to use clean containers and to rinse them out with river water before filling them. Also, the samples should be chilled to prevent the loss of certain polyatomic ions to bacteria in the water. Most importantly, the dilutions must be made accurately and without any contact of the skin with the samples. The instruments are easily sensitive enough to register small variations in ion concentrations due simply to the ions on your skin washing off into the samples.

As an update, Mr. Rubchinuk is still in jail and the Middleton Conservation Commission is looking to cap the landfill ($20,000 → 40,000 an acre -- don't hold your breath) as soon as the red tape is cut through. On a good note, Bostik appears to have cleaned up its act.

(over)

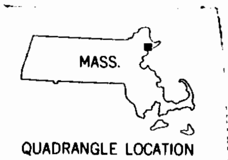
Map of the Rubchinuk Landfill Area:



Scale 1:25,000 1 km. 1 mile.

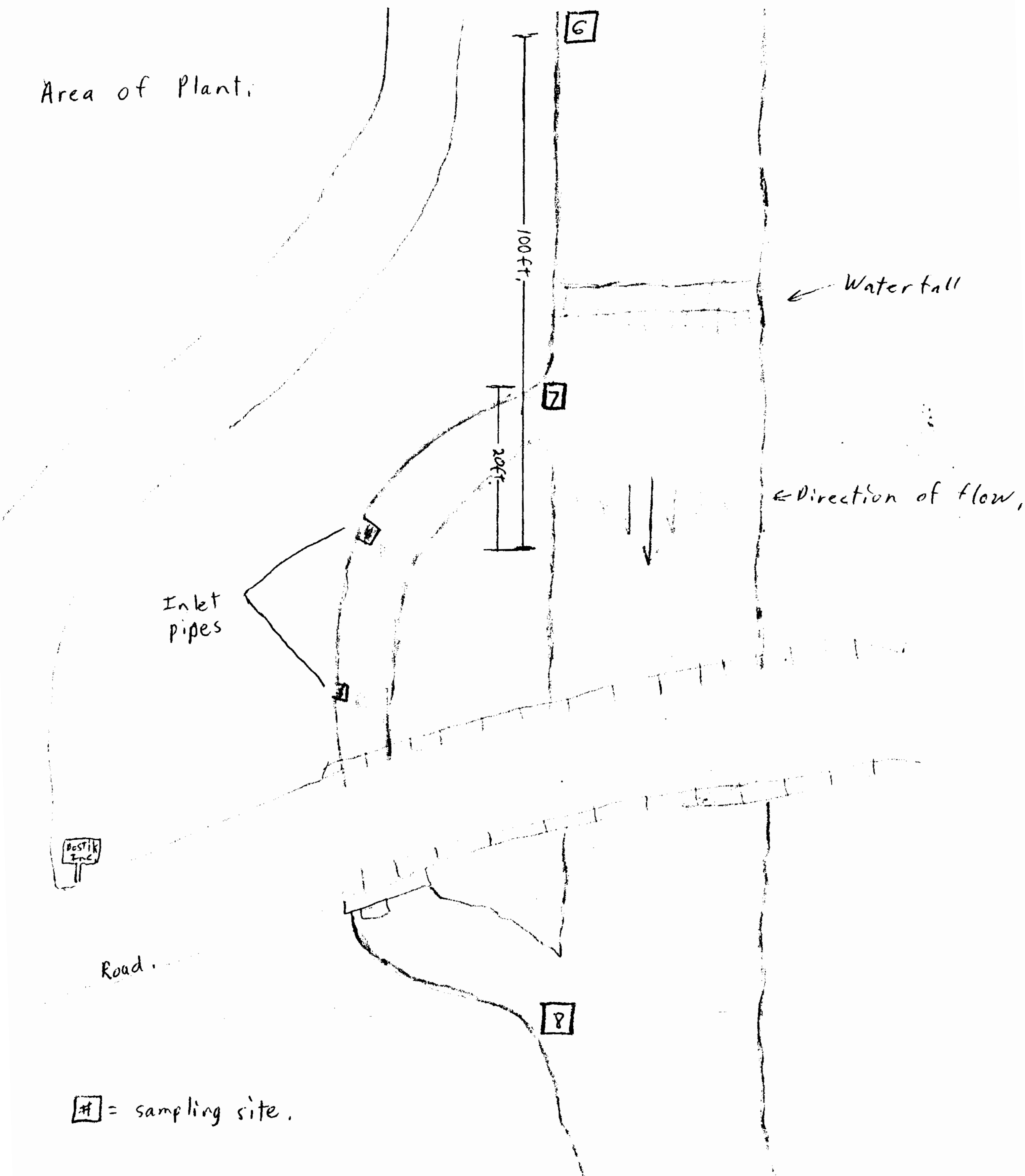
Contour interval = 10 ft.

Topography by planetable surveys 1942.
Photo revised 1979.



- Ipswich River
- Approximate site of landfill.
[#] - Sampling sites.

Map of the Bostik Plant Area:

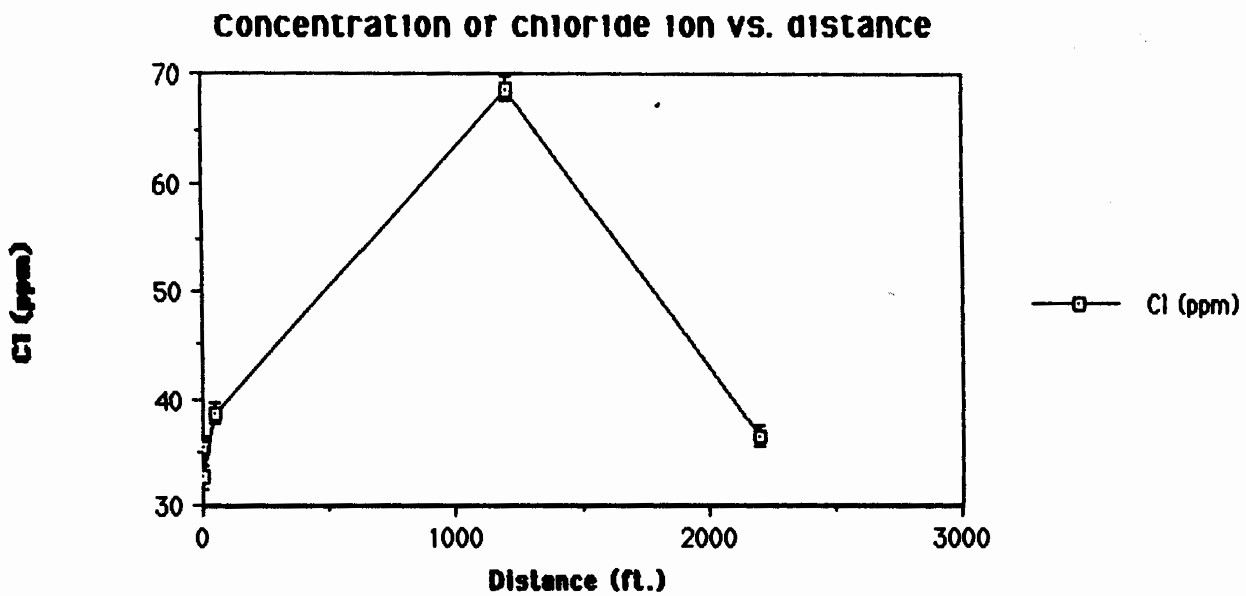


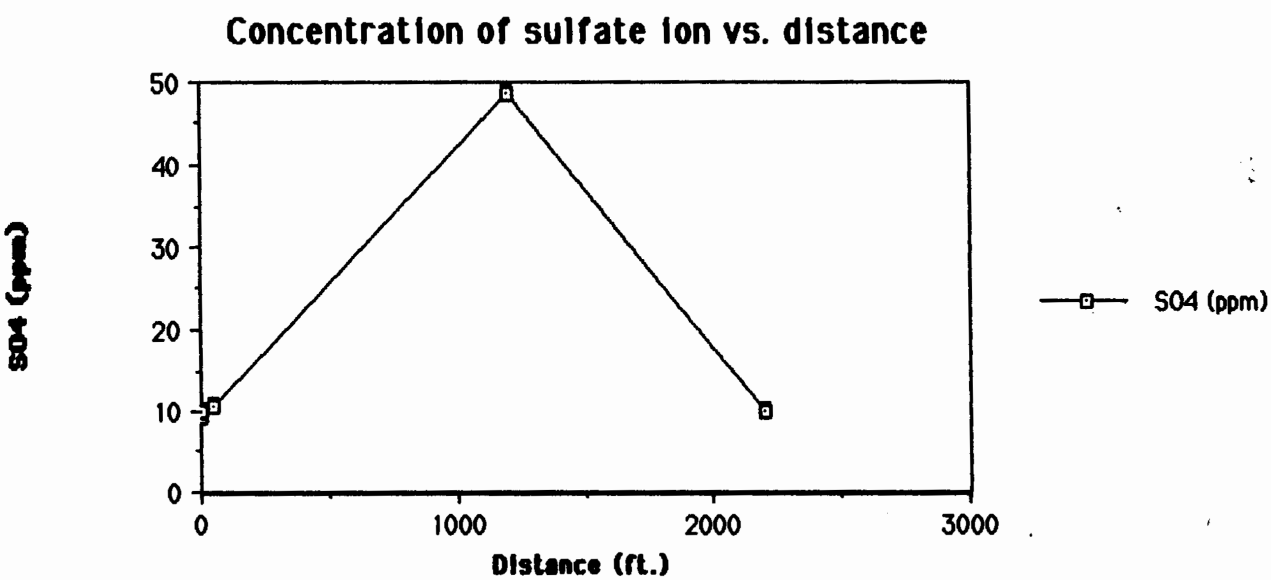
Data:

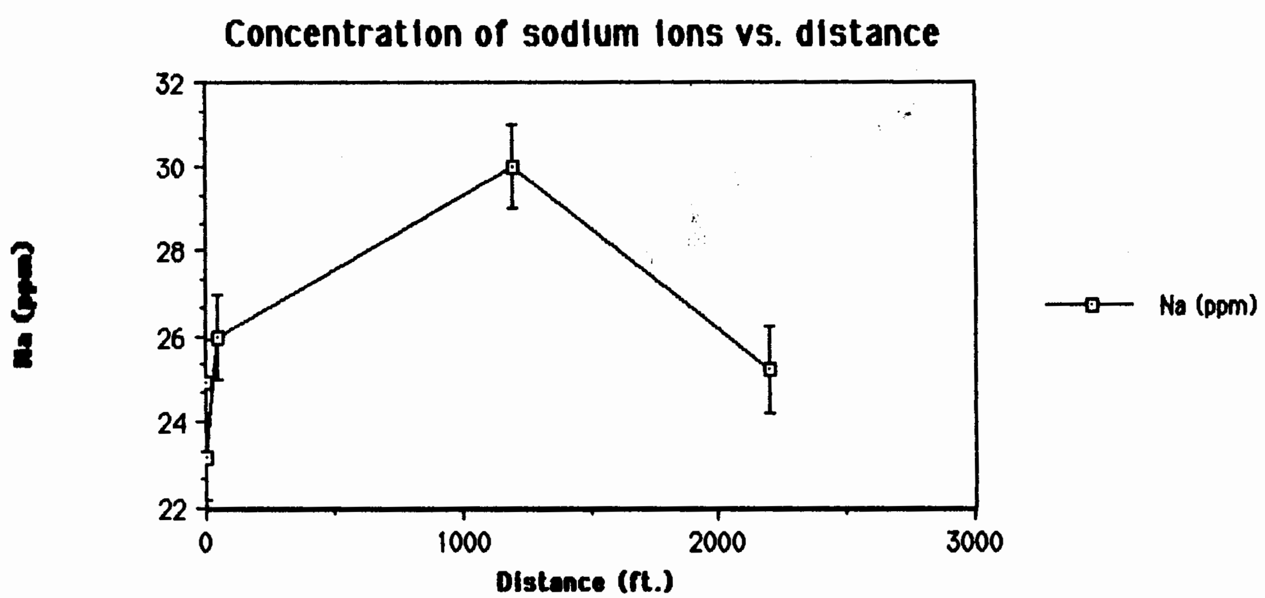
Table of IC and AA (anion and cation) data:

Sample #	Description of sample	Cl^- (mg/L) or (ppm)	SO_4^{-2} (ppm)	Na^+ (ppm)	K^+ (ppm)
1.	Collected 3/28 before Thunder Bridge (about 200 ft. upstream from the landfill. Diluted 1:10.	35.5	9.4	24.9	.5
2.	Collected 3/28 after Thunder Bridge (≈ 150 ft. upstream from the landfill). Diluted 1:10.	38.6	10.7	26.0	.7
3.	Collected 3/28 at Masconomet R.H.S. (≈ 2,000 ft. downstream). Diluted 1:10.	36.5	9.9	25.2	.5
4.	Collected 4/12 before Thunder Bridge (≈ 200 ft. upstream). Diluted 1:10.	32.6	10.0	23.2	1.0
5.	Collected 4/12 before Rt. 95 (≈ 1,000 ft. downstream). Diluted 1:20 for IC only.	68.8	48.6	(>30.0) peg	.8
6.	Collected 3/28 before waterfall at Bostik plant. Very slightly upstream (≈ 100 ft.). Diluted 1:20 for IC.	41.2	33.6	27.3	.7
7.	Collected 3/28 after waterfall at Bostik plant. About 20 ft. upstream. Diluted 1:20 for IC.	39.6	13.4	28.2	1.0
8.	Collected 3/28 after bridge at Bostik plant. About 150 ft. downstream. Diluted 1:20 for IC.	42.2	24.6	28.3	.9

Graphs Pertaining to the Landfill:

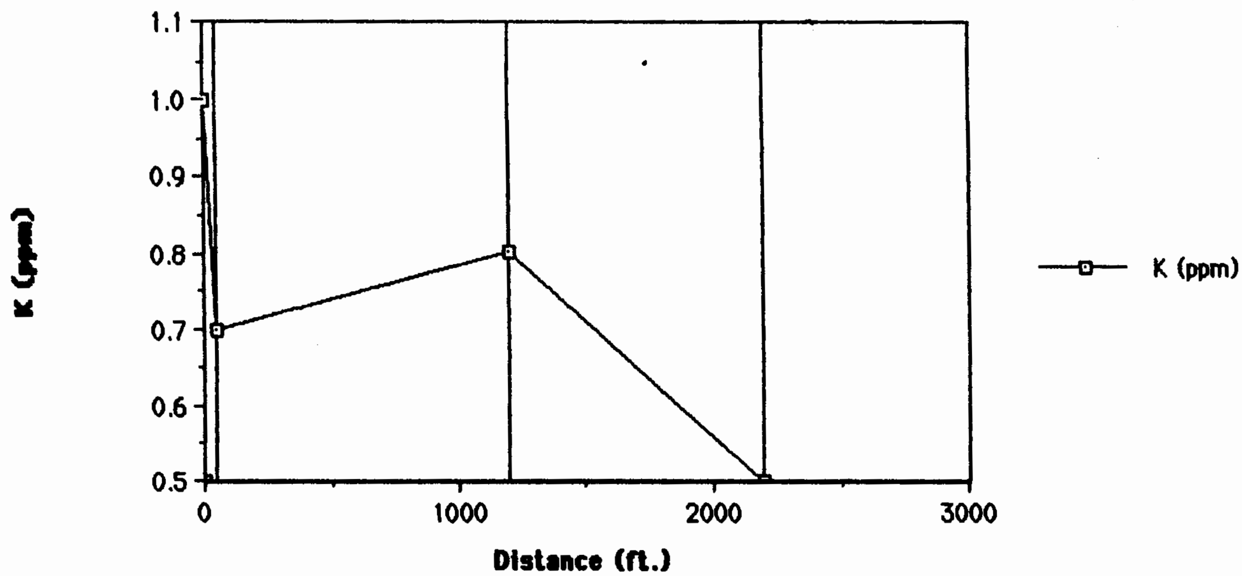






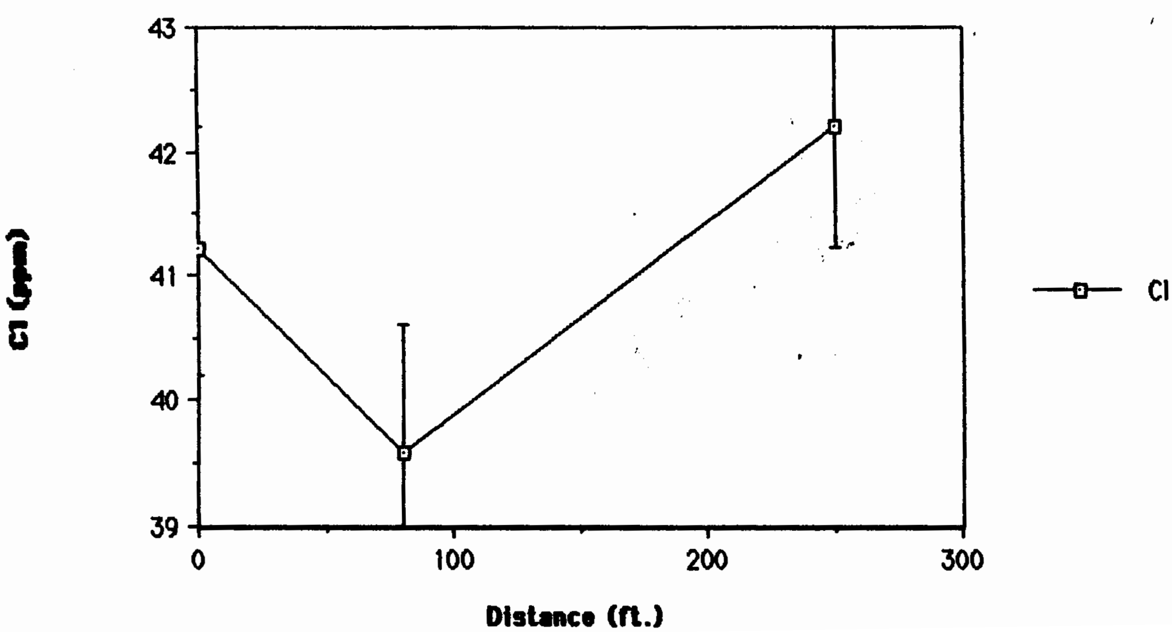
Graphs (cont.):

Concentration of potassium ions vs. distance

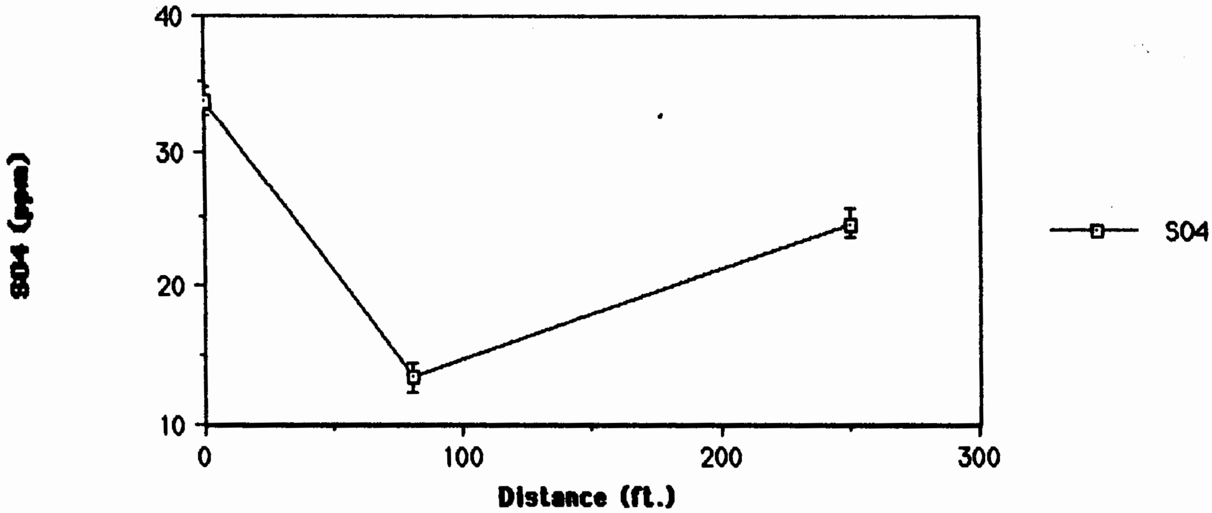


Graphs Pertaining to the Bostik Plant:

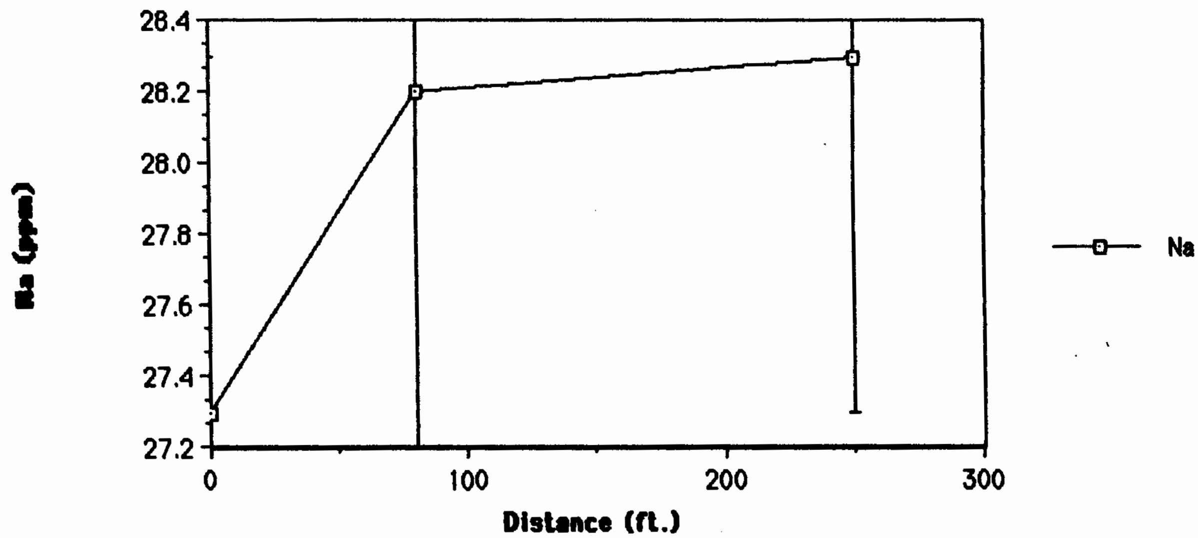
Concentration of chloride ions vs. distance



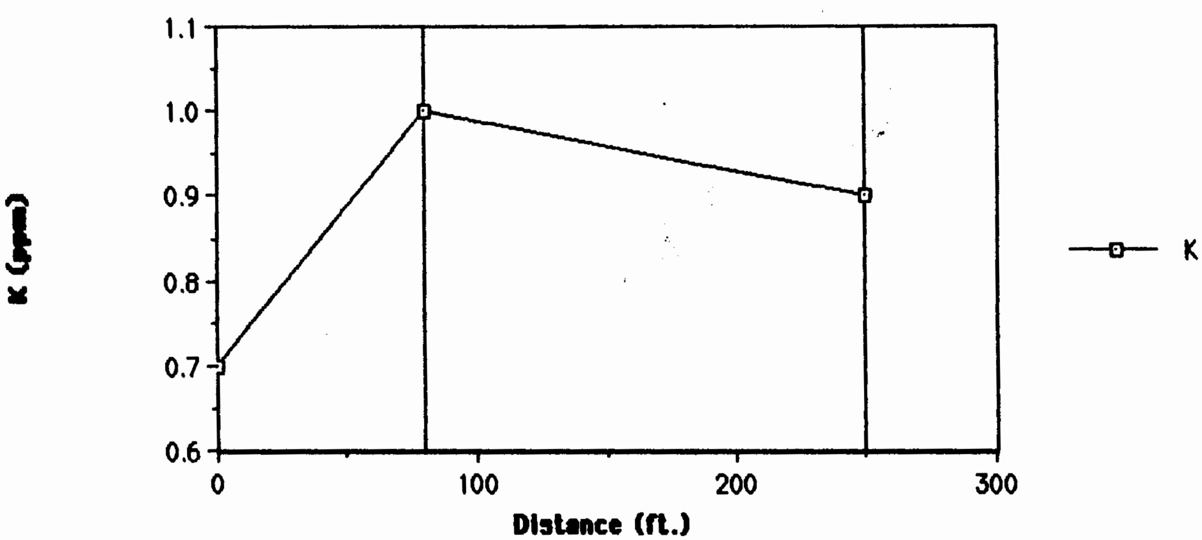
Concentration of sulfate ions vs. distance



Concentration of sodium ions vs. distance



Concentration of potassium ions vs. distance



REFERENCES:

1. "Environmental Science Readings," compiled by Art, Dethier, and Kegley, 1990.

2. "Study and Interpretation of the Chemical Characteristics of Natural Water," John D. Hem, United States Geologic Survey, Third ed.

3. "Tri-Town Transcript," March 22 edition through April 5.

4. "Van Nostrand's Scientific Encyclopedia," Ed. Douglas M. Considine, Van Nostrand Reinhold Co., New York, Fifth ed.