

Fate of Priority Pollutants in Publicly Owned Treatment Works

Pilot Study

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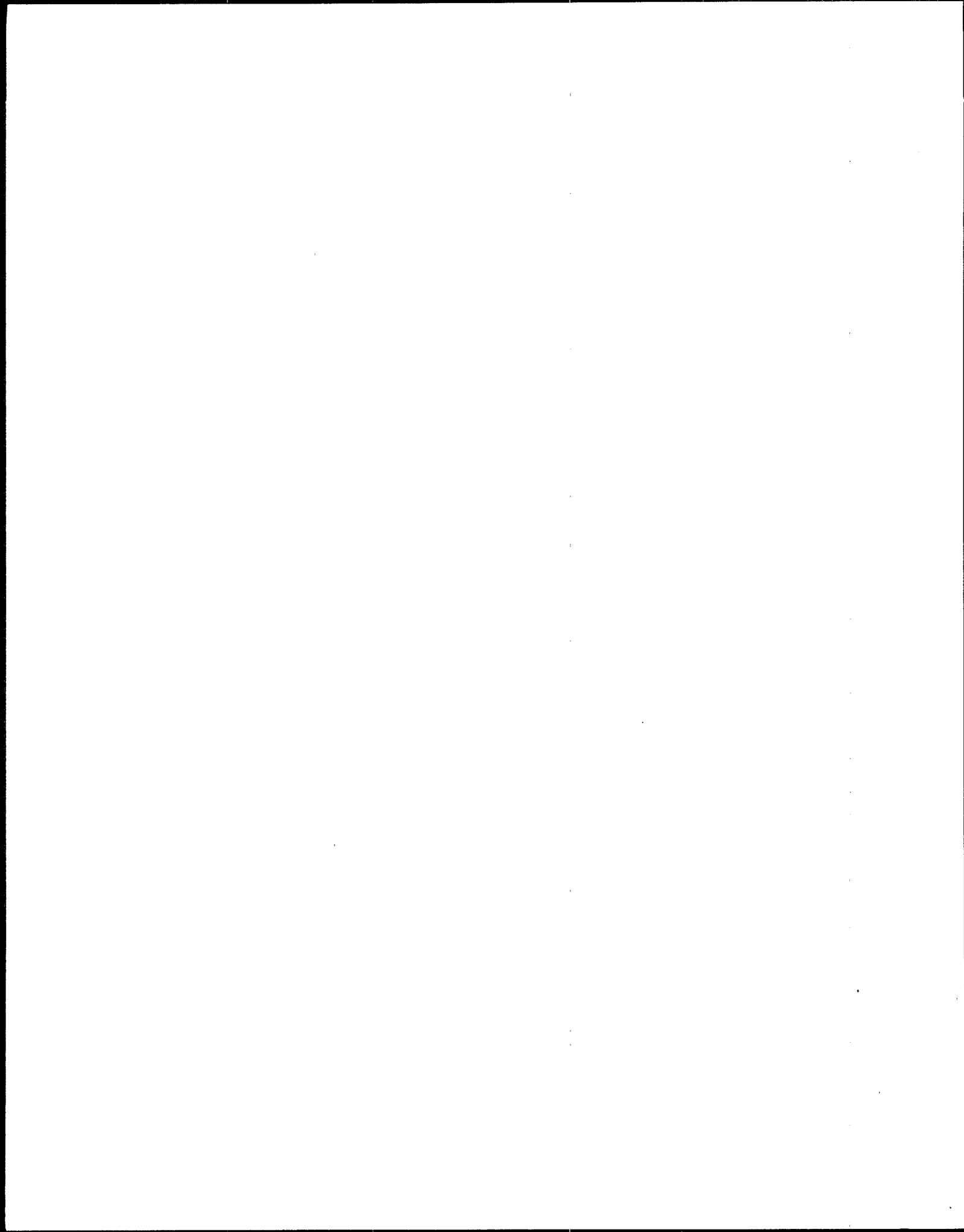
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I. SUMMARY AND CONCLUSIONS

Summary

The purpose of this report is to present the results of a two-plant pilot study designed to determine future operating parameters to be used during a study of the fate of priority pollutants in publicly owned treatment works (POTW's). The scope of the overall project is anticipated to encompass 7-day, 24-hour sampling at 40 strategically located POTW's, representing a variety of municipal treatment technologies, size ranges, and percentages of industrial flow. A major goal of the project is to characterize the impact of toxic pollutants, from all sources, on POTW operations. In addition the effect of secondary treatment on priority pollutants will be studied.

The pilot study was conducted at two POTW's with significantly different characteristics. These two plants provided contrasts in many areas, including size, percent industrial flow, age, operation, sludge conditioning methodology, and capacity utilized.

During the two-plant program the analytical and logistical factors of field sampling were tested to determine the optimum field methodologies and also to ascertain the feasibility of studying other aspects of POTW operations. Additionally, preliminary information regarding the incidence, impact and fate of priority pollutants in POTW's was developed. The data obtained from this study will impact the pretreatment regulations for indirect dischargers as to credits allowed (if any) for acceptable treatability or removal of toxics in POTW's.

Conclusions

1. A significantly higher incidence of organic priority pollutants was observed at the more industrial Plant A as compared to the essentially non-industrial Plant B.
2. Seven of nine metallic priority pollutants were found to have higher average concentrations in the Plant A influent.
3. Of nine organic priority pollutants measured in Plant A's influent at an average concentration greater than 10 $\mu\text{g/l}$, eight were reduced by a minimum of 50 percent. Organic priority pollutants at Plant B occurred at such low levels that percent removal data could not be determined.
4. Metallic priority pollutants were removed over a broad range of efficiencies at both plants.
5. The following priority pollutants were concentrated in the residues generated at Plant A: cadmium, copper, lead, nickel, zinc, acenaphthene, dichlorobromomethane, 1,2-benzanthracene, 3,4-benzofluoranthene, fluorene and pyrene. Similarly, at Plant B, chromium, copper, lead, nickel, zinc, acrylonitrile, dichlorobromomethane and 3,4 benzofluoranthene were concentrated in the sludge.
6. Refractory, but volatile organic priority pollutants such as benzene, 1,1,1-trichloroethane, ethylbenzene, toluene and trichloroethylene were well removed but not concentrated in plant sludges, suggesting air stripping as a possible removal mechanism.

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7. Daily variation of influent metallic priority pollutant concentrations was observed at both POTW's, but the variation was most pronounced at Plant A. Metals concentrations increased during the latter parts of the work week and dipped during weekends. Similar effects were recorded for conventional pollutants, but, in general, for organic priority pollutants, levels were too low to permit observation of trends.
 8. The 8-hour versus 24-hour composite experiment that was carried out on the Plant A influent showed that there was no appreciable difference between daily concentration values of organic priority pollutants. However, at the more industrial Plant A, metals concentrations were found to be significantly higher during the 0800 to 1600 (8:00 a.m. to 4:00 p.m.) period.
 9. Sampling and analysis of prechlorinated effluent samples produced evidence that formation of toxic chlorinated hydrocarbons in chlorine contact chambers and receiving streams does occur.
 10. The mass loading of priority pollutants in the floatables and sludge filtrate was found to be very small, as compared to the mass loading in total POTW residues.

II. INTRODUCTION

The United States Environmental Protection Agency (EPA) has initiated a program to study the occurrence and fate of 129 selected toxic organic and inorganic pollutants (priority pollutants) by means of a sampling program, at 40 publicly owned treatment works (POTW's). The first phase of this work was a pilot study at two POTW's to select the parameters of interest and establish detailed technical procedures that will be used for the overall project. In this report, data obtained from the two POTW's selected for the pilot study are presented. Since these two plants have different proportions of industrial flow, the relationship between industrial contributions and priority pollutant levels in POTW influents is examined. Additionally, other specific phenomena were studied, including the overall removal of toxic pollutants, removal mechanisms, concentration of toxic pollutants in sludge and the formation of chlorinated hydrocarbons during chlorine disinfection. EPA protocol¹ for collection, sampling and analysis of priority pollutants was followed for each procedure performed in the study, except where noted. Details of specific goals of the pilot study are outlined below.

¹Guidelines Establishing Test Procedures for the Analysis of Pollutants. To be published in the *Federal Register*. Proposed Amendments to 40 CFR Part 136.

Establishment of Sampling Techniques

An effort was made during sampling at the pilot facilities to determine the procedure best suited for obtaining the most representative samples from each treatment plant over the course of the entire 40-plant program. The effort focused on determining an appropriate sample frequency for obtaining the most representative picture of wastewater fluctuations which occur at a typical sewage treatment facility, as well as determining which days would yield the most representative samples, should the final sampling plan be limited to less than seven days of sampling per week.

Establishment of Appropriate Sampling Points

Determination of the appropriate sampling points to be used in the remainder of the 40-plant program was another focus of the pilot study. Samples were taken at different intermediate points in the wastewater treatment processes to ascertain which sampling points would provide the best information on the fate of priority pollutants as they pass through the POTW.

Development of Analytical Protocol for Samples

Another goal of the pilot study was to provide samples to be used in analytical protocol development. The present EPA protocol for the analysis of industrial wastewater samples is not specifically suitable for evaluation of municipal wastewater or sludge samples.

For example, analytical techniques for municipal sludges, which are characterized by high solids content, require different techniques from those required for the cleaner effluent streams or industrial wastewaters for which the protocols were originally developed. To assure that repeatable and accurate results are obtained throughout the duration of the 40-plant study, the samples collected during the pilot work were provided to analytical laboratories for the experimental development of new protocol procedures. Replicate analyses were completed using different methods in order to develop appropriate procedures to be used for the full study.

Fate of Priority Pollutants in POTW's

A further goal of the pilot program was to develop preliminary conclusions on the fate of the priority pollutants in POTW's. These conclusions will be substantiated as the sampling progresses through the 40-plant schedule and a detailed technical report will be forthcoming after completion of the project.

III. PLANT SELECTION

For the pilot study, two conventional activated sludge facilities were chosen for evaluation. Plant A is a 120 Mgal/d design capacity plant with approximately 70 percent of its organic loading and 30 percent of its flow contributed by industry, while Plant B is a 15 Mgal/d design capacity plant with approximately 2 percent industrial flow.

The following is a characterization of the two POTW's sampled during the pilot study.

Plant A

The design capacity of Plant A is 300 Mgal/d primary flow and 120 Mgal/d secondary flow. Under normal dry weather conditions, the flow through this system varies between 85 percent to 90 percent of its secondary capacity. During the first week of sampling at the plant, the flow averaged only 91.0 Mgal/d.

The original primary treatment facility was constructed in 1924, and most of the sewers are as old or older than the primary system. It is estimated that the collection system is 60 percent separate sewers and 40 percent combined sewers.

The treatment unit operations at this conventional activated sludge POTW begin with gravity flow from the drainage area to the bar screens and grit chambers, from which lift pumps elevate the wastewater for gravity flow through the rest of the plant. After the lift pumps, the wastewater passes through pre-aeration, primary settling, clarification, and into the aeration chambers. After aeration, clarification, and chlorination, the wastewater is discharged to a local stream.

Sludge handling at this POTW involves primary sludge thickening by gravity thickeners, secondary sludge thickening by dissolved air flotation (DAF), vacuum filtration and incineration. During the sampling period at Plant A, the primary sludge flow averaged 325,000 gal/d and the secondary (waste activated) sludge flow averaged 1.5 Mgal/d.

Industrial contributions to the flow are primarily from several major industries: pharmaceutical manufacture, petrochemicals, plating operations, and automotive foundries. Also contributing to Plant A's sewage collection system are some coking operations and some food processing plants.

Plant B

The design capacity of Plant B is 15 Mgal/d, but under normal operations between 8 and 10 Mgal/d receive secondary treatment. During the sampling period of this pilot study the influent flow to the facility averaged 8.09 Mgal/d (56,635,000 gallons during the period August 6 to 13, 1978). This 18-year-old treatment facility (updated and expanded most recently in 1973) is designed for a discharge with an effluent quality of not more than 10 mg/l biochemical oxygen demand and 12 mg/l of suspended solids. The average biochemical oxygen demand and total suspended solids discharges during the week of sampling were 25 mg/l and 19 mg/l, respectively.

The treatment unit operations utilized at this conventional activated sludge facility are as follows: Wastewater flows from the sewer system to a diversion chamber from which it is pumped to a height which allows gravity flow to the rest of the plant. The wastewater then passes through parallel detritus tanks (grit chambers), comminutors, pre-aeration chambers and into the primary settling tank. After primary settling, wastewater flows to the aeration tanks, secondary settling, chlorination, and is discharged.

The primary sludge flow at this POTW is pumped to sludge holding tanks where it is combined with the thickened (via DAF) waste activated sludge. From this point, the combined sludge passes to the sludge conditioning facilities where it is heated and pressurized prior to vacuum filtration. The decant from the sludge conditioning system and the filtrate is either returned to the sludge conditioning building, or bled to the head of the aeration tanks. The filter cake is incinerated with the resulting ash being slurried to a diked lagoon on the plant property.

During the sampling period, the primary sludge flow averaged 29,400 gal/d (205,860 gallons over the 7-day period). Sludge was usually pumped once per 8-hour work shift, and samples were taken during each pumping. The waste activated sludge was usually wasted only one time per week; the one time it was pumped during the sampling period, a sample was collected after the pumping. The estimated flow during that one pumping was 8,000 gallons. (No accurate flow reading for this pumping was available.)

The sewer system for Plant B consists primarily of combined sewers, broken down into four main trunk lines covering the far sections of the 29.4-square mile (or 22.5 according to POTW handout) drainage area. The sewer lines are mostly concrete construction and average 20 years in age, with some lines being over 50 years old. The age of the sewer lines accounts for the estimate that as much as 40 to 50 percent of the total flow to the POTW can be attributed to infiltration in the subsystems and interceptors, according to the facilities plan, completed under the authority of Section 201 of the Clean Water Act (PL 95-217).

The industrial contribution to the wastewater flow to Plant B can be considered minimal, because the areawide waste treatment management plan under Section 208 of the Clean Water Act lists the zoning breakdown of the drainage area as 96.6 percent residential, 1.0 percent retail business and offices, and 2.4 percent industrial. The industries associated with this drainage area are grain elevators, oil and fuel terminals, machine tool and metalworking companies, box and insulation companies, and one major chemical facility with its own National Pollutant Discharge Elimination System (NPDES) discharge permit. With such a small industrial flow, Plant B is considered to give a general approximation of a typical residential treatment facility.

IV. SAMPLE POINT DESCRIPTION

In an effort to determine the priority pollutant loads on the different waste streams within the two POTW's studied, several additional sample points were selected that would not normally be evaluated. The results of these analyses will be discussed in a following section of this report.

At Plant A, nine sampling points were used, as listed in Table IV-1. Samples were taken on seven consecutive days at the major points (influent, sludges, effluent), and an additional seven consecutive days at the influent only. (Extra influent samples were taken for analyses of 8-hour versus 24-hour compositing of influent. See Section VII.)

TABLE IV-1. SAMPLING FREQUENCY AT PLANT A

Point	Collection Method	Grabs for VOA, O&G Cn and Phenol	Type of Composite Samples	Duration
Influent	Automatic Sampler	6 times daily	3, 8-hr composites	7 days
Effluent before Chlorination	Automatic Sampler	6 times daily ¹	24 hr	days 5-7 ²
Final Effluent	Automatic Sampler	6 times daily	24 hr	7 days
Primary Sludge	Manual Composite	6 times daily ³	24 hr	7 days
Secondary Sludge	Automatic Sampler	6 times daily ³	24 hr	7 days
Floatables (scum)	Manual Composite	6 times daily ³	24 hr	7 days
Combined Sludge	Manual Composite	None (proportion of primary secondary)	24 hr	7 days
Tap Water	One Time Grab	One Time Grab	N/A	1 day
Vacuum Filter Filtrate	One Time Grab	One Time Grab	N/A	1 day

¹Volatile organic analysis (VOA) grabs only

²Chlorination system was not operative day 1, and had chlorine leaks days 2, 3, 4

³Composited by laboratory

At Plant B, seven separate waste streams were sampled, as listed in Table IV-2. As at Plant A, seven days of sampling were undertaken at Plant B to observe variations over the course of a complete week.

Each sample point that was chosen best characterized the wastewater at a particular stage of treatment. An effort was made to choose the sample points in such a way that any extraneous factors which might affect the validity of the sample would be eliminated. This involved selecting sampling points that allowed collection of samples before settling, volatilization, or contamination from other waste streams could occur. In instances where more than one parallel stream flowed through the same treatment process, the sample

was taken at the junction of the parallel streams if it was accessible. In all sampling, the EPA procedure for obtaining screening samples was used as the guide for gathering samples, and any deviation from the aforementioned procedure was documented.

The individual sampling points used at Plant A and nature of the wastewater that was sampled were as follows:

Plant A

Influent

Influent samples were obtained from one of four parallel flow grit chambers (usually only two in operation at one time) after the bar screens. The influent flow to Plant A was pumped to a wet well. From there it flowed by gravity and was split into several parallel streams prior to passing

through the bar screens and into the grit chamber. An automatic sampler was set up at the grit chamber (Figure IV-1) to draw equal aliquots over the 8-hour composite period during the first week and over the 24-hour composite period during the second week. Tubing for the samples was positioned inside a fixed conduit which was mounted to the safety railing around the grit chambers in such a way that the conduit could be adjusted vertically to keep the submerged end approximately one foot below the surface of the flow in the grit chamber. The daily flow fluctuations and the adjustments and openings and closings of the other grit chambers would affect the level of the flow in the grit chamber from which the sample was being extracted. Thus, to keep the exposed end of the

TABLE IV-2. SAMPLING FREQUENCY AT PLANT B.

Point	Collection Method	Grabs for VOA, O&G Cn and Phenol	Type of Composite Samples	Duration
Influent	Automatic Sampler	6 times daily	24 hr	7 days
Effluent before Chlorination	Automatic Sampler	6 times daily	24 hr	7 days
Final Effluent	Automatic Sampler	6 times daily	24 hr	7 days
Combined Sludge	Manual Composite	3 times daily ¹	24 hr	7 days
Secondary Sludge	One Time Grab	One Time Grab	N/A	1 day
Secondary Sludge after DAF thickening	One Time Grab	One Time Grab	N/A	1 day
Tap Water	One Time Grab	One Time Grab	N/A	1 day

¹Composited by laboratory

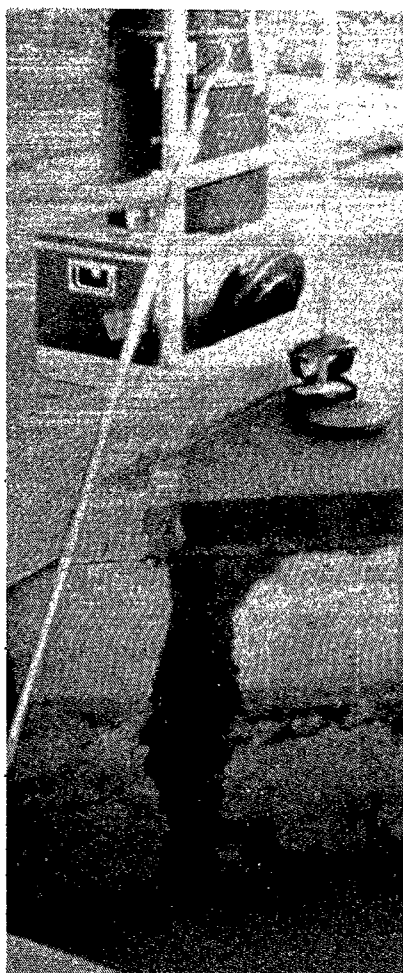


Figure IV-1. Influent sampling point at Plant A.

sample tubing below the top layer of wastewater flow, the conduit was checked and adjusted, if necessary, at least once every four hours. Samples for the fractions that were not automatically composited were grabbed via a glass dipping pitcher at the sample midstream point where the tubing was positioned. Influent flow readings were supplied by the treatment plant after the sampling period was complete.

Primary Sludge

Samples for the primary sludge were taken from the main line between the primary settling tanks and the sludge conditioning system. Samples were taken every four hours for both the composites and the grabs, with the composite portion of the sample being held in a 3-gallon container and kept on ice at the sample point. A sludge flow totalizer was located adjacent to the sample valve and provided sludge flow information for each sample period.

Floatables (Scum)

The floatables samples, which were taken from the primary settling tanks, represented the material which had been skimmed off the tanks and had accumulated at the discharge end of the primaries. These samples were obtained by manually dipping into this floating layer each sample period.

Secondary (Waste Activated) Sludge

The secondary sludge samples were taken from a lift pump tower. This tower provided the only access point to the secondary sludge before it flowed (by gravity) to the DAF thickener. An automatic sampler was set up on this tower to obtain the composite samples. Totalizer readings were read at the secondary control building and were recorded for each sample period.

Combined Sludge

The combined sludge sample was a flow-proportioned composite sample of the primary and waste activated sludges. A total of 1600 ml of sludge was composited for each 4-hour grab sample period. The ratio of primary sludge to waste activated sludge was determined by the flow rate of each sludge during the preceding four hours. Each sludge allotment was measured in a graduated beaker and transferred to a 3-gallon container for storage in an ice bath for the 24-hour sample period.

Pre-chlorinated Effluent

Samples of the pre-chlorinated effluent were taken immediately upstream of the chlorination point. The chlorine is added to the effluent stream underground, and a piece of conduit was positioned at the sample point with the instream end upstream of the chlorine contact point. Chlorination facilities were not operational during the first few days of the sampling and, consequently, no samples of the pre-chlorinated effluent were obtained until July 26. Once the sampling was begun at this point,

a small chlorine gas leak developed, and it was judged unsafe to enter the 10-foot access hole to gather the grab samples. To remedy this problem, an additional sampler was set up to collect the grab fraction samples (volatile organic analyses—VOA's only) from the stream and deliver them to the surface.

Final Effluent

The final effluent sample point was located at the discharge end of the chlorine contact chamber, just prior to the overflow weir to the river. Composite samples, where appropriate, were collected with an automatic sampler, utilizing a conduit to fix the intake tube's position.

Vacuum Filter Filtrate

One grab sample was taken of the vacuum filter filtrate from the vacuum discharge line in the filter building. (All sample bottles were filled as grabs at this one time.) Each filling yielded approximately 250 ml of sample. No values for the flow of this waste stream were available.

Tap Water

A single grab sample for all parameters was taken of the tap water in the Plant's laboratory sink. The sample point was considered representative of the city water supply.

The individual sampling points at Plant B and the nature of the wastewater sampled are as follows:

Plant B

Influent

The influent sample point was at the head end of the grit chambers (detritus tanks). At this point an automatic sampler was set up with the sample tubing secured inside a stationary conduit so as to maintain the wetted end in a position in the center of the turbulent zone. This area was subject to surges of wastewater flow, and a secure placement of the tubing was the only way to obtain a representative sample of the influent. The grab fractions for the influent were obtained via a glass pitcher which was dipped directly into the wastewater. Flow readings of the influent flow rates were supplied by the treatment plant after the sampling period had been completed. Additional parallel sampling at the sampling point was done by another EPA contractor who is also sampling wastewater collection systems for priority pollutants.

Combined Sludge

The combined sludge sample was to be a flow composite of the primary sludge and the secondary sludge, but until the last day of sampling, there was no secondary sludge being wasted. Thus, the sludge sample for the first six of seven days was only primary sludge, and the seventh sample was a flow-proportioned composite of both the primary and secondary sludges.

The primary sludge sample point was a tap off of the sludge pump which was used to transport the primary sludge from the raw sludge well to the sludge holding tanks. The pumping of the sludge was not a continuous operation and required that samples be taken during the three daily pumping periods. The samples were grabbed from the tap on the pump (after an appropriate purge time) after an initial startup period of between 10 and 15 minutes and before the end of the pumping period when the sludge would become too watery to yield a representative sample. The primary sludge flow was read in the sludge pumping building each time a sample was grabbed.

The secondary sludge samples were taken only on the last day of sampling, as this was the only time during the 7-day sampling period when any secondary sludge was wasted. Two samples of the secondary sludge were grabbed, one before and one after the thickening process. With each sample, an appropriate amount (by flow) was composited with the primary sludge sample for that time period. The secondary sludge sample prior to thickening was grabbed as it flowed into the holding tank (after pumping from secondary clarifiers). The secondary sludge sample, after thickening, was grabbed by dipping into the surface layer of thickened sludge on the discharge end of the sludge thickening unit. No accurate flow measurements of the flow of this secondary sludge were available. Therefore, an operator estimate was used for the flow information.

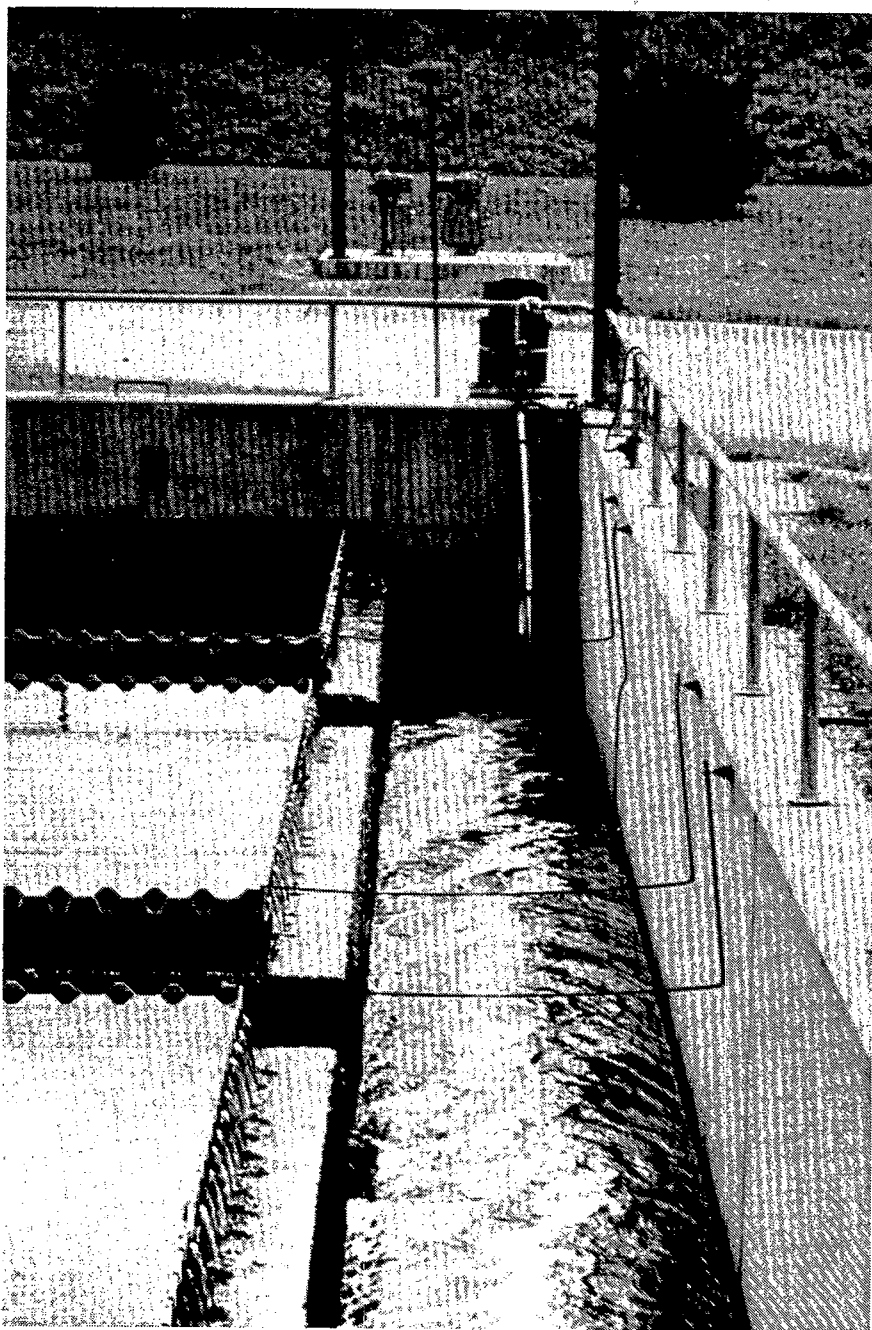


Figure IV-2. Prechlorinated effluent sampling point Plant B.

Pre-chlorinated Effluent

The pre-chlorinated effluent sample point was located in the discharge trough of the secondary clarifiers after all the flows of the clarifiers had converged and were flowing to the chlorination chamber. An automatic sampler was set up at this point (Figure IV-2) to obtain the composite sample. The automatic sampler tubing was also secured with conduit facing into the wastewater flow. The grab samples were taken at the same sample point.

Final Effluent

The final effluent sampling point was at the overflow weir of the chlorine contact chamber just prior to the flow into the discharge flume (Figure IV-3). The sample point was approximately 20 feet below ground level, and samples were collected with an automatic sampler and a glass beaker dipping pole. As with the other automatic sampler points, the sampler tubing was rigidly held by a fixed piece of conduit facing upstream.

Tap Water

One tap water sample was taken at Plant B to obtain background information on the city water supply. The sample point chosen was the water tap in the sludge concentration tank's control building, which was being used as a staging area by the sampling crew. Each of the sample bottles was filled directly from the tap.

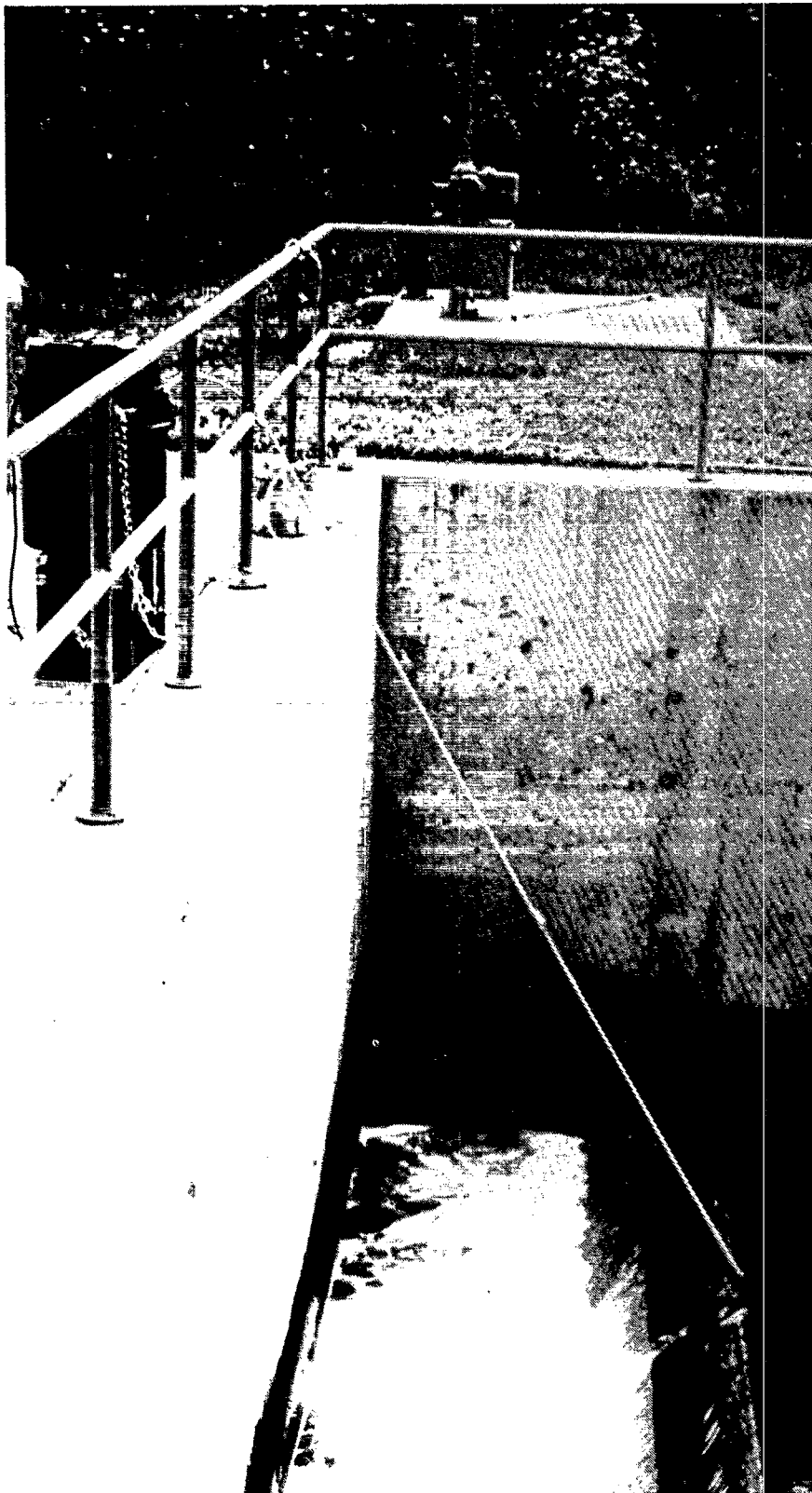


Figure IV-3. Final effluent sampling point Plant B.

V. SAMPLING

Sampling Frequency

The sampling activities at both of the pilot study POTW's were scheduled over a 1-week period so that information could be gathered on operational and pollutant loading variations on individual days.

Sampling at Plant A spanned 14 days, Saturday, July 22, 1978 to Saturday, August 5, 1978, with the general all-points sampling taking place only during the first seven days and sampling of the influent only during the second seven days. Similarly, at Plant B, the seven days of sampling were Sunday, August 6, 1978 to Sunday, August 13, 1978.

To obtain a cross section of pollutant levels through the treatment plants, multiple grabs were taken during each 24-hour sampling period (0800-0800). As a result, grab samples were taken six times daily (1000, 1400, 1800, 2200, 0200, 0600). During the second week at Plant A when only the influent was being sampled, grab times were moved ahead two hours to coincide with the 24-hour composite (0800, 1200, 1600, 2000, 2400, 0400).

Sampling Techniques

Identical sampling techniques were used at both POTW's throughout the study, and unless noted below, sampling protocols developed by the EPA were followed.

To obtain the most representative sample from each sample point, automatic samplers (Figure V-1) were used wherever possible to gather frequent, equal-sized sample aliquots. This procedure was only possible where flows were continuous and accessible to automatic sampling equipment. At each POTW, the influent and effluent streams were easily accessible and could be sampled at points where the flow was representative of the total plant influent and effluents, respectively. On the other hand, a sample point for primary sludge at Plant A posed special problems where waste flow was confined to a pipe; thus, as a result, the only feasible method for retrieving a sample involved opening a gate valve. Because the valve tended to clog, repeated opening and closing was required to avoid backups or blockages. For such sample points manual compositing had to be employed. Each sample point presented its own peculiarities and had to be handled individually. No single standard technique could be developed to cover all sample points under all situations.

Sample Collection Procedures

For those samples which could be collected using automatic samplers, tubing was changed once per day, and sampler blanks were run at the beginning of each day's new composite. The automatic samplers were calibrated to pull sample aliquots of at least 100 ml at time intervals not to exceed 30 minutes. Composites in the automatic samplers were collected in 2.5-gallon glass jars which were kept in an ice bath at 4°C for the entire 24-hour period of sampling.

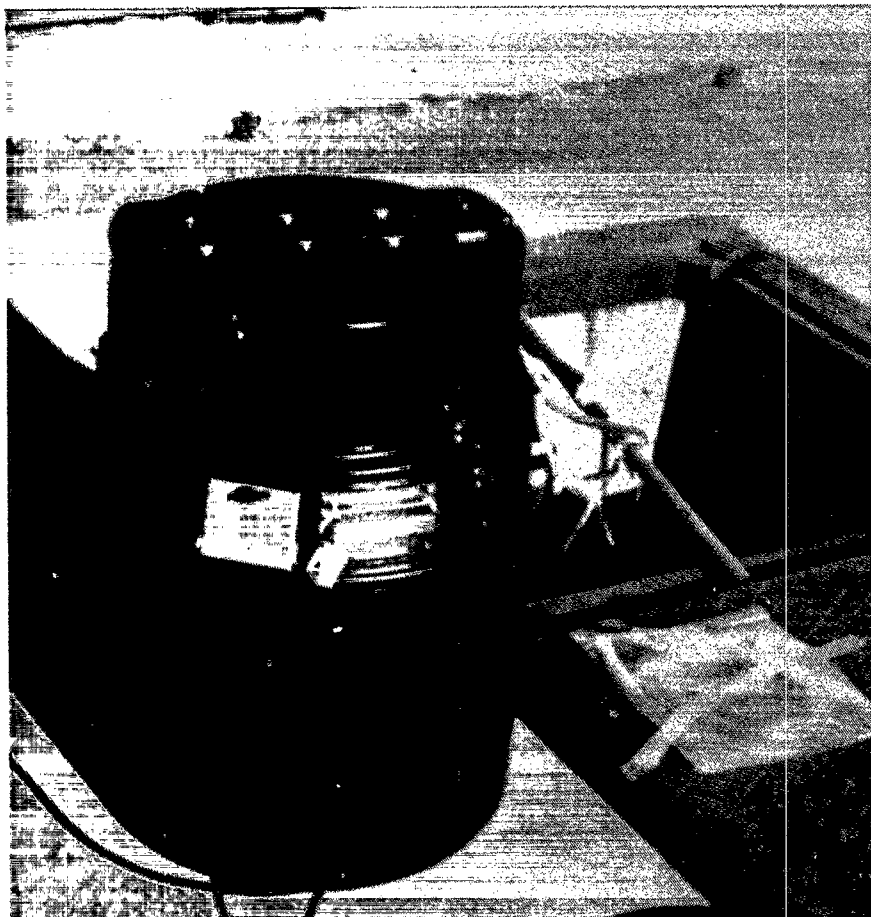


Figure V-1. Automatic sampler.

For those composite samples which could not be gathered by automatic samplers, aliquots were taken with the regular grab samples and composited into jugs which were kept in an ice bath at 4°C.

At sample points in the two pilot study POTW's, except for the two tap water sample points and the vacuum filter filtrate sample point at Plant A, the sample containers were filled via an intermediate gathering beaker of glass or stainless steel. The intermediate beakers were used to obtain the most representative sample, while maintaining accuracy and safety. Safety was an important factor, since many sampling points were constructed in a fashion that precluded direct collection of grab samples. Stainless steel and glass beakers were used exclusively as the intermediate beakers because these two materials are defined in the EPA sampling protocol as having characteristics such that they will not contaminate the samples, nor will they contribute any extra pollutants by deterioration or breakdown that might be detected in the wastewater analysis. Each sample point at each plant had its own beaker to eliminate cross contamination, and each sampling container was thoroughly rinsed with new sample prior to each sample collection.

At the two tap water sample points the flow from the taps could be regulated so as to facilitate direct filling of the sample containers. At the vacuum filter filtrate sample point in Plant A, the only way to obtain a sample was off of the vacuum line. By inserting a plastic bottle (which had been used repeatedly for this purpose) into an exposed air port, a disruption of the vacuum caused some of the filtrate to be deposited in the bottle. This plastic bottle was thoroughly rinsed with sample prior to each use.

Protocol and Protocol Modifications

Samples from both plants were collected in accordance with EPA protocols, including the proper preparation of bottles, the addition of prescribed preservatives and the collection of appropriate sampler blanks. All samples were shipped by air to the appropriate laboratories within prescribed time limits and were analyzed according to protocols for organic analysis. Metals from influent and effluent samples were analyzed according to protocols developed by EPA for priority pollutants. Metals from influent and effluent samples

were analyzed by EPA's Region VII laboratory, using Plasma Atomic Emission Spectroscopy supplemented with flameless atomic absorption spectrophotometry, where appropriate. Organic priority pollutants from influent and effluent samples were analyzed by an EPA contract laboratory utilizing liquid-liquid extraction and gas chromatography-mass spectroscopy (gc-ms) for the acid and base neutral fractions, electron capture gas chromatography for pesticides, and purge and trap followed by gc-ms for volatile organics. All sludge samples were analyzed by the EPA contractor laboratory who developed some of the specific protocols for priority pollutant analysis of sludge samples during the study. Conventional pollutant analyses for all samples were performed by a branch office of this same laboratory in a different city.

The aforementioned protocol was followed as closely as possible during the pilot study but, in certain instances, modifications were required to suit individual sampling situations. Specific modifications to the protocol are discussed below.

The protocol states that Teflon tubing should be used on all automatic sampler applications. For this initial screening vinyl tubing was used instead. This tubing was thoroughly purged with distilled water prior to its use, and a sampler blank was run on each piece of tubing daily at each site before the sampler was started.

The method of grabbing samples via an intermediate vessel is a modification to the protocol for fractions such as oil and grease, where the sample container is supposed to be filled directly from the wastewater stream. This modification was made for safety and practical reasons since positioning of the sample container into most of these waste streams was either impossible or very dangerous, and the induced error through use of an intermediate beaker was of lesser consequence. In all cases where an intermediate beaker was used, it was used exclusively at one point for the duration of sampling at the plant, and it was repeatedly purged with fresh sample at each sample period.

VI. DATA SUMMARY

Major Trends

The priority pollutants detected in the influents, effluents, and sludges of the two pilot POTW's are depicted in Tables VI-1 and VI-2. These tables point out the predominance of the solvents and the phthalates in the influents. In Plant A's influent, eight of the ten most prominent pollutants were solvents, with only one phthalate and phenol detected in more than 80 percent of the samples. In Plant B, the smaller industrial contribution is evident in that only six of the ten most prominent pollutants are solvents, with the remaining four being phthalates. Phenol was not among the ten most common pollutants at Plant B.

The sludge and effluent data in these tables also show that many priority pollutants are concentrated in residues, while others are removed by different mechanisms.

The occurrence of selected conventional and priority pollutants in Plant A's influent, effluent and sludges is presented in Section VII. The organic pollutants with the highest concentration in the influent were benzene, 1,1,1 trichloroethane, chloroform, ethylbenzene, bis (2-ethylhexyl) phthalate, tetrachloroethylene, toluene and trichloroethylene. All of these parameters were reduced by an average of 50 percent or more during treatment, and all except chloroform were detected in one or more of the sludges. Metallic priority pollutants which occurred at relatively high levels in Plant A's influent included chromium, copper, lead, nickel and zinc. These metals were all reduced at least 50 percent during treatment, and all were detected at high levels in both the primary and secondary sludge.

A data summary of the weekly average concentration of selected conventional and priority pollutants from Plant B is presented in Section VII. No organic priority pollutant occurred at an average of over 20 $\mu\text{g}/\text{l}$ in the plant's influent. The organic pollutants which were present in the highest concentrations, however, were benzene, methylene chloride, and bis (2-ethylhexyl) phthalate. Methylene chloride values must be viewed with some suspicion since this substance was used as a bottle preparation additive. Metallic priority pollutants which were present at over 50 $\mu\text{g}/\text{l}$ in the influent included chromium, copper, cyanide and zinc. (For this discussion, cyanide has been classified as a metallic priority pollutant.)

TABLE VI-1
SUMMARY
PERCENT OCCURENCES OF ORGANIC PRIORITY POLLUTANTS
PLANT A

5-30-79

PP	PARAMETER NAME	INFLUENT		FINAL EFFLUENT		PRIMARY SLUDGE		SECONDARY SLUDGE	
		SAMPLES ANALYZED	TIMES DETECTED (PERCENT)	SAMPLES ANALYZED	TIMES DETECTED (PERCENT)	SAMPLES ANALYZED	TIMES DETECTED (PERCENT)	SAMPLES ANALYZED	TIMES DETECTED (PERCENT)
86	TOLUENE	41	41(100)	40	38(95)	7	7(100)	7	2(29)
44	METHYLENE CHLORIDE	41	41(100)	40	39(98)	7	7(100)	7	7(100)
87	TRICHLOROETHYLENE	41	40(98)	40	36(90)	7	7(100)	7	1(14)
85	TETRACHLOROETHYLENE	41	40(98)	40	39(98)	7	7(100)	7	5(71)
23	CHLOROFORM	41	40(98)	40	39(98)	7	0(0)	7	0(0)
4	BENZENE	41	40(98)	40	18(45)	7	7(100)	7	4(57)
66	BIS(2-ETHYLHEXYL) PHTHALATE	21	20(95)	7	7(100)	7	6(86)	5	2(40)
65	PHENDL	21	20(95)	7	7(100)	7	2(29)	5	1(20)
38	ETHYLBENZENE	41	37(90)	40	25(63)	7	7(100)	7	2(29)
11	1,1,1-TRICHLOROETHANE	41	35(85)	40	30(75)	7	4(57)	7	0(0)
29	1,1-DICHLOROETHYLENE	41	32(78)	40	33(83)	7	2(29)	7	0(0)
68	DI-N-BUTYL PHTHALATE	21	16(76)	7	4(57)	7	0(0)	5	0(0)
55	NAPHTHALENE	21	16(76)	7	3(43)	7	5(71)	5	1(20)
30	1,2-TRANS-DICHLOROETHYLENE	41	31(76)	40	7(18)	7	3(43)	7	0(0)
81	PHENANTHRENE	21	15(71)	7	3(43)	7	6(86)	5	2(40)
78	ANTHRACENE	21	15(71)	7	3(43)	7	6(86)	5	2(40)
70	DIETHYL PHTHALATE	21	13(62)	7	2(29)	7	0(0)	5	0(0)
25	1,2-DICHLOROBENZENE	21	9(43)	7	1(14)	7	0(0)	5	0(0)
71	DIMETHYL PHTHALATE	21	8(38)	7	1(14)	7	0(0)	5	0(0)
67	BUTYL BENZYL PHTHALATE	21	8(38)	7	3(43)	7	1(14)	5	0(0)
27	1,4-DICHLOROBENZENE	21	8(38)	7	2(29)	7	0(0)	5	0(0)
84	PYRENE	21	7(33)	7	4(57)	7	6(86)	5	0(0)
80	FLUORENE	21	6(29)	7	1(14)	7	3(43)	5	0(0)
64	PENTACHLOROPHENOL	21	6(29)	7	1(14)	7	1(14)	5	1(20)
39	FLUORANTHENE	21	6(29)	7	3(43)	7	0(0)	5	0(0)
26	1,3-DICHLOROBENZENE	21	5(24)	7	1(14)	7	0(0)	5	0(0)
13	1,1-DICHLOROETHANE	41	8(20)	7	0(0)	7	4(57)	5	0(0)
7	CHLOROBENZENE	41	6(15)	40	1(3)	7	0(0)	7	0(0)
76	CHRYSENE	21	2(10)	7	1(14)	7	6(86)	5	0(0)
72	1,2-BENZANTHRACENE	21	2(10)	7	1(14)	7	6(86)	5	0(0)
43	BIS(2-CHLOROETHOXY) METHANE	21	2(10)	7	0(0)	7	0(0)	5	0(0)
6	CARBON TETRACHLORIDE	41	4(10)	40	0(0)	7	2(29)	7	2(29)
1	ACENAPHTHENE	21	2(10)	7	0(0)	7	0(0)	5	0(0)
14	1,1,2-TRICHLOROETHANE	41	3(7)	40	0(0)	7	0(0)	7	0(0)
83	INDENO(1,2,3-C,D) PYRENE	21	1(5)	7	1(14)	7	0(0)	5	1(20)
82	1,2:5,6-DIBENZANTHRACENE	21	1(5)	7	1(14)	7	0(0)	5	1(20)
79	1,12-BENZOPERYLENE	21	1(5)	7	0(0)	7	0(0)	5	0(0)
77	ACENAPHTHYLENE	21	1(5)	7	0(0)	7	0(0)	5	0(0)
69	DI-N-OCTYL PHTHALATE	21	1(5)	7	1(14)	7	0(0)	5	0(0)
52	HEXACHLOROBUTADIENE	21	1(5)	7	0(0)	7	0(0)	5	0(0)
45	CHLOROMETHANE	41	2(5)	40	0(0)	7	0(0)	7	0(0)
32	1,2-DICHLOROPROPANE	41	2(5)	7	0(0)	7	0(0)	40	0(0)
22	PARACHLOROMETA CRESOL	21	1(5)	7	0(0)	7	0(0)	5	0(0)
21	2,4,6-TRICHLOROPHENOL	21	1(5)	7	0(0)	7	0(0)	5	0(0)
9	HEXACHLOROBENZENE	21	1(5)	7	0(0)	7	0(0)	5	0(0)
8	1,2,4-TRICHLOROBENZENE	21	1(5)	7	0(0)	7	0(0)	5	0(0)
49	TRICHLOROFLUOROMETHANE	41	1(2)	40	2(5)	7	0(0)	7	0(0)
48	DICHLOROBROMOMETHANE	41	1(2)	40	9(23)	7	7(100)	7	6(86)
10	1,2-DICHLOROETHANE	41	1(2)	40	0(0)	7	0(0)	7	0(0)
74	3,4-BENZOFLUORANTHENE	21	0(0)	7	0(0)	7	5(71)	5	1(20)
51	CHLORODIBROMOMETHANE	41	0(0)	40	2(5)	7	3(43)	7	4(57)
34	2,4-DIMETHYLPHENOL	21	0(0)	7	1(14)	7	0(0)	5	0(0)
28	3,3'-DICHLOROBENZIDINE	21	0(0)	7	1(14)	7	0(0)	5	0(0)
24	2-CHLOROPHENOL	21	0(0)	7	1(14)	7	0(0)	5	0(0)
3	ACRYLONITRILE	41	0(0)	40	0(0)	7	0(0)	7	1(14)

NOTES: ALL UNITS UG/L UNLESS OTHERWISE SPECIFIED
PRIORITY POLLUTANTS NOT LISTED WERE NOT DETECTED IN ANY SAMPLES

TABLE VI-2
SUMMARY
PERCENT OCCURENCES OF ORGANIC PRIORITY POLLUTANTS
PLANT B

5-30-79

PP	PARAMETER NAME	INFLUENT		FINAL EFFLUENT		COMBINED SLUDGE	
		SAMPLES ANALYZED	TIMES DETECTED (PERCENT)	SAMPLES ANALYZED	TIMES DETECTED (PERCENT)	SAMPLES ANALYZED	TIMES DETECTED (PERCENT)
67	BUTYL BENZYL PHTHALATE	6	6(100)	8	4(50)	7	0(0)
66	BIS(2-ETHYLHEXYL) PHTHALATE	6	6(100)	8	7(88)	7	7(100)
85	TETRACHLOROETHYLENE	42	41(98)	41	23(56)	7	6(86)
23	CHLOROFORM	42	40(95)	41	38(93)	7	0(0)
44	METHYLENE CHLORIDE	42	39(93)	41	39(95)	7	7(100)
70	DIETHYL PHTHALATE	6	5(83)	8	3(38)	7	0(0)
68	DI-N-BUTYL PHTHALATE	6	5(83)	8	5(63)	7	0(0)
25	1,2-DICHLOROBENZENE	6	5(83)	8	3(38)	7	0(0)
86	TOLUENE	42	32(76)	41	29(71)	7	6(86)
4	BENZENE	42	31(74)	41	10(24)	7	6(86)
69	DI-N-OCTYL PHTHALATE	6	4(67)	8	1(13)	7	0(0)
65	PHENOL	6	4(67)	8	7(88)	7	1(14)
55	NAPHTHALENE	6	4(67)	8	3(38)	7	3(43)
84	PYRENE	6	3(50)	8	0(0)	7	5(71)
81	PHENANTHRENE	6	3(50)	8	0(0)	7	5(71)
78	ANTHRACENE	6	3(50)	8	0(0)	7	5(71)
71	DIMETHYL PHTHALATE	6	3(50)	8	2(25)	7	0(0)
39	FLUORANTHENE	6	3(50)	8	0(0)	7	0(0)
38	ETHYLBENZENE	42	18(43)	41	2(5)	7	2(29)
29	1,1-DICHLOROETHYLENE	42	16(38)	41	14(34)	7	0(0)
87	TRICHLOROETHYLENE	42	14(33)	41	1(2)	7	0(0)
11	1,1,1-TRICHLOROETHANE	42	10(24)	41	1(2)	7	0(0)
64	PENTACHLOROPHENOL	6	1(17)	8	1(13)	7	0(0)
54	ISOPHORONE	6	1(17)	8	0(0)	7	0(0)
36	2,6-DINITROTOLUENE	6	1(17)	8	0(0)	7	0(0)
27	1,4-DICHLOROBENZENE	6	1(17)	8	0(0)	7	0(0)
26	1,3-DICHLOROBENZENE	6	1(17)	8	4(50)	7	0(0)
10	1,2-DICHLOROETHANE	42	5(12)	41	6(15)	7	0(0)
48	DICHLOROBROMOMETHANE	42	4(10)	41	11(27)	7	7(100)
51	CHLORODIBROMOMETHANE	42	3(7)	41	11(27)	7	2(29)
13	1,1-DICHLOROETHANE	42	2(5)	41	1(2)	7	0(0)
7	CHLOROBENZENE	42	2(5)	41	0(0)	7	0(0)
32	1,2-DICHLOROPROPANE	42	1(2)	41	0(0)	7	0(0)
77	ACENAPHTHYLENE	6	0(0)	8	2(25)	7	0(0)
76	CHRYSENE	6	0(0)	8	1(13)	7	2(29)
74	3,4-BENZOFUORANTHENE	6	0(0)	8	0(0)	7	5(71)
72	1,2-BENZANTHRACENE	6	0(0)	8	1(13)	7	2(29)
58	4-NITROPHENOL	6	0(0)	8	2(25)	7	0(0)
57	2-NITROPHENOL	6	0(0)	8	3(38)	7	0(0)
28	3,3'-DICHLOROBENZIDINE	6	0(0)	8	1(13)	7	0(0)
3	ACRYLONITRILE	42	0(0)	41	0(0)	7	1(14)

NOTES: ALL UNITS UG/L UNLESS OTHERWISE SPECIFIED
PRIORITY POLLUTANTS NOT LISTED WERE NOT DETECTED IN ANY SAMPLES

VII. ANALYSIS OF RESULTS

Fate of Priority Pollutants

Impact of Industrial Contribution on Influent Quality

As previously outlined, Plant A accepts a large proportion of its total flow from industrial sources, whereas Plant B treats practically no heavy industrial wastewater. Tables VII-1 and VII-2 summarize the individual influent data points for these two plants. An examination of the two tables shows a significantly higher incidence of priority pollutants in Plant A as compared to Plant B. In total, 52 organic priority pollutants were found in the Plant A influent, while in the Plant B raw wastewater only 33 were detected. Similarly at Plant A, 18 organic priority pollutants were measured at above the detection limit, but at Plant B only five were found at above detectable levels. It was also found that Plant A influent contained 21 organic priority pollutants which were absent in the Plant B influent; only two organic priority pollutants were found exclusively in the Plant B raw wastewater. Twenty organics found in both raw wastewaters had higher average concentrations in the Plant A influent, but only six organic priority pollutants common to both raw wastewater streams were more concentrated in the Plant B influent. It is also interesting to note that 13 of the 20 organics found at higher average concentrations in the predominantly industrial Plant A influent are solvents.

Nine metallic priority pollutants were detected in the influents to both plants. Seven of these were found to have higher average concentrations in both influents; only zinc was measured at a higher level in Plant B, as compared to Plant A influent. It should be noted that the traditional (conventional and non-conventional) pollutant parameters (BOD, COD, TSS, residue, etc.) were also consistently higher in the Plant A raw wastewater, as compared to the Plant B influent.

Removal of Priority Pollutants

Tables VII-3 and VII-4 depict percent removals for conventional, non-conventional and priority pollutants at Plants A and B. During the week of sampling, Plant A achieved good removals of conventional pollutants. BOD was reduced from an average influent concentration of 201 mg/l to 13 mg/l (94 percent) and TSS from 140 mg/l to 20 mg/l (86 percent). Priority pollutant metals that were present in detectable amounts were also removed reasonably well. Antimony, arsenic, beryllium, selenium and thallium were never found above their detection limits in influent or effluent samples and percent removals could not be calculated. Chromium and copper both were reduced to less than 50 µg/l (90 and 86 percent removal, respectively). Cadmium, nickel, and zinc were removed somewhat less effectively (59 to 65 percent each, on an average). Lead and silver were both reduced to below their detection limits, accounting for the wide range shown in VII-3 for their percent removals. Nine organic priority pollutants were detected in Plant A's influent at an average of over 10 µg/l. Eight of the nine (benzene; 1,1,1-trichloroethylene; chloroform; ethylbenzene; bis(2-ethylhexyl)

TABLE VII-1
PERCENT OCCURRENCES FOR PRIORITY POLLUTANTS
PLANT A
SAMPLE POINT: INFLUENT
5/30/79

PP	PARAMETER	NUMBER OF		AVERAGE	MEDIAN	MINIMUM	MAXIMUM
		SAMPLES ANALYZED	TIMES DETECTED (PERCENT)				
1	ACENAPHTHENE	28	2(7)	0(0)	0-	1	N-D LT 10
4	BENZENE	82	81(99)	45(55)	288-	292	N-D 5600
6	CARBON TETRACHLORIDE	82	6(7)	1(1)	0-	1	N-D 39
7	CHLOROBENZENE	82	9(11)	0(0)	0-	1	N-D LT 10
8	1,2,4-TRICHLOROBENZENE	28	1(4)	0(0)	0-	1	N-D LT 10
9	HEXACHLOROBENZENE	28	1(4)	0(0)	0-	1	N-D LT 10
10	1,2-DICHLOROETHANE	82	1(1)	0(0)	0-	1	N-D LT 10
11	1,1,1-TRICHLOROETHANE	82	71(87)	45(55)	15-	18	N-D 220
13	1,1-DICHLOROETHANE	82	19(23)	0(0)	1-	2	N-D LT 10
14	1,1,2-TRICHLOROETHANE	82	3(4)	1(1)	LT	3	N-D 270
21	2,4,6-TRICHLOROPHENOL	28	1(4)	0(0)	0-	1	N-D LT 10
22	PARACHLOROMETA CRESOL	28	1(4)	0(0)	0-	1	N-D LT 10
23	CHLOROFORM	82	79(96)	67(82)	43-	44	N-D 440
25	1,2-DICHLOROBENZENE	28	15(54)	0(0)	1-	5	LT N-D LT 10
26	1,3-DICHLOROBENZENE	28	6(21)	0(0)	1-	2	N-D LT 10
27	1,4-DICHLOROBENZENE	28	14(50)	0(0)	1-	5	LT N-D LT 10
29	1,1-DICHLOROETHYLENE	82	60(73)	5(6)	1-	7	LT N-D 15
30	1,2-TRANS-DICHLOROETHYLENE	82	49(84)	18(22)	4-	11	LT N-D 64
32	1,2-DICHLOROPROPANE	82	2(2)	0(0)	0-	1	N-D LT 10
38	ETHYLBENZENE	82	75(91)	28(34)	21-	27	LT N-D 890
39	FLUORANTHENE	28	8(29)	0(0)	1-	2	N-D LT 10
43	BIS(2-CHLOROETHOXY) METHANE	28	2(7)	0(0)	0-	1	N-D LT 10
44	METHYLENE CHLORIDE	82	82(100)	20(24)	8-	16	LT N-D 100
45	CHLOROMETHANE	82	2(2)	0(0)	0-	1	N-D LT 10
47	BROMOFORM	82	1(1)	0(0)	0-	1	N-D LT 10
48	DICHLOROBROMOMETHANE	82	1(1)	0(0)	0-	1	N-D LT 10
49	TRICHLOROFLUOROMETHANE	82	2(2)	0(0)	0-	1	N-D LT 10
51	CHLORODIBROMOMETHANE	82	1(1)	0(0)	0-	1	N-D LT 10
52	HEXACHLOROBUTADIENE	28	1(4)	0(0)	0-	1	N-D LT 10
55	NAPHTHALENE	28	23(82)	1(4)	1-	8	LT N-D 13
64	PENTACHLOROPHENOL	28	7(25)	0(0)	1-	2	N-D LT 10
65	PHENOL	28	27(96)	9(32)	13-	19	LT N-D 200
66	BIS(2-ETHYLHEXYL) PHTHALATE	28	26(93)	14(50)	25-	29	5 N-D 250
67	BUTYL BENZYL PHTHALATE	28	11(39)	1(4)	1-	4	N-D 12
68	DI-N-BUTYL PHTHALATE	28	19(68)	1(4)	1-	8	LT N-D 44
69	DI-N-OCTYL PHTHALATE	28	1(4)	0(0)	0-	1	N-D LT 10
70	DIETHYL PHTHALATE	28	17(61)	0(0)	1-	6	LT N-D LT 10
71	DIMETHYL PHTHALATE	28	11(39)	0(0)	1-	3	N-D LT 10
72	1,2-BENZANTHRACENE	28	5(18)	0(0)	0-	1	N-D LT 10
73	BENZO (A)PYRENE	28	1(4)	0(0)	0-	1	N-D LT 10
74	CHRYSENE	28	5(18)	0(0)	0-	1	N-D LT 10
77	ACENAPHTHYLENE	28	1(4)	0(0)	0-	1	N-D LT 10
78	ANTHRACENE	28	21(75)	0(0)	1-	7	LT N-D LT 10
79	1,12-BENZOPERYLENE	28	1(4)	0(0)	0-	1	N-D LT 10
80	FLUORENE	28	8(29)	0(0)	1-	2	N-D LT 10
81	PHENANTHRENE	28	21(75)	0(0)	1-	7	LT N-D LT 10
82	1,2,5,6-DIBENZANTHRACENE	28	2(7)	0(0)	0-	1	N-D LT 10
83	INDENO(1,2,3-C,D) PYRENE	28	2(7)	0(0)	0-	1	N-D LT 10
84	PYRENE	28	10(36)	1(4)	3-	6	N-D 84
85	TETRACHLOROETHYLENE	82	81(99)	58(71)	47-	50	16 N-D 1500
86	TOLUENE	82	81(99)	56(68)	35-	38	13 N-D 440
87	TRICHLOROETHYLENE	82	81(99)	49(60)	28-	32	11 N-D 440
114	ANTIMONY	23	0(0)	0(0)	1-	50	LT 50
115	ARSENIC	23	0(0)	0(0)	1-	50	LT 50
117	BERYLLIUM	23	0(0)	0(0)	1-	2	LT 2
118	CADMIUM	23	21(91)	0(0)	LT	12	9 39
119	CHROMIUM	23	23(100)	0(0)	450	372	63 1360
120	COPPER	23	23(100)	0(0)	191	154	35 864
121	CYANIDE	84	57(68)	0(0)	124-	128	24 LT 1280
122	LEAD	23	16(70)	0(0)	55-	61	41 LT 216
123	MERCURY	23	15(65)	0(0)	0.0-	0.3	LT 0.2 0.8
124	NICKEL	23	22(96)	0(0)	LT	98	66 LT 347
125	SELENIUM	23	0(0)	0(0)	1-	50	LT 50
126	SILVER	23	18(78)	0(0)	LT	8	9 LT 18
127	THALLIUM	23	0(0)	0(0)	1-	50	LT 50

NOTES: 1) ALL UNITS IN UG/L UNLESS OTHERWISE NOTED
2) METALS AND CLASSICAL POLLUTANTS ARE NEVER REPORTED AS NOT DETECTED
3) POLLUTANTS NOT DETECTED ARE NOT LISTED
4) PP - PRIORITY POLLUTANT NUMBER
N-D - NOT DETECTED
LT - LESS THAN

TABLE VII-1
PERCENT OCCURRENCES FOR PRIORITY POLLUTANTS
PLANT A
SAMPLE POINT: INFLUENT
5/30/79

PP	PARAMETER	-----NUMBER OF-----		AVERAGE	MEDIAN	MINIMUM	MAXIMUM
		SAMPLES ANALYZED	TIMES DETECTED (PERCENT)				
128	ZINC	23	23(100)	264	258	23	503
	BOD(MG-L)	27	27(100)	215	180	82	450
	COD(MG-L)	26	26(100)	431	435	180	630
	TOD(MG-L)	27	27(100)	205	240	39	340
	OIL & GREASE(MG-L)	78	78(100)	49	40	18	340
	TOTAL PHENOLS	83	82(99)	LT	48	LT	5200
	TOTAL SOLIDS(MG-L)	27	27(100)	939	970	670	1300
	TOTAL SUSP. SOLIDS(MG-L)	27	27(100)	175	130	77	560
	TOTAL VOLATILE SOLIDS(MG-L)	27	27(100)	252	260	130	540
	TOTAL VOL. SUS. SOLIDS(MG-L)	27	27(100)	113	89	56	300
	AMMONIA NITROGEN	27	27(100)	7230	6500	3600	18000
	ALUMINUM	23	23(100)	1460	1400	248	2420
	BARIUM	23	23(100)	129	131	66	203
	IRON	23	23(100)	2990	1770	404	26000
	MANGANESE	23	23(100)	104	107	56	154
	CALCIUM(MG-L)	23	23(100)	83	87	53	102
	MAGNESIUM(MG-L)	23	23(100)	27	29	17	33

NOTES: 1) ALL UNITS IN UG/L UNLESS OTHERWISE NOTED
2) METALS AND CLASSICAL POLLUTANTS ARE NEVER REPORTED AS NOT DETECTED
3) POLLUTANTS NOT DETECTED ARE NOT LISTED
4) PP - PRIORITY POLLUTANT NUMBER
N-D - NOT DETECTED
LT - LESS THAN

phthalate; tetrachloroethylene; toluene, and trichloroethylene) were reduced by a minimum of 50 percent. Only phenol was not effectively removed. Carbon tetrachloride and 1,1,2-trichloroethane were each measured at an average concentration of several micrograms per liter ($\mu\text{g/l}$) in the influent, and were not detected in any effluent samples, resulting in a computed 100 percent removal.

During the week of sampling, Plant B achieved moderate removals of BOD and TSS (74 percent and 80 percent, respectively). The influent values for these parameters (95 and 97 mg/l) were approximately half those of Plant A. Metals at Plant B occurred at relatively low levels. Antimony, arsenic, beryllium, selenium and thallium were not measured above their detection limit in either influent or effluent samples. Cadmium and silver were both reduced from several $\mu\text{g/l}$ to below their detection limits. Cadmium, copper and zinc were reduced effectively, between 69 and 81 percent. Lead and nickel were removed less effectively. Organic priority pollutants at Plant B occurred at such low average concentrations that percent removal data were not meaningful.

Concentrations of Priority Pollutants in Sludge

The concentrations of conventional and priority pollutants in primary and secondary sludge and floatables for Plant A are also indicated on Table VII-3. Most of the metals occurred in high concentrations in both the primary and secondary sludge. Cadmium, copper, lead, nickel and zinc were each found in primary sludge at concentrations over 100 times greater than their concentration in the influent. Antimony, arsenic, and beryllium, which were never measured above their detection limit in the influent, were all measured in the primary sludge. Chromium and cyanide were found in the primary sludge at 30 to 50 times their influent concentration. Chromium had a higher than expected concentration in the secondary sludge.

TABLE VII-2
PERCENT OCCURENCES OF PRIORITY POLLUTANTS
PLANT B SAMPLE POINT: INFLUENT

5/30/79

PP	PARAMETER	NUMBER OF		AVERAGE	MEDIAN	MINIMUM	MAXIMUM
		SAMPLES ANALYZED	TIMES DETECTED (PERCENT)				
4	BENZENE	42	31(74)	7- 14	LT 10	N-D	260
7	CHLOROBENZENE	42	2(5)	0- 1	N-D	N-D	10
10	1,2-DICHLOROETHANE	42	5(12)	0- 1	N-D	N-D	13
11	1,1,1-TRICHLOROETHANE	42	10(24)	1- 2	N-D	N-D	10
13	1,1-DICHLOROETHANE	42	2(5)	0- 1	N-D	N-D	10
23	CHLOROFORM	42	40(95)	1- 9	LT 10	N-D	10
25	1,2-DICHLOROBENZENE	6	5(83)	1- 8	LT 10	N-D	10
26	1,3-DICHLOROBENZENE	6	1(17)	0- 1	N-D	N-D	10
27	1,4-DICHLOROBENZENE	6	1(17)	0- 1	N-D	N-D	10
29	1,1-DICHLOROETHYLENE	42	16(38)	1- 3	N-D	N-D	10
32	1,2-DICHLOROPROPANE	42	1(2)	0- 1	N-D	N-D	10
34	2,6-DINITROTOLUENE	6	1(17)	0- 1	N-D	N-D	10
38	ETHYLBENZENE	42	18(43)	1- 4	N-D	N-D	10
39	FLUORANTHENE	6	3(50)	1- 5	LT 5	N-D	10
44	METHYLENE CHLORIDE	42	39(93)	5(12)	LT 10	N-D	180
48	DICHLOROBROMOMETHANE	42	4(10)	0- 1	N-D	N-D	10
51	CHLORODIBROMOMETHANE	42	3(7)	0- 1	N-D	N-D	10
54	ISOPHORONE	6	1(17)	0- 1	N-D	N-D	10
55	NAPHTHALENE	6	4(67)	1- 6	LT 10	N-D	10
64	PENTACHLOROPHENOL	6	1(17)	0- 1	N-D	N-D	10
65	PHENOL	6	4(67)	1- 6	LT 10	N-D	10
66	BIS(2-ETHYLHEXYL) PHTHALATE	6	6(100)	3(50)	8- 14	1	19
67	BUTYL BENZYL PHTHALATE	6	6(100)	0(0)	1- 10	LT 10	10
68	DI-N-BUTYL PHTHALATE	6	5(83)	0(0)	1- 8	LT 10	10
69	DI-N-OCTYL PHTHALATE	6	4(67)	0(0)	1- 6	LT 10	10
70	DIETHYL PHTHALATE	6	5(83)	0(0)	1- 8	LT 10	10
71	DIETHYL PHTHALATE	6	3(50)	0(0)	1- 5	LT 5	10
78	ANTHRACENE	6	3(50)	0(0)	1- 5	LT 5	10
81	PHENANTHRENE	6	3(50)	0(0)	1- 5	LT 5	10
84	PYRENE	6	3(50)	0(0)	1- 5	LT 5	10
85	TETRACHLOROETHYLENE	42	41(98)	0(0)	1- 9	LT 10	10
86	TOLUENE	42	32(76)	1(2)	1- 8	LT 10	37
87	TRICHLOROETHYLENE	42	14(33)	0(0)	1- 3	N-D	10
114	ANTIMONY	7	0(0)	1- 50	LT 50	LT 50	50
115	ARSENIC	7	0(0)	1- 50	LT 50	LT 50	50
117	BERYLLIUM	7	0(0)	1- 2	LT 2	LT 2	2
118	CADMIUM	7	6(86)	LT 4	4	LT 2	9
119	CHROMIUM	7	7(100)	71	67	12	131
120	COPPER	7	7(100)	54	55	39	72
121	CYANIDE	41	34(83)	77- 78	66	LT 10	240
122	LEAD	7	2(29)	16- 30	LT 20	LT 20	79
123	MERCURY	7	5(71)	0.0- 0.3	0.2	LT 0.2	0.4
124	NICKEL	7	7(100)	30	31	11	48
125	SELENIUM	7	0(0)	1- 50	LT 50	LT 50	50
126	SILVER	7	2(29)	1- 2	LT 2	LT 2	6
127	THALLIUM	7	0(0)	1- 50	LT 50	LT 50	50
128	ZINC	7	7(100)	278	302	111	439
	BOD(MG-L)	7	7(100)	95	96	73	130
	COD(MG-L)	7	7(100)	183	180	150	230
	TOC(MG-L)	7	7(100)	70	69	61	82
	OIL & GREASE(MG-L)	40	40(100)	24	26	5	48
	TOTAL PHENOLS	42	40(95)	LT 20	12	LT 1	160
	TOTAL SOLIDS(MG-L)	7	7(100)	619	610	510	750
	TOTAL SUSP. SOLIDS(MG-L)	7	7(100)	97	87	55	220
	TOTAL VOLATILE SOLIDS(MG-L)	7	7(100)	143	140	88	200
	TOTAL VOL. SUS. SOLIDS(MG-L)	7	7(100)	54	42	27	120
	AMMONIA NITROGEN	7	7(100)	11700	11000	9000	17000
	ALUMINUM	7	7(100)	537	452	262	1410
	BARIUM	7	7(100)	74	75	57	93
	IRON	7	7(100)	1640	1370	1100	3610
	MANGANESE	7	7(100)	280	271	255	334
	CALCIUM(MG-L)	7	7(100)	69	68	67	75
	MAGNESIUM(MG-L)	7	7(100)	15	14	14	16

NOTES: 1) ALL UNITS IN UG/L UNLESS OTHERWISE NOTED
2) METALS AND CLASSICAL POLLUTANTS ARE NEVER REPORTED AS NOT DETECTED
3) POLLUTANTS NOT DETECTED ARE NOT LISTED
4) PP - PRIORITY POLLUTANT NUMBER
N-D - NOT DETECTED
LT - LESS THAN

TABLE VII-3
PLANT A
DATA SUMMARY-WEEK 1 AVERAGE

05/30/79

DATE	PP	PARAMETER	INFLUENT	EFFLUENT PRE CL-	FINAL EFFLUENT	PERCENT REMOVAL	PRIMARY SLUDGE	SECONDARY SLUDGE	COMBINED SLUDGE	FLOTA- BLES
JULY 78	1	ACENAPHTHENE	0-	1	N-D		169	N-D	75	189
JULY 78	3	ACRYLONITRILE	N-D		N-D		N-D	3	NOT RUN	2
JULY 78	4	BENZENE	5-	13	L	1	0-	5	171	10
JULY 78	6	CARBON TETRACHLORIDE	1-	2	N-D		11	6	NOT RUN	42
JULY 78	7	CHLORO BENZENE	0-	2	N-D	100	N-D	N-D	NOT RUN	7
JULY 78	8	1,2,4-TRICHLORO BENZENE	N-D		N-D		N-D	N-D	NOT RUN	N-D
JULY 78	9	HEXACHLORO BENZENE	N-D		N-D		N-D	N-D	N-D	N-D
JULY 78	10	1,2-DICHLOROETHANE	N-D		N-D		N-D	N-D	NOT RUN	N-D
JULY 78	11	1,1,1-TRICHLOROETHANE	17-	20	L	10	0-	7	59-100	24
JULY 78	13	1,1-DICHLOROETHANE	0-	2	N-D		11	N-D	NOT RUN	2
JULY 78	14	1,1,2-TRICHLOROETHANE	7		N-D	100	N-D	N-D	NOT RUN	N-D
JULY 78	21	2,4,6-TRICHLOROPHENOL	N-D		N-D		N-D	N-D	NOT RUN	N-D
JULY 78	22	PARACHLOROMETA CRESOL	N-D		N-D		N-D	N-D	N-D	N-D
JULY 78	23	CHLOROFORM	49-	50	L	28	15-	21	57- 70	N-D
JULY 78	24	2-CHLOROPHENOL	N-D		N-D		0-	1		N-D
JULY 78	25	1,2-DICHLORO BENZENE	0-	4	N-D		0-	1		N-D
JULY 78	26	1,3-DICHLORO BENZENE	0-	2	N-D		0-	1		N-D
JULY 78	27	1,4-DICHLORO BENZENE	0-	4	N-D		0-	3		N-D
JULY 78	28	3,3'-DICHLOROBENZIDINE	N-D		N-D		0-	1		N-D
JULY 78	29	1,1-DICHLOROETHYLENE	1-	8	L	5	0-	7		N-D
JULY 78	30	1,2-TRANS-DICHLOROETHYLENE	0-	8	N-D		0-	2		N-D
JULY 78	32	1,2-DICHLOROPROPANE	N-D		N-D		N-D	N-D	NOT RUN	4
JULY 78	34	2,4-DIMETHYLPHENOL	N-D		N-D		N-D	N-D	NOT RUN	N-D
JULY 78	38	ETHYLBENZENE	30-	36	L	10	0-	1		N-D
JULY 78	39	FLUORANTHENE	0-	3	N-D		0-	7	77- 99	276
JULY 78	43	BIS(2-CHLOROETHOXY) METHANE	0-	1	N-D		N-D	N-D	NOT RUN	51
JULY 78	44	METHYLENE CHLORIDE	6-	14	L	10	1-	10	0- 91	222
JULY 78	45	CHLOROMETHANE	N-D		N-D		N-D	N-D	NOT RUN	249
JULY 78	48	DICHLOROBROMOMETHANE	N-D		N-D		0-	2		N-D
JULY 78	49	TRICHLOROFLUOROMETHANE	N-D		N-D		0-	1		N-D
JULY 78	51	CHLORODIBROMOMETHANE	N-D		N-D		N-D	N-D	NOT RUN	N-D
JULY 78	52	HEXACHLOROBUTADIENE	N-D		N-D		17	29	NOT RUN	25
JULY 78	55	NAPHTHALENE	1-	8	N-D		0-	4		N-D
JULY 78	64	PENTACHLOROPHENOL	0-	3	L	7	0-	1		N-D
JULY 78	65	PHENOL	13-	19	L	10	18-	23	0- 5	93
JULY 78	66	BIS(2-ETHYLHEXYL) PHTHALATE	32-	36	L	19	11-	16	50- 69	94
JULY 78	67	BUTYL BENZYL PHTHALATE	1-	4	N-D		0-	4		2230
JULY 78	68	DI-N-BUTYL PHTHALATE	2-	9	L	3	0-	6		42
JULY 78	69	DI-N-OCTYL PHTHALATE	N-D		N-D		0-	1		1240
JULY 78	70	DIETHYL PHTHALATE	0-	6	N-D		0-	3		N-D
JULY 78	71	DIMETHYL PHTHALATE	0-	4	N-D		0-	1		N-D
JULY 78	72	1,2-BENZANTHRACENE	0-	1	N-D		0-	1		N-D
JULY 78	74	3,4-BENZOFUORANTHENE	N-D		N-D		N-D	N-D		479
JULY 78	76	CHRYSENE	0-	1	N-D		0-	1		675
JULY 78	77	ACENAPHTHYLENE	N-D		N-D		0-	1		479
JULY 78	78	ANTHRACENE	0-	7	N-D		N-D	N-D		N-D
JULY 78	79	1,12-BENZOPERYLENE	N-D		N-D		0-	4		1570
JULY 78	80	FLUORENE	0-	3	N-D		0-	1		N-D
JULY 78	81	PHENANTHRENE	0-	7	N-D		0-	4		313
JULY 78	82	1,2,5,6-DIBENZANTHRACENE	N-D		N-D		0-	1		N-D
JULY 78	83	INDENO(1,2,3-C,D) PYRENE	N-D		N-D		0-	1		N-D
JULY 78	84	PYRENE	0-	3	N-D		0-	6		757
JULY 78	85	TETRACHLOROETHYLENE	53-	57	L	10	1-	9	83- 98	293
JULY 78	86	TOLUENE	18-	23	L	10	0-	9	51-100	284
JULY 78	87	TRICHLOROETHYLENE	24-	29	L	9	0-	9	65-100	284
JULY 78	114	ANTIMONY	0-	50	L	50	0-	50		146
JULY 78	115	ARSENIC	0-	50	L	50	0-	50		1260
JULY 78	117	BERYLLIUM	0-	2	L	2	0-	2		37
JULY 78	118	CADMIUM	12		L	4	4-	5	60- 65	1220
JULY 78	119	CHROMIUM	443			42	46		90	14600
JULY 78	120	COPPER	194			13	27		86	77400
JULY 78	121	CYANIDE	13-	18	NOT RUN		3-	11	15- 83	626
JULY 78	122	LEAD	48-	56	L	20	0-	20	58-100	46900
JULY 78	123	MERCURY	0.3		L	0.4	0.4		24	3.1
JULY 78	124	NICKEL	98		L	50	40		59	13300
JULY 78	125	SELENIUM	0-	50	L	50	0-	50		10
JULY 78	126	SILVER	8		L	2	0-	2	74-100	25
JULY 78	127	THALLIUM	0-	50	L	50	0-	50		182
JULY 78	128	ZINC	252			42	90		64	153000
JULY 78		BOD(MG-L)	201			22	13		94	20200
JULY 78		COD(MG-L)	416			69	68		84	57500
JULY 78		TOC(MG-L)	255			55	65		75	23500
JULY 78		OIL & GREASE(MG-L)	53		NOT RUN		4-	6	89- 92	9070
JULY 78		TOTAL PHENOLS	178		NOT RUN		13-	14	92- 93	672
JULY 78		TOTAL SOLIDS(MG-L)	931			835	834		10	56700
JULY 78		TOTAL SUSP. SOLIDS(MG-L)	140			10	20		86	46700
JULY 78		TOTAL VOLATILE SOLIDS(MG-L)	232			130	262			26800
JULY 78		TOTAL VOL. SUS. SOLIDS(MG-L)	105			8	14			3290
JULY 78		AMMONIA NITROGEN	4170			5450	4920		87	23300
JULY 78		ALUMINUM	1360			128	203		20	58500
JULY 78		BARIUM	127			42	50		61	NOT RUN
JULY 78		IRON	3210			256	392		88	NOT RUN
JULY 78		MANGANESE	100			120	111			NOT RUN
JULY 78		CALCIUM(MG-L)	82			86	79		3	NOT RUN
JULY 78		MAGNESIUM(MG-L)	26			30	27			NOT RUN

ALL UNITS UG/L UNLESS OTHERWISE NOTED. PP- PRIORITY POLLUTANT NUMBER. N-D NOT DETECTED; L-LESS THAN
PRIORITY POLLUTANTS NOT LISTED WERE NOT DETECTED IN ANY SAMPLES
NOT RUN INDICATES THAT NO SAMPLE WAS COLLECTED OR ANALYTICAL RESULTS HAVE NOT BEEN RECEIVED

TABLE VII-4
PLANT B
DATA SUMMARY

05/30/79

DATE	PP	PARAMETER	INFLUENT	EFFLUENT PRE CL-	FINAL EFFLUENT	PERCENT REMOVAL	SECONDARY SLUDGE	COMBINED SLUDGE	TAP WATER	DAF BLANKET
AUG. 78	3	ACRYLONITRILE	N-D	N-D	N-D	N-D	N-D	41	N-D	N-D
AUG. 78	4	BENZENE	7- 14	L 1	L 4	44- 84	L 5	33	N-D	10
AUG. 78	10	1,2-DICHLOROETHANE	0- 1	L 2	L 2		N-D	N-D	N-D	N-D
AUG. 78	11	1,1,1-TRICHLOROETHANE	0- 2	L 1	L 0.5		N-D	N-D	N-D	N-D
AUG. 78	23	CHLOROFORM	0- 10	L 10	L 10	0- 91	N-D	N-D	N-D	N-D
AUG. 78	25	1,2-DICHLOROBENZENE	0- 8	L 1	L 4		NOT RUN	N-D	L 10	NOT RUN
AUG. 78	26	1,3-DICHLOROBENZENE	0- 2	L 3	L 5		NOT RUN	N-D	N-D	NOT RUN
AUG. 78	27	1,4-DICHLOROBENZENE	0- 2	N-D	N-D		NOT RUN	N-D	N-D	NOT RUN
AUG. 78	28	3,3'-DICHLOROBENZIDINE	N-D	N-D	L 1		NOT RUN	N-D	N-D	NOT RUN
AUG. 78	29	1,1-DICHLOROETHYLENE	0- 4	L 2	L 3		N-D	N-D	N-D	N-D
AUG. 78	30	1,2-TRANS-DICHLOROETHYLENE	N-D	L 0.5	N-D	N-D	N-D	N-D	N-D	N-B
AUG. 78	36	2,6-DINITROTOLUENE	0- 2	N-D	N-D		NOT RUN	N-D	N-D	NOT RUN
AUG. 78	38	ETHYLBENZENE	0- 4	L 0.5	L 1		NOT RUN	N-D	N-D	NOT RUN
AUG. 78	39	FLUORANTHENE	0- 5	N-D	N-D		NOT RUN	N-D	N-D	NOT RUN
AUG. 78	44	METHYLENE CHLORIDE	6- 14	L 9	L 10		180	247	30	250
AUG. 78	47	BROMOFORM	N-D	N-D	N-D	N-D	N-D	N-D	L 10	N-D
AUG. 78	48	DICHLOROBROMOMETHANE	0- 1	L 2	L 3		35	74	N-D	35
AUG. 78	51	CHLORODIBROMOMETHANE	0- 1	L 2	L 3		N-D	9	20	N-D
AUG. 78	54	ISOPHORONE	0- 2	N-D	N-D		NOT RUN	N-D	N-D	NOT RUN
AUG. 78	55	NAPHTHALENE	0- 7	L 1	L 4		NOT RUN	91	N-D	NOT RUN
AUG. 78	57	2-NITROPHENOL	N-D	L 8	L 4		NOT RUN	N-D	N-D	NOT RUN
AUG. 78	58	4-NITROPHENOL	N-D	L 34	L 14		NOT RUN	N-D	N-D	NOT RUN
AUG. 78	64	PENTACHLOROPHENOL	0- 2	L 4	L 1		NOT RUN	N-D	N-D	NOT RUN
AUG. 78	65	PHENOL	0- 7	L 9	L 9		NOT RUN	4	L 10	NOT RUN
AUG. 78	66	BIS(2-ETHYLHEXYL) PHTHALATE	9- 14	L 11	L 9		NOT RUN	1490	L 10	NOT RUN
AUG. 78	67	BUTYL BENZYL PHTHALATE	0- 10	L 3	L 5		NOT RUN	N-D	L 10	NOT RUN
AUG. 78	68	DI-N-BUTYL PHTHALATE	0- 8	L 6	L 6		NOT RUN	N-D	L 10	NOT RUN
AUG. 78	69	DI-N-OCTYL PHTHALATE	0- 7	L 1	L 1		NOT RUN	N-D	N-D	NOT RUN
AUG. 78	70	DIETHYL PHTHALATE	0- 8	L 3	L 4		NOT RUN	N-D	L 10	NOT RUN
AUG. 78	71	DIMETHYL PHTHALATE	0- 5	L 1	L 3		NOT RUN	N-D	N-D	NOT RUN
AUG. 78	72	1,2-BENZANTHRACENE	N-D	N-D	L 1		NOT RUN	8	N-D	NOT RUN
AUG. 78	74	3,4-BENZOFUORANTHENE	N-D	N-D	N-D		NOT RUN	43	N-D	NOT RUN
AUG. 78	76	CHRYSENE	N-D	N-D	L 1		NOT RUN	8	N-D	NOT RUN
AUG. 78	77	ACENAPHTHYLENE	N-D	L 1	L 3		NOT RUN	N-D	N-D	NOT RUN
AUG. 78	78	ANTHRACENE	0- 5	N-D	N-D		NOT RUN	91	N-D	NOT RUN
AUG. 78	81	PHENANTHRENE	0- 5	N-D	N-D		NOT RUN	45	N-D	NOT RUN
AUG. 78	84	PYRENE	0- 5	N-D	N-D		NOT RUN	61	N-D	15
AUG. 78	85	TETRACHLOROETHYLENE	0- 10	L 5	L 6		N-D	336	L 10	230
AUG. 78	86	TOLUENE	1- 8	L 5	L 7		N-D	N-D	N-D	N-D
AUG. 78	87	TRICHLOROETHYLENE	0- 3	L 0.5	L 0.5		NOT RUN	39	L 50	NOT RUN
AUG. 78	114	ANTHONY	0- 50	L 50	L 50		NOT RUN	149	L 50	NOT RUN
AUG. 78	115	ARSENIC	0- 50	L 50	L 50		NOT RUN	12.0	L 2.0	-888.0
AUG. 78	117	BERYLLIUM	L 2.0	L 2.0	L 2.0	55-100	NOT RUN	305	L 2	NOT RUN
AUG. 78	118	CADMIUM	4- 5	L 2	L 2		NOT RUN	8110	L 5	NOT RUN
AUG. 78	119	CHROMIUM	71	26	22	69	NOT RUN	10700	L 6	NOT RUN
AUG. 78	120	COPPER	54	11	10	81	NOT RUN	1690	L 10	2870
AUG. 78	121	CYANIDE	77- 30	NOT RUN	L 141		NOT RUN	7390	L 20	NOT RUN
AUG. 78	122	LEAD	16- 30	L 23	L 20		NOT RUN	5.1	L 0.2	NOT RUN
AUG. 78	123	MERCURY	L 0.3	L 0.2	L 0.2	5-100	NOT RUN	3100	L 10	NOT RUN
AUG. 78	124	NICKEL	30	21	20	33	NOT RUN	28	L 50	NOT RUN
AUG. 78	125	SELENIUM	0- 50	L 50	L 50		NOT RUN	79	L 2	NOT RUN
AUG. 78	126	SILVER	1- 3	L 7	L 2	0- 84	NOT RUN	2	L 50	NOT RUN
AUG. 78	127	THALLIUM	0- 50	L 50	L 50		NOT RUN	26700	L 7	NOT RUN
AUG. 78	128	ZINC	278	83	52	81	NOT RUN	8460	L 10	NOT RUN
AUG. 78		BOD(MG-L)	95	20	57	69	NOT RUN	32400	L 1	NOT RUN
AUG. 78		COD(MG-L)	183	52	57	69	NOT RUN	11900	22	NOT RUN
AUG. 78		TOC(MG-L)	70	29	33	53	NOT RUN	3510	7	11000
AUG. 78		OIL & GREASE(MG-L)	24	NOT RUN	L 8	66- 67	L 250	464	6	2800
AUG. 78		TOTAL PHENOLS	20	NOT RUN	L 4	81- 84	NOT RUN	25600	300	NOT RUN
AUG. 78		TOTAL SOLIDS(MG-L)	619	496	564	9	NOT RUN	21700	3	NOT RUN
AUG. 78		TOTAL SUSP. SOLIDS(MG-L)	97	12	19	80	NOT RUN	14300	85	NOT RUN
AUG. 78		TOTAL VOLATILE SOLIDS(MG-L)	143	129	136	5	NOT RUN	12100	2	NOT RUN
AUG. 78		TOTAL VOL. SUS. SOLIDS(MG-L)	54	7	12	78	NOT RUN	76900	74000	NOT RUN
AUG. 78		AMMONIA NITROGEN	11700	1830	3300	72	NOT RUN	108	NOT RUN	NOT RUN
AUG. 78		ALUMINUM	537	74	L 54	90- 91	NOT RUN	40	NOT RUN	NOT RUN
AUG. 78		BARIUM	74	26	25	66	NOT RUN	108	NOT RUN	NOT RUN
AUG. 78		IRON	1640	198	188	89	NOT RUN	5	NOT RUN	NOT RUN
AUG. 78		MANGANESE	280	194	186	34	NOT RUN	40	NOT RUN	NOT RUN
AUG. 78		CALCIUM(MG-L)	69	64	65	6	NOT RUN	9	NOT RUN	NOT RUN
AUG. 78		MAGNESIUM(MG-L)	15	14	14	7	NOT RUN			

ALL UNITS UG/L UNLESS OTHERWISE NOTED: PP-PRIORITY POLLUTANT NUMBER: N-D NOT DETECTED: L- LESS THAN
NOT RUN INDICATES SAMPLES WERE NOT COLLECTED OR DATA HAS NOT BEEN RECEIVED
PRIORITY POLLUTANTS NOT LISTED WERE NOT DETECTED IN ANY SAMPLES

Several organic priority pollutants that were detected at very low concentrations in the influent accumulated in the primary or secondary sludge. Among them were acenaphthene (0 to 1 $\mu\text{g}/\text{l}$ average in the influent and 169 $\mu\text{g}/\text{l}$ in the primary sludge); 1,2-benzanthracene (less than 1 and 479); 3,4-benzofluoranthene (not detected and 675); fluorene (less than 3 and 313); and pyrene (less than 3 and 757).

Data from Plant B indicated the same general trends (Table VII-4). Chromium, copper, lead, nickel and zinc were found in the combined sludge at approximately 100 times their concentration in the influent. Arsenic, cadmium, cyanide, mercury and silver also accumulated in the sludge, but occurred at overall lower levels. Antimony, beryllium, selenium and thallium, which were never measured above their detection limits in the influent, were all found at concentrations below 50 $\mu\text{g}/\text{l}$ in the sludge. Consequently, no conclusions regarding build-up of these metals in the sludge can be developed.

Several organic priority pollutants present at very low levels in influent also were concentrated in the sludge. They included acrylonitrile (not detected in the influent and 41 $\mu\text{g}/\text{l}$ in the combined sludge); dichlorobromomethane (0 to 1 and 74); and 3,4-benzofluoranthene (not detected and 43).

Mass Balances

Additional information correlating the influent and sludge concentrations of priority pollutants is indicated in Tables VII-5 and VII-6. These tables show the approximate pounds of each pollutant present in the influent, effluent and sludge from Plants A and B, respectively. For Plant A there was moderately good agreement on the pounds entering and leaving the POTW for most conventional parameters and metallic priority pollutants. However, copper, lead and zinc balanced poorly. Most metals did show a tendency to accumulate in the sludge. The pounds of cadmium, chromium, copper, lead, nickel, silver and zinc in the primary and secondary sludge were each 2 to 15 times the amount calculated to be in the final effluent. An average of less than one pound per day of antimony, beryllium, selenium and thallium was measured in the sludge of Plant A. Arsenic was detected in Plant A's sludges at over four pounds per day despite the fact that it had never been measured above the detection limit in the influent.

For many organic priority pollutants, the mass balance data support the removal mechanisms of either oxidation, biodegradation or air stripping. The most striking example is chloroform, where none was detected in any sludge samples, despite an overall reduction from 37 to 38 pounds per day in the influent to less than 16 pounds per day in the effluent. Similar tendencies were exhibited for other refractory but volatile pollutants, such as benzene; 1,1,1-trichloroethylene;

ethyl benzene; tetrachloroethylene; toluene; and trichloroethylene. Organic compounds which seemed to build up in the sludge include acenaphthene; dichlorobromomethane; chlorodibromomethane; 1,2-benzanthracene; 3,4-benzofluoranthene; anthracene; and fluorene.

Overall, Plant B had lower concentrations of priority pollutants than Plant A and the accumulation of materials in the sludge was less pronounced. Of the metals, only chromium, copper, lead and zinc accumulated to some degree in the sludge, and all were present in greater quantity in the combined sludge than in the final effluent. There were insufficient data upon which to draw many conclusions regarding organic priority pollutant removal mechanisms or accumulation in sludges at Plant B. No organic priority pollutants were present at an average of over one pound per day in Plant B's influent, or combined sludge.

Mechanisms for Toxic Pollutant Removal

Removal of toxic pollutants in a POTW can occur as a result of various physical, chemical or biological processes that take place within the treatment system. The exact combination of these phenomena affecting any particular priority pollutant depends largely on the nature of the pollutant itself.

TABLE VII-5
PLANT A
MASS BALANCE
WEEKLY SUMMARY (LB/DAY)

5-30-79

PP	PARAMETER NAME	INFLUENT		TOTAL OUT		FINAL EFFLUENT	PRIMARY SLUDGE	SECONDARY SLUDGE
1	ACENAPHTHENE	0	-	0.72	0.46 -	0.46	N-D	N-D
3	ACRYLONITRILE		N-D		0.035-	0.035	N-D	0.035
4	BENZENE	3.6	-	10	0.58 -	4.1	L	3.5
6	CARBON TETRACHLORIDE	0.72	-	1.3	0.099-	0.099	N-D	0.46
7	CHLOROBENZENE	0	-	1.1	N-D	N-D	N-D	0.029
8	1,2,4-TRICHLOROBENZENE	0	-	0.36	N-D	N-D	N-D	N-D
9	HEXACHLOROBENZENE	0	-	0.36	N-D	N-D	N-D	N-D
10	1,2-DICHLOROETHANE	0	-	0.19	N-D	N-D	N-D	N-D
11	1,1,1-TRICHLOROETHANE	13	-	15	0.064-	5.3	L	5.2
13	1,1-DICHLOROETHANE	0	-	1.5	0.029-	0.029	N-D	0.064
14	1,1,2-TRICHLOROETHANE	5	-	5.4	N-D	N-D	N-D	0.029
21	2,4,6-TRICHLOROPHENOL	0	-	0.36	N-D	N-D	N-D	N-D
22	PARACHLOROMETA CRESOL	0	-	0.36	N-D	N-D	N-D	N-D
23	CHLOROFORM	37	-	38	12 -	16	L	16
24	2-CHLOROPHENOL		N-D		0 -	1.1	L	1.1
25	1,2-DICHLOROBENZENE	0	-	3.3	0 -	1.1	L	1.1
26	1,3-DICHLOROBENZENE	0	-	1.8	0 -	1.1	L	1.1
27	1,4-DICHLOROBENZENE	0	-	2.9	0 -	2.1	L	2.1
28	3,3'-DICHLOROBENZIDINE		N-D		0 -	1.1	L	1.1
29	1,1-DICHLOROETHYLENE	0.44	-	6	0.023-	5.4	L	5.4
30	1,2-TRANS-DICHLOROETHYLENE	0.37	-	5.7	0.062-	1.4	L	1.3
32	1,2-DICHLOROPROPANE	0	-	0.37	N-D	N-D	N-D	N-D
34	2,4-DIMETHYLPHENOL		N-D		0 -	1.1	L	1.1
38	ETHYLBENZENE	23	-	28	1 -	5.9	L	5.1
39	FLUORANTHENE	0	-	2.2	0 -	3.2	L	3.2
43	BIS(2-CHLOROETHOXY) METHANE	0	-	0.72	N-D	N-D	N-D	N-D
44	METHYLENE CHLORIDE	4.3	-	10	4.6 -	11	L	7.8
45	CHLOROMETHANE	0	-	0.37	N-D	N-D	N-D	0.6
48	DICHLOROBROMOMETHANE	0	-	0.19	0.84 -	2.5	L	1.7
49	TRICHLOROFLUOROMETHANE	0	-	0.19	0 -	0.37	L	0.37
51	CHLORODIBROMOMETHANE		N-D		0.4 -	0.4	N-D	N-D
52	HEXACHLOROBUTADIENE	0	-	0.36	N-D	N-D	N-D	N-D
55	NAPHTHALENE	0.47	-	5.9	0.50 -	3.8	L	3.2
64	PENTACHLOROPHENOL	0	-	2.2	1.6 -	2.7	L	1.1
65	PHENOL	9.7	-	15	15 -	19	L	17
66	BIS(2-ETHYLHEXYL) PHTHALATE	24	-	27	15 -	18	L	12
67	BUTYL BENZYL PHTHALATE	0.43	-	3	0.001-	3.2	L	3.2
68	DI-N-BUTYL PHTHALATE	1.6	-	7	0 -	4.3	L	4.3
69	DI-N-OCTYL PHTHALATE	0	-	0.36	0 -	1.1	L	1.1
70	DIETHYL PHTHALATE	0	-	4.7	0 -	2.1	L	2.1
71	DIETHYL PHTHALATE	0	-	2.9	0 -	1.1	L	1.1
72	1,2-BENZANTHRACENE	0	-	0.72	1.3 -	2.4	L	1.1
74	3,4-BENZOFUORANTHENE		N-D		1.8 -	1.8	N-D	1.8
76	CHRYSENE	0	-	0.72	1.3 -	2.4	L	1.1
77	ACENAPHTHYLENE	0	-	0.36	N-D	N-D	N-D	N-D
78	ANTHRACENE	0	-	5.4	4.3 -	7.5	L	3.2
79	1,12-BENZOPERYLENE	0	-	0.36	N-D	N-D	N-D	N-D
80	FLUORENE	0	-	2.2	0.84 -	1.9	L	1.1
81	PHENANTHRENE	0	-	5.4	4.3 -	7.5	L	3.2
82	1,2,5,6-DIBENZANTHRACENE	0	-	0.36	0.12 -	1.2	L	1.1
83	INDENO(1,2,3-C,D) PYRENE	0	-	0.36	0.098-	1.2	L	1.1
84	PYRENE	0	-	2.5	2 -	6.3	L	4.3
85	TETRACHLOROETHYLENE	40	-	43	1.8 -	7.5	L	6.7
86	TOLUENE	14	-	17	0.79 -	7.3	L	6.5
87	TRICHLOROETHYLENE	18	-	22	0.78 -	7.1	L	6.3
114	ANTIMONY	0	-	38	0.67 -	38	L	37
115	ARSENIC	0	-	38	4.2 -	41	L	37
117	BERYLLIUM	0	-	1.5	0.22 -	1.7	L	1.5
118	CADMIUM	8.9	-	9.1	11 -	11	L	3.6
119	CHROMIUM	337	-	337	296 -	295	L	34
120	COPPER	148	-	148	340 -	339	L	20
121	CYANIDE	9.5	-	14	4.9 -	11	L	8
122	LEAD	37	-	43	146 -	161	L	15
123	MERCURY	0.21	-	0.26	0.24 -	0.34	L	0.300
124	NICKEL	74	-	75	108 -	107	L	30
125	SELENIUM	0	-	38	0.3 -	38	L	37
126	SILVER	5.8	-	6.3	2.3 -	3.8	L	1.5
127	THALLIUM	0	-	38	0.022-	37	L	37

NOTES: L - LESS THAN
AVERAGE DAILY FLOWS (MGD): INFLUENT - 91.25
PRIMARY SLUDGE - 0.324
SECONDARY SLUDGE - 1.47

TABLE VII-5
PLANT A
MASS BALANCE
WEEKLY SUMMARY (LB/DAY)

5-30-77

PP	PARAMETER NAME	INFLUENT	TOTAL OUT	FINAL EFFLUENT	PRIMARY SLUDGE	SECONDARY SLUDGE
128	ZINC	192	638	67	413	157
	BOD(MG-L)	153000	138000	9940	54400	73900
	COD(MG-L)	316000	288000	50700	155000	82200
	TOC(MG-L)	193000	145000	48600	63400	33300
	OIL & GREASE(MG-L)	40100	34800	L 4450	24500	L 5910
	TOTAL PHENOLS	135	12	L 10	1.8	L 0.5
	TOTAL SOLIDS(MG-L)	707000	848000	621000	153000	73800
	TOTAL SUSP. SOLIDS(MG-L)	107000	218000	14800	126000	77100
	TOTAL VOLATILE SOLIDS(MG-L)	176000	308000	175000	72400	40300
	TOTAL VOL. SUS. SOLIDS(MG-L)	79700	125000	10300	63000	51400
	AMMONIA NITROGEN	4690	3930	3660	158	106
	ALUMINUM	1030000	151000	151000	N-D	N-D
	BARIUM	96600	36900	36900	N-D	N-D
	IRON	2440000	292000	292000	N-D	N-D
	MANGANESE	76200	82400	82400	N-D	N-D
	CALCIUM(MG-L)	62400	59100	59100	N-D	N-D
	MAGNESIUM(MG-L)	20100	19700	19700	N-D	N-D

NOTES: L - LESS THAN,
AVERAGE DAILY FLOWS (MGD): INFLUENT - 91.25
PRIMARY SLUDGE - 0.324
SECONDARY SLUDGE - 1.47

Physical removal mechanisms fall into three broad categories: removal as a solid with other suspended solids, adsorption onto suspended solids with subsequent removal, and atmospheric stripping. Removal of toxic pollutants with suspended solids in primary sludge is most prevalent for the heavy metals. Combination of the heavy metals with alkalinity or sulfide will produce insoluble species that settle out of raw sewage simultaneously with other wastewater solids.

Adsorption onto solid surfaces provides an additional removal mechanism for some organic priority pollutants. If an organic material is insoluble in water, slightly soluble or hydrophobic, the organic pollutant may preferentially adsorb on solid surfaces. In raw sewage, both suspended solids and floatables (greases) may be available for sorption. Therefore, when scum or primary sludge is removed, organic priority pollutants, which may be concentrated in these materials, may also be removed.

A significant proportion of the organic priority pollutants are relatively volatile. It has been postulated that during aeration some of these materials may be air stripped and subsequently released to the atmosphere. This phenomena might account for some observed removals of biologically refractory volatile organics, especially aromatic species, in activated sludge plants.

Chemical removal of toxic pollutants generally is applicable to organic materials which may come in contact with strong oxidants in the POTW. Most commonly, chlorine used for disinfection or odor control reacts with organic pollutants. At times, the organic species are simply chlorinated, sometimes creating toxic materials. However, removal may occur when the oxidation of the organic material goes to completion, destroying the toxic pollutant and forming carbon dioxide and water. Chlorine is not the only oxidant used within a POTW which could destroy organic pollutants. Hydrogen peroxide, which is sometimes used to

control filamentous bulking, or ozone, which is gaining acceptance as a disinfectant, can also provide beneficial oxidation and removal of organic pollutants. Oxygen from aeration processes may also contribute to the oxidation of some materials.

Under the proper conditions, organic toxic pollutants may be biologically removed from sewage by acting as substrate for organisms in the treatment plant's biomass. Aliphatic compounds are generally more amenable to breakdown in biological systems than aromatic compounds, straight chain aliphatics being most easily degraded. In order for an organic pollutant to compete as a food source with normal organic constituents in sewage (carbohydrates, proteins, fatty acids, etc.) certain conditions should be maintained, such as acclimation to the possible toxic effects of the pollutant. If these conditions can be met, significant removal by biodegradation can occur.

PLANT B

TABLE VII-6

5-30-79

MASS BALANCE
WEEKLY SUMMARY (LB/DAY)

PP	PARAMETER NAME	INFLUENT		TOTAL OUT		FINAL EFFLUENT		COMBINED SLUDGE
3	ACRYLONITRILE		N-D	0.011-	0.011	N-D		0.011
4	BENZENE	0.480-	0.910	0.160-	0.280	L	0.270	0.008
7	CHLOROBEZENE	0 -	0.032		N-D		N-D	N-D
10	1,2-DICHLOROETHANE	0.021-	0.085	0 -	0.098	L	0.098	N-D
11	1,1,1-TRICHLOROETHANE	0 -	0.160	0 -	0.033	L	0.033	N-D
13	1,1-DICHLOROETHANE	0 -	0.032		N-D		N-D	N-D
23	CHLOROFORM	0 -	0.640	0.056-	0.680	L	0.680	N-D
25	1,2-DICHLOROBEZENE	0 -	0.560	0 -	0.250	L	0.250	N-D
26	1,3-DICHLOROBEZENE	0 -	0.110	0 -	0.340	L	0.340	N-D
27	1,4-DICHLOROBEZENE	0 -	0.110		N-D		N-D	N-D
28	3,3'-DICHLOROBEZIDINE		N-D	0 -	0.084	L	0.084	N-D
29	1,1-DICHLOROETHYLENE	0 -	0.260	0 -	0.180	L	0.180	N-D
32	1,2-DICHLOROPROPANE	0 -	0.016		N-D		N-D	N-D
36	2,6-DINITROTOLUENE	0 -	0.110		N-D		N-D	N-D
38	ETHYLBENZENE	0 -	0.290	0.001-	0.050	L	0.049	0.001
39	FLUORANTHENE	0 -	0.340		N-D		N-D	N-D
44	METHYLENE CHLORIDE	0.420-	0.960	0.064-	0.700	L	0.640	0.064
48	DICHLOROBROMOMETHANE	0 -	0.064	0.019-	0.230	L	0.210	0.019
51	CHLORODIBROMOMETHANE	0 -	0.048	0.002-	0.180	L	0.180	0.002
54	ISOPHORONE	0 -	0.110		N-D		N-D	N-D
55	NAPHTHALENE	0 -	0.450	0.023-	0.280	L	0.250	0.023
57	2-NITROPHENOL		N-D	0 -	0.250	L	0.250	N-D
58	4-NITROPHENOL		N-D	0.840-	0.920	L	0.920	N-D
64	PENTACHLOROPHENOL	0 -	0.110	0 -	0.084	L	0.084	N-D
65	PHENOL	0 -	0.450	0.130-	0.720	L	0.590	0.130
66	BIS(2-ETHYLHEXYL) PHTHALATE	0.570-	0.910	0.380-	0.970	L	0.590	0.380
67	BUTYL BENZYL PHTHALATE	0 -	0.670	0 -	0.340	L	0.340	N-D
68	DI-N-BUTYL PHTHALATE	0 -	0.560	0 -	0.420	L	0.420	N-D
69	DI-N-OCTYL PHTHALATE	0 -	0.450	0 -	0.084	L	0.084	N-D
70	DIETHYL PHTHALATE	0 -	0.560	0 -	0.250	L	0.250	N-D
71	DIMETHYL PHTHALATE	0 -	0.340	0 -	0.170	L	0.170	N-D
72	1,2-BENZANTHRACENE		N-D	0.002-	0.086	L	0.084	0.002
76	CHRYSENE		N-D	0.002-	0.086	L	0.084	0.002
77	ACENAPHTHYLENE		N-D	0 -	0.170	L	0.170	N-D
78	ANTHRACENE	0 -	0.340	0.023-	0.023		N-D	0.023
81	PHENANTHRENE	0 -	0.340	0.023-	0.023		N-D	0.023
84	PYRENE	0 -	0.340	0.012-	0.012		N-D	0.012
85	TETRACHLOROETHYLENE	0 -	0.660	0.016-	0.440	L	0.430	0.016
86	TOLUENE	0.059-	0.560	0.087-	0.550	L	0.460	0.087
87	TRICHLOROETHYLENE	0 -	0.220	0 -	0.016	L	0.016	N-D
114	ANTIMONY	0 -	3.400	0.010-	3.400	L	3.400	0.010
115	ARSENIC	0 -	3.400	0.039-	3.400	L	3.400	0.039
117	BERYLLIUM	0 -	0.130	0.003-	0.140	L	0.130	0.003
118	CADMIUM	0.290-	0.310	0.079-	0.210	L	0.130	0.079
119	CHROMIUM	4.800-	4.800	3.600-	3.600		1.500	2.100
120	COPPER	3.600-	3.600	3.500-	3.500		0.700	2.800
121	CYANIDE	5.200-	5.300	9.900-	9.900	L	9.500	0.440
122	LEAD	1.100-	2.000	1.900-	3.200	L	1.300	1.900
123	MERCURY	0.014-	0.018	0.001-	0.015	L	0.013	0.001
124	NICKEL	2.000-	2.000	2.100-	2.100		1.300	0.800
125	SELENIUM	0 -	3.400	0.007-	3.400	L	3.400	0.007
126	SILVER	0.087-	0.180	0.049-	0.160	L	0.140	0.020
127	THALLIUM	0 -	3.400	0 -	3.400	L	3.400	N-D
128	ZINC	19.000-	19.000	10.000-	10.000		3.500	6.900
	BOD(MG-L)		6370		3840		1650	2180
	COD(MG-L)		12300		12200		3840	8370
	TOC(MG-L)		4710		5300		2220	3080
	OIL & GREASE(MG-L)		1640		1460	L	549	907
	TOTAL PHENOLS		1.3		0.4	L	0.3	0.1
	TOTAL SOLIDS(MG-L)		41700		44400		37800	6600
	TOTAL SUSP. SOLIDS(MG-L)		6550		6910		1300	5610
	TOTAL VOLATILE SOLIDS(MG-L)		9610		12800		9110	3690
	TOTAL VOL. SUS. SOLIDS(MG-L)		3660		3900		780	3120
	AMMONIA NITROGEN		787		242		222	20

AVERAGE DAILY FLOWS (MGD): INFLUENT - 8.09
COMBINED SLUDGE - 0.031

A sometimes overlooked mechanism for the removal of inorganic priority pollutants via biological processes is the uptake of trace quantities of these pollutants as micronutrients. These materials may find their way into the biomass as a result of being complexed and incapsulated in a material that is consumed by cells.

In summary, in terms of organic priority pollutant removal, the preliminary findings presented herein indicate that aside from standard physical and biological removal mechanisms, atmospheric stripping of refractory volatile organics appears to be a significant phenomenon. Aromatic volatiles, which are resistant to biodegradation, were removed from the treatment system, but not concentrated in the sludge. It appears, therefore, that these materials were air stripped.

Polynuclear aromatics (PNA), which are also biologically difficult to remove, exhibited a different fate in the two POTW's studied. PNA's are less volatile than the other aromatics on the priority pollutant list, yet these materials were removed. However, the PNA's were concentrated in sludges at the two plants. This seems to indicate that for these less volatile refractory materials, air stripping is not an important removal mechanism. Further evaluations of removal mechanisms will be carried out over the full 40-plant program.

Formation of Chlorinated Hydrocarbons

At both POTW's sampled during the pilot study, treated wastewater was collected immediately before chlorination and at the plant outfall after chlorine disinfection. Samples of the chlorinated final effluent were split, creating duplicate aliquots for analysis. One set was analyzed as collected from the outfall. The other set of samples was preserved by adding sufficient thiosulfate to consume any residual chlorine.

The purpose of collecting duplicate effluent samples, as described above, was to study the possible formation of chlorinated hydrocarbons. If the preserved sample was found to contain a lower concentration of a chlorinated priority pollutant than the unpreserved sample, it was concluded that formation of chlorinated hydrocarbons might continue in the receiving stream after discharge.

In Table VII-7 for Plant A and Table VII-8 for Plant B, summaries of data showing the formation of chlorinated priority pollutants across the disinfection process are presented. In total, evidence of the formation of chlorinated hydrocarbons was detected in 49 individual grab sample sets over a 3-day period at Plant A and in 59 grab sample sets over one week of sampling at Plant B.

By far the most common situation was one in which the chlorinated priority pollutant was not detected in the pre-chlorinated sample but was found at below the detection limit in either of the final effluent samples, or both. Usually this type of result would be considered insignificant; however, since the analyses presented herein were compiled utilizing gc-ms, the results obtained are meaningful. With gc-ms, the identification of an organic molecule is based on an analysis of ion fragments observed in mass spectra. If no ion fragments for a particular molecule at a specified gc retention time are observed, the result is reported as "not detected." This is significantly different from the results that are reported at "less than 10." For these analyses, some fragments were found but not at proper levels to assign a concentration even though the material was probably present. Therefore, for parameters that go from not detected to a value below the detection limit, formation of the chlorinated molecule may be indicated.

The predicted higher chlorinated hydrocarbon concentrations in unpreserved samples as compared to preserved samples did not occur in a consistent manner. However, over the course of the full 40-POTW program it is expected that more definitive data on these phenomena will be developed.

TABLE VII-7
PLANT A
EFFECT OF CHLORINE ON PRIORITY POLLUTANT CONCENTRATIONS 5-30-79

---SAMPLE---	DATE	TIME	PP	PARAMETER NAME	PRE-CHLORINATED			UNPRESERVED		PRESERVED	
					CHLORINATED	EFFLUENT	FINAL	EFFLUENT	FINAL	EFFLUENT	FINAL
7-26-78	1800	23	CHLOROFORM	LT	10		10	LT	10		
7-27-78	1000	23	CHLOROFORM	LT	10		100	LT	10		
7-27-78	1800	23	CHLOROFORM		110		190		170		
7-28-78	1000	23	CHLOROFORM	LT	10		130		110		
7-28-78	1400	23	CHLOROFORM	LT	10		10	LT	10		
7-29-78	0200	23	CHLOROFORM		18		32	LT	10		
7-29-78	0600	23	CHLOROFORM	LT	10		28	LT	10		
7-27-78	0800	25	1,2-DICHLOROBENZENE	N-D	LT	10		NOT	APP.		
7-29-78	0800	26	1,3-DICHLOROBENZENE	N-D	LT	10		NOT	APP.		
7-27-78	0800	27	1,4-DICHLOROBENZENE	N-D	LT	10		NOT	APP.		
7-27-78	0800	28	3,3'-DICHLOROBENZIDINE	N-D	LT	10		NOT	APP.		
7-27-78	1400	29	1,1-DICHLOROETHYLENE	N-D	LT	10		LT	10		
7-27-78	1800	29	1,1-DICHLOROETHYLENE	N-D	LT	10		LT	10		
7-28-78	0600	29	1,1-DICHLOROETHYLENE	N-D	LT	10		LT	10		
7-28-78	1000	29	1,1-DICHLOROETHYLENE	N-D	LT	10		LT	10		
7-28-78	1400	29	1,1-DICHLOROETHYLENE	N-D	LT	10		LT	10		
7-28-78	1800	29	1,1-DICHLOROETHYLENE	N-D	LT	10		N-D			
7-28-78	1800	29	1,1-DICHLOROETHYLENE	N-D	LT	10		N-D			
7-29-78	0200	29	1,1-DICHLOROETHYLENE	N-D	LT	10		N-D			
7-27-78	0200	30	1,2-TRANS-DICHLOROETHYLENE	N-D		N-D		LT	10		
7-27-78	1400	30	1,2-TRANS-DICHLOROETHYLENE	N-D		N-D		LT	10		
7-27-78	1800	30	1,2-TRANS-DICHLOROETHYLENE	N-D	LT	10		LT	10		
7-27-78	2200	30	1,2-TRANS-DICHLOROETHYLENE	N-D	LT	10		LT	10		
7-28-78	0200	30	1,2-TRANS-DICHLOROETHYLENE	N-D		N-D		LT	10		
7-28-78	0600	30	1,2-TRANS-DICHLOROETHYLENE	N-D	LT	10		LT	10		
7-28-78	1000	30	1,2-TRANS-DICHLOROETHYLENE	N-D	LT	10		N-D			
7-28-78	1400	30	1,2-TRANS-DICHLOROETHYLENE	N-D	LT	10		LT	10		
7-29-78	0200	30	1,2-TRANS-DICHLOROETHYLENE	N-D	LT	10		N-D			
7-27-78	0200	44	METHYLENE CHLORIDE	LT	10		LT	10		17	
7-27-78	0200	48	DICHLOROBROMOMETHANE	N-D		N-D		LT	10		
7-27-78	1000	48	DICHLOROBROMOMETHANE	N-D		LT	10		N-D		
7-27-78	1400	48	DICHLOROBROMOMETHANE	N-D		N-D		LT	10		
7-27-78	1800	48	DICHLOROBROMOMETHANE	N-D		LT	10		LT	10	
7-28-78	0200	48	DICHLOROBROMOMETHANE	N-D		N-D		LT	10		
7-28-78	0600	48	DICHLOROBROMOMETHANE	N-D		LT	10		LT	10	
7-28-78	1000	48	DICHLOROBROMOMETHANE	N-D		LT	10		LT	10	
7-28-78	1400	48	DICHLOROBROMOMETHANE	N-D		LT	100		LT	10	
7-28-78	1800	48	DICHLOROBROMOMETHANE	N-D		LT	10		N-D		
7-28-78	1800	48	DICHLOROBROMOMETHANE	N-D		LT	10		N-D		
7-29-78	0200	48	DICHLOROBROMOMETHANE	N-D		LT	10		N-D		
7-29-78	0600	48	DICHLOROBROMOMETHANE	N-D		LT	10		N-D		
7-28-78	1000	49	TRICHLOROFLUOROMETHANE	N-D		N-D		LT	10		
7-28-78	1400	49	TRICHLOROFLUOROMETHANE	N-D		LT	10		LT	10	
7-28-78	1800	49	TRICHLOROFLUOROMETHANE	N-D		LT	10		N-D		
7-28-78	1800	49	TRICHLOROFLUOROMETHANE	N-D		LT	10		N-D		
7-28-78	1400	51	CHLORODIBROMOMETHANE	N-D		LT	10		N-D		
7-29-78	0200	51	CHLORODIBROMOMETHANE	N-D		LT	10		N-D		
7-27-78	1800	85	TETRACHLOROETHYLENE	LT	10		11		13		
7-27-78	0200	87	TRICHLOROETHYLENE	N-D		LT	10		LT	10	

NOTES: 1) ALL UNITS IN UG/L UNLESS OTHERWISE NOTED
2) POLLUTANTS WHICH DID NOT EXHIBIT INCREASED CONCENTRATIONS AFTER CHLORINATION ARE NOT LISTED
3) PP - PRIORITY POLLUTANT NUMBER
LT - LESS THAN
N-D - NOT DETECTED
NOT APP. - NOT APPLICABLE (EXTRACTABLE PARAMETERS)

Results of Sampling Frequency and Sample Point Selection Experiments

Through the first seven days of sampling at Plant A influent composites were taken every eight hours, starting at 0800 on Saturday, July 22, 1978 and running through 0800 on Saturday, July 29, 1978. During the second week of sampling at Plant A the composites were changed to cover the entire 24-hour (0800 to 0800) period. On a daily basis the averages of the three 8-hour composites match the corresponding 24-hour composites. The composites which end at 1600 and 1200 have consistently higher loadings than the composites ending at 0800. This phenomena is particularly evident in the metals concentrations which exhibited much higher concentrations during the working hour composites (0800 to 1600) than during the other two 8-hour periods. Table VII-9 shows this phenomenon for the first week of sampling at Plant B.

This phenomenon would follow the diurnal variation in the wastewater flow and the work day of the industrial dischargers, combined with the detention time of the sewer system. This timed, higher loading of the priority pollutants, which were not detected in the Plant B sampling, is further evidence of the contribution from the industrial discharges which was present in Plant A's system, but not in Plant B's system.

TABLE VII-8
PLANT B
EFFECT OF CHLORINE ON PRIORITY POLLUTANT CONCENTRATIONS 5-30-79

DATE	TIME	PP	PARAMETER NAME	PRE-CHLORINATED EFFLUENT	UNPRESERVED FINAL EFFLUENT	PRESERVED FINAL EFFLUENT
8- 9-78	0600	11	1,1,1-TRICHLOROETHANE	N-D	N-D	LT 10
8-13-78	0600	13	1,1,1-DICHLOROETHANE	N-D	LT 10	N-D
8- 7-78	0200	23	CHLOROFORM	N-D	LT 10	LT 10
8- 9-78	1000	23	CHLOROFORM	N-D	LT 10	LT 10
8-11-78	1000	23	CHLOROFORM	LT 10	LT 10	34
8-11-78	0800	25	1,2-DICHLOROBENZENE	N-D	LT 10	NOT APP.
8- 8-78	0800	26	1,3-DICHLOROBENZENE	N-D	LT 10	NOT APP.
8- 9-78	0800	26	1,3-DICHLOROBENZENE	N-D	LT 10	NOT APP.
8-13-78	0800	26	1,3-DICHLOROBENZENE	N-D	LT 10	NOT APP.
8-13-78	0800	28	3,3'-DICHLOROBENZIDINE	N-D	LT 10	NOT APP.
8- 7-78	0200	29	1,1-DICHLOROETHYLENE	N-D	N-D	LT 10
8-10-78	1000	29	1,1-DICHLOROETHYLENE	N-D	N-D	LT 10
8-10-78	1400	29	1,1-DICHLOROETHYLENE	N-D	LT 10	LT 10
8-10-78	1800	29	1,1-DICHLOROETHYLENE	N-D	LT 10	LT 10
8-11-78	0600	29	1,1-DICHLOROETHYLENE	N-D	LT 10	LT 10
8-11-78	1400	29	1,1-DICHLOROETHYLENE	N-D	LT 10	LT 10
8-11-78	2200	29	1,1-DICHLOROETHYLENE	N-D	LT 10	LT 10
8-12-78	1400	29	1,1-DICHLOROETHYLENE	N-D	LT 10	LT 10
8- 6-78	1400	44	METHYLENE CHLORIDE	N-D	LT 10	LT 10
8- 7-78	0200	44	METHYLENE CHLORIDE	N-D	LT 10	LT 10
8- 9-78	1000	44	METHYLENE CHLORIDE	N-D	LT 10	LT 10
8- 9-78	1800	44	METHYLENE CHLORIDE	N-D	LT 10	LT 10
8- 6-78	2200	48	DICHLOROBROMOMETHANE	N-D	N-D	LT 10
8- 7-78	0200	48	DICHLOROBROMOMETHANE	N-D	N-D	LT 10
8- 7-78	1400	48	DICHLOROBROMOMETHANE	N-D	LT 10	LT 10
8- 8-78	0600	48	DICHLOROBROMOMETHANE	N-D	LT 10	LT 10
8- 8-78	1000	48	DICHLOROBROMOMETHANE	N-D	LT 10	N-D
8- 8-78	1400	48	DICHLOROBROMOMETHANE	N-D	LT 10	LT 10
8- 8-78	1800	48	DICHLOROBROMOMETHANE	N-D	N-D	LT 10
8-10-78	1800	48	DICHLOROBROMOMETHANE	N-D	N-D	LT 10
8-11-78	1800	48	DICHLOROBROMOMETHANE	N-D	LT 10	N-D
8-11-78	2200	48	DICHLOROBROMOMETHANE	N-D	N-D	LT 10
8- 6-78	1000	51	CHLORODIBROMOMETHANE	N-D	LT 10	LT 10
8- 6-78	1400	51	CHLORODIBROMOMETHANE	N-D	N-D	LT 10
8- 6-78	1800	51	CHLORODIBROMOMETHANE	N-D	LT 10	N-D
8- 6-78	2200	51	CHLORODIBROMOMETHANE	N-D	N-D	LT 10
8- 7-78	0600	51	CHLORODIBROMOMETHANE	N-D	LT 10	LT 10
8- 7-78	1400	51	CHLORODIBROMOMETHANE	N-D	LT 10	LT 10
8- 8-78	0600	51	CHLORODIBROMOMETHANE	N-D	LT 10	LT 10
8- 8-78	1400	51	CHLORODIBROMOMETHANE	N-D	LT 10	LT 10
8- 8-78	1800	51	CHLORODIBROMOMETHANE	N-D	N-D	LT 10
8-11-78	1800	51	CHLORODIBROMOMETHANE	N-D	LT 10	N-D
8- 7-78	0800	64	PENTACHLOROPHENOL	N-D	LT 10	NOT APP.
8- 6-78	1000	85	TETRACHLOROETHYLENE	N-D	LT 10	LT 10
8- 6-78	1800	85	TETRACHLOROETHYLENE	N-D	LT 10	N-D
8- 6-78	2200	85	TETRACHLOROETHYLENE	N-D	LT 10	LT 10
8- 7-78	0600	85	TETRACHLOROETHYLENE	N-D	LT 10	LT 10
8- 7-78	1400	85	TETRACHLOROETHYLENE	N-D	LT 10	N-D
8- 8-78	1000	85	TETRACHLOROETHYLENE	N-D	LT 10	LT 10
8- 8-78	1400	85	TETRACHLOROETHYLENE	N-D	LT 10	LT 10
8- 8-78	1800	85	TETRACHLOROETHYLENE	N-D	LT 10	N-D
8- 9-78	1000	85	TETRACHLOROETHYLENE	N-D	LT 10	LT 10
8- 9-78	1800	85	TETRACHLOROETHYLENE	N-D	LT 10	N-D
8-10-78	1400	85	TETRACHLOROETHYLENE	N-D	N-D	LT 10
8-11-78	2200	85	TETRACHLOROETHYLENE	N-D	N-D	LT 10
8-12-78	1000	85	TETRACHLOROETHYLENE	N-D	N-D	LT 10
8-13-78	0200	85	TETRACHLOROETHYLENE	N-D	N-D	LT 10
8- 7-78	0600	87	TRICHLOROETHYLENE	N-D	N-D	LT 10
8- 8-78	1000	87	TRICHLOROETHYLENE	N-D	LT 10	N-D

NOTES: 1) ALL UNITS IN UG/L UNLESS OTHERWISE NOTED
2) POLLUTANTS WHICH DID NOT EXHIBIT INCREASED CONCENTRATIONS AFTER CHLORINATION ARE NOT LISTED
3) PP - PRIORITY POLLUTANT NUMBER
LT - LESS THAN
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Unless diurnal variation and the effect of sewer detention time are to be subjects of further study, the additional sampling effort and analysis expense to do three or more complete sets of composites per day do not seem to be warranted. Satisfactory results may be obtained with a daily composite.

Variation Between Various Days of the Week

The presence of and variation in influent pollutant concentrations over the weekly sampling period showed a few general trends. At Plant A the priority pollutant metals, especially chromium, copper and nickel, showed a marked increase during the middle and latter parts of the Monday-Friday work week, and their concentrations dipped during the non-working day composites. The same general trend with the metals was noticed at Plant B, but with the smaller industrial contribution and the smaller wastewater flow, the concentrations were not as large, and similarly, the variations not as pronounced.

A general trend for the conventional parameters (BOD and TSS) was not established at either of the pilot plants. Both of the aforementioned conventional pollutants fluctuated up and down throughout the 2-week period at Plant A and the 1-week period in Plant B to such an extent that no meaningful conclusions could be drawn on the daily conventional pollutant variation.

TABLE VII-9 8-HOUR COMPOSITES VS. METALS CONCENTRATIONS¹

	July 20 — July 23			July 23 — July 24			July 24 — July 25			July 25 — July 26		
	0800	1600	2400	0800	1600 ²	2400 ²	0800	1600	2400	0800	1600	2400
Cadmium	LT2 ³	7	5	9	-	-	LT2	6	3	8	13	11
Chromium	76	151	133	63	-	-	100	884	139	428	1360	563
Copper	35	228	94	70	-	-	105	267	128	154	864	205
Lead	LT20	LT20	LT20	32	-	-	LT20	139	LT20	41	216	29
Nickel	LT10	39	32	19	-	-	31	260	43	39	347	66
Zinc	23	124	116	303	-	-	135	162	379	190	503	223
	July 26 — July 27			July 27 — July 28			July 28 — July 29					
	0800	1600	2400 ²	0800	1600	2400	0800	1600	2400			
Cadmium	6	30	-	9	22	12	9	39	18			
Chromium	361	1025	-	321	870	364	372	455	311			
Copper	101	333	-	152	207	119	157	154	120			
Lead	LT20	110	-	LT20	117	21	33	44	86			
Nickel	27	273	-	20	269	54	75	63	98			
Zinc	149	473	-	303	362	347	197	345	204			

¹All units $\mu\text{g}/\text{l}$ ²Bottle broken³LT = less than

Due to the very low concentrations of the organics in most of the samples, little correlation on a daily basis could be drawn from the organic results. The variation of toluene during the first week at Plant A showed increased concentrations during the work week, but during the second week, this trend was not shown. With the majority of the analytical results reported as less than $10\mu\text{g}/\text{l}$ for these organics, there would have to be a very heavy organics discharger to the system on a regular basis for these organic results to show any kind of a trend worthy of definitive

conclusions. The one organic pollutant which did show up with values consistently above the detection limit was chloroform, with a trend toward higher values at the end of each sample week at Plant A (except for the composite ending on Thursday each week). The values for chloroform in Plant B were always below the detection limit, so a similar comparison could not be made.

Therefore, as discussed above, it is apparent that day-by-day differences may be more readily apparent in treatment facilities with larger industrial contributors, and the amounts of the priority pollutants which are being contributed by the residential contributors are small enough to be diluted below the detection concentrations by the time they reach the treatment plants. Source sampling at industrial dischargers and selected sampling under controlled conditions (i.e., new sewer, little groundwater inflow, etc.) of

totally residential areas, may yield trends for those priority pollutants which are introduced into sewers.

Potential of Additional Sample Points

During the first week of sampling at Plant A and the week at Plant B, certain additional points were sampled to scan for priority pollutant levels which might impact mass balances calculated for these or future plants. In addition, certain other waste streams, should they be accessible, may yield sufficient information to warrant future sampling.

Sludge Dewatering/Thickening Recycle Streams

This waste stream is usually readily accessible in the sludge handling system of each POTW and can be sampled to obtain an indication of the level of pollutants which are recycled for further biological treatment. Samples of the filtrate at Plant A show that the priority pollutant concentrations in these streams are generally of such small magnitude that they do not warrant the effort in obtaining them.

If this type of waste stream is recycled in such a way so as to affect another sample point, background sampling should be practiced, on a case-by-case basis only, to provide a total picture of the flow of priority pollutants through the POTW

Floatable

The pollutant levels in the floatables samples taken at Plant A and the corresponding sludge concentrations correlate reasonably well. However, since the volume of floatables removed from the wastewater is very small when compared to the sludge volumes, additional samples of this type are not deemed necessary.

Primary Effluent

One of the principal goals of the 40-plant sampling effort is to determine the fate of priority pollutants by calculating mass balances. A more accurate calculation can be made if all factors are expressed in the same terms (i.e., liquid flow in mg/l rather than solids in mg/kg). To accurately calculate mass balances through the primary treatment process, a sample point in the primary effluent will be needed.

Tap Water

The tap water sample is a necessary background sample which should be obtained at each POTW so that a total understanding of what pollutants are already in the water prior to its use may be ascertained.

Effluent Before Chlorination

Since the use of chlorine as a disinfecting agent has been questioned because of the possible formation of chlorinated hydrocarbons, the collection of effluent before chlorination could offer a means of obtaining valuable information. Should a chlorinated hydrocarbon be detected in all the samples throughout the POTW (influent, sludges, effluent), its fate would still be in question as to whether it was removed in any of the treatment processes or if it was generated in the disinfection process. This doubt on the fate of such compounds would be resolved should the wastewater be sampled both before and after chlorination.

Digester Supernatant/Heat Treatment Recycle Streams

Both of these waste streams are concentrated flows which are liable to contain very high concentrations of conventional, non-conventional and selected priority pollutants. Neither of these streams was sampled at either of the pilot plants, but each could yield valuable data on the processes involved and how they impact the fate of priority pollutants in POTW's.

