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U. S. ENVIRONMENTAL PROTECTION AGENCY
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REGION VIII

REPORT ON THE PLANT EVALUATION AT FISHING BRIDGE WASTEWATER TREATMENT PLANT YELLOWSTONE NATIONAL PARK

OPERATION & MAINTENANCE SECTION
WATER DIVISION
AUGUST, 1977

EPA-908-77-005

PLANT EVALUATION

AT

FISHING BRIDGE WASTEWATER TREATMENT PLANT
YELLOWSTONE NATIONAL PARK

AUGUST 1977

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DISCLAIMER

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I. INTRODUCTION

The National Park Service (NPS) has recently constructed several new waste water treatment facilities at the Yellowstone National Park. These facilities represent a major commitment by the Park Serivce to ensure that the high quality of water in the Park is not degraded by the presence of man.

To ensure that their new facilities perform as expected, the Superintendent of Yellowstone National Park requested assistance from EPA to train Park personnel in process control procedures and to provide performance evaluations of treatment facilities. Specific technical assistance was requested for the nitrification-denitrification facility located at Fishing Bridge. Additional assistance was provided for the Old Faithful facility. Two weeks of troubleshooting on-site technical assistance was conducted in August 1976 and extensive follow-up through telephone calls continued for the remainder of the operating season.

The intent of this report is to document the technical assistance activities and to provide recommendations to the Park Service relating to the problems that were encountered.

II. SUMMARY AND CONCLUSIONS

An operations evaluation and process control training program was provided to the National Park Service (NPS) at Yellowstone National Park. Process control training was given to four NPS Engineers (one from Glacier National Park), three NPS operators (one from Mount Rushmore National Park) and six part-time-summer employees.

Operations evaluations were conducted at the Fishing Bridge waste water treatment facility. Various deficiencies were noted during these evaluations and are discussed in this report.

Several problems were of such magnitude that the facility was not capable of producing the degree of treatment that was expected.

The NPS has already initiated appropriate action for reducing infiltration problems and for increasing the area available for percolation. Other actions, however, are still needed to ensure that efficient and reliable treatment will be provided. Recommendations for these actions follow.

III. RECOMMENDATIONS

1. Continue using the Process Control Plan as instituted. Especially utilize trend charts to chart plant process characteristics.

2. Provide permanent staff and seasonal employees with refresher training prior to start-up of plants.

3. Expand the plant monitoring program to include a complete nitrogen profile of the treatment plant and periodically run a profile of the plant loading fluctuations for a typical day.

4. Evaluate the addition of inert media to the denitrification ponds. A pilot study could be especially useful for determining appropriate design criteria.

5. Strongly consider providing the capability to add alkalinity to the wastewater to support the stoichimetric requirements for nitrification.

6. Correct flow controller and flow measuring equipment problems.

7. Take appropriate measures to ensure that gasoline or other toxic substances do not get into the sewer system.

8. Evaluate and correct the problem of solids separation in the oxidation ditches.

9. Operate the return sludge system to minimize sludge detention time in the final clarifier. If this cannot significantly reduce the solids loss associated with denitrification, then, consider installing surface skimmers.

10. A permanent scum collection system should be installed on the final clarifiers to eliminate nuisance problem from septic scum.

11. Construct a permanent return sludge flow splitting and flow measuring box in the headworks.

12. Ensure that the percolation ponds are operated so that one pond is allowed to dry out every two to three weeks.

13. Closely monitor the dissolved oxygen in the basins to determine if aerators are supplying sufficient dissolved oxygen.

14. Consider adding recycle capability to the denitrification ponds.

15. Consider adding an aerobic digester for waste sludge and scum.

IV. PLANT DESCRIPTION

A schematic flow diagram of the treatment facilities is presented in Figure 1. The use of this figure in conjunction with the following brief description of the various processes will aid in understanding the overall treatment system. Figure 2 shows the overall treatment plant layout and piping.

1. Headworks: Wastewater receives comminution at the pump station and then enters the plant through a 12-inch force main which is an extension of the parallel 8-inch force main from the Fishing Bridge pump station. Flow entering the plant passes through a 9-inch Parshall flume to a distribution box, which splits the flow to either or both oxidation ditches. At the inlet box, flow may also be diverted to the clarifier or directly to the evaporation-percolation ponds.

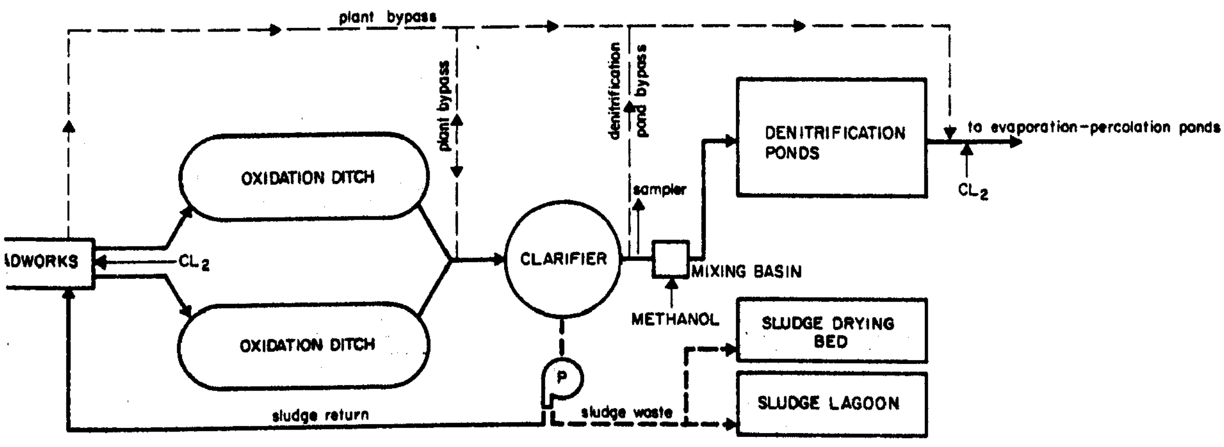
2. Oxidation Ditch: In the oxidation ditch, the incoming wastewater is brought into intimate contact with the micro-organisms (mixed liquor suspended solids, MLSS). Initially, the biodegradable organic matter is adsorbed on the surface of the micro-organisms. Then, over a period of hours, the organic matter is absorbed by the micro-organisms causing the growth of more organisms. The oxidation ditch contents, flow over an adjustable weir and to the clarifier by means of a 14-inch pipe.

3. Clarifier: The mixed liquor from the oxidation ditch is transferred to the clarifier where the most of the micro-organisms are separated by gravity. The mixed liquor enters the clarifier along the perimeter of the basin and flows inward to the weirs at the center. The solids settle to the bottom and are scraped toward a hopper by means of a rotating arm assembly. Settled sludge is pumped from the bottom of the clarifier by the return sludge pumps (located in the control building) back to the headworks.

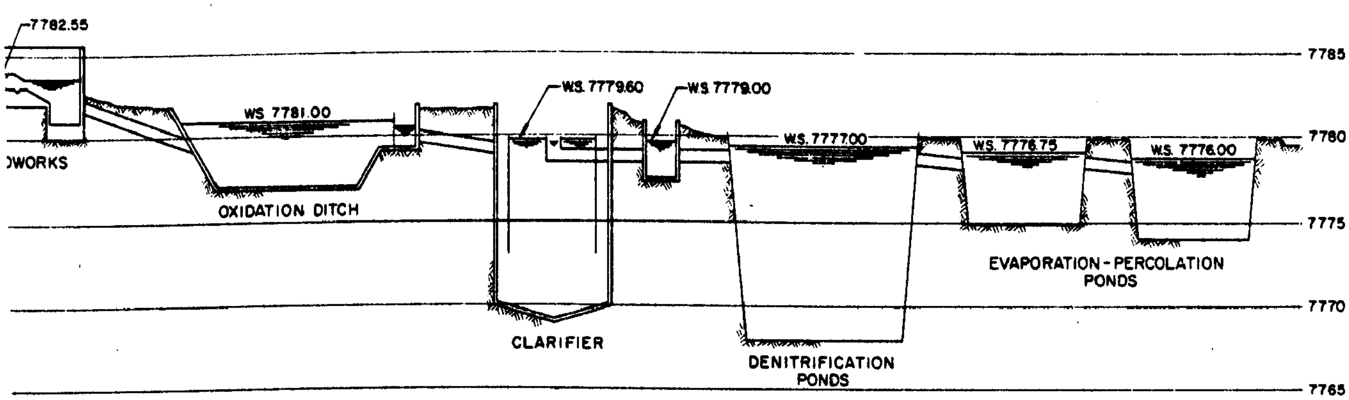
   Scum which collects in the clarifier is collected into a slotted pipe and falls into the sump at the east side of the clarifier. It is pumped back to the headworks by means of a pump located in the control building.

4. Solids Disposal: Solids from the clarifier are returned to the oxidation ditch with a portion being periodically wasted to the sludge drying beds or the sludge lagoon to prevent an excessive build-up of solids in the ditch. Biological solids generated in the anaerobic denitrification ponds will be allowed to pass to the disposal (evaporation-percolation) ponds where they will be filtered out in the soil.

FIGURE I



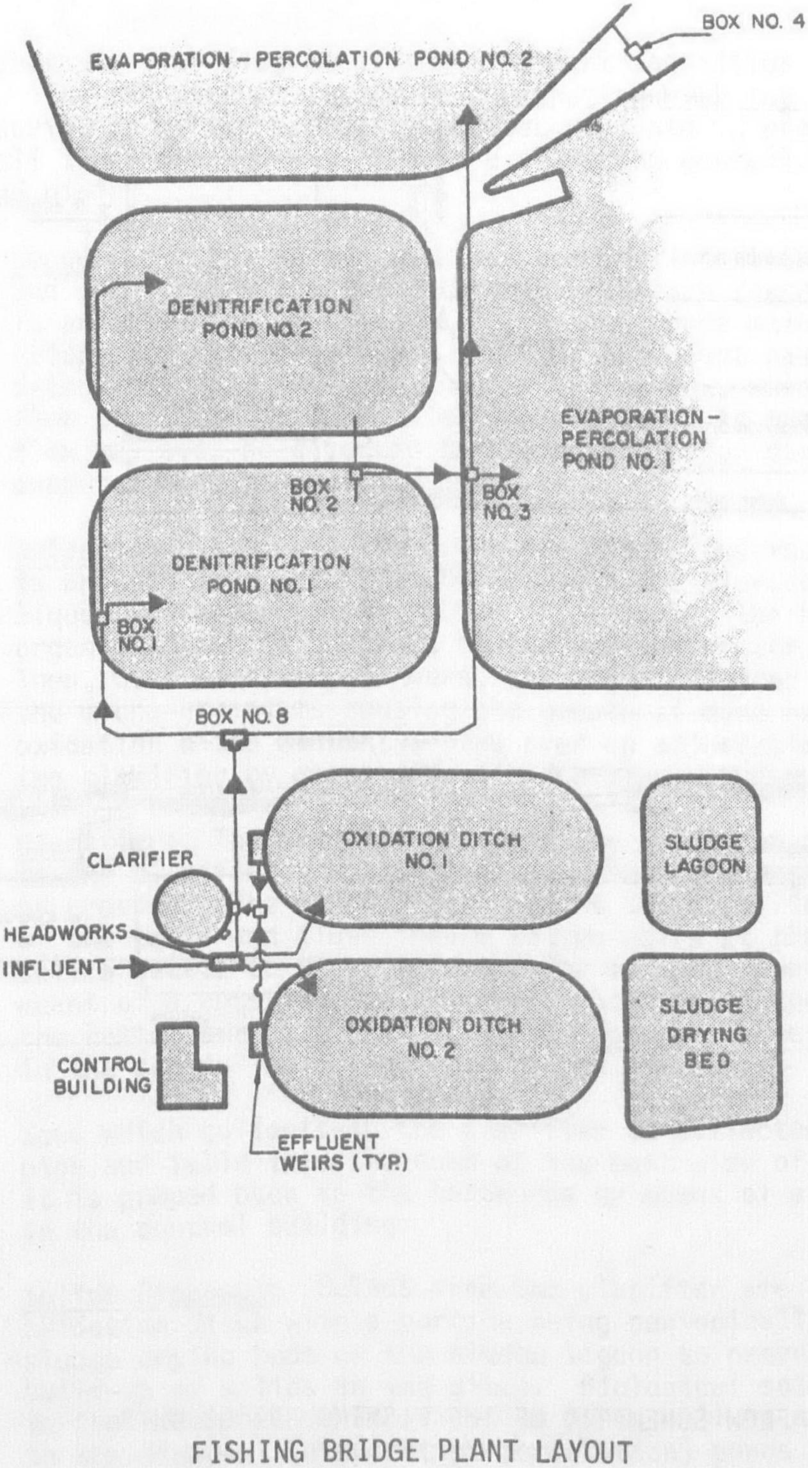
FLOW DIAGRAM



HYDRAULIC PROFILE

FLOW SCHEMATIC OF THE FISHING BRIDGE WWTP

FIGURE II



FISHING BRIDGE PLANT LAYOUT

5. Denitrification: Flow from the clarifier can be directed to either the evaporation-percolation ponds or the deep denitrification ponds. Methanol addition to the denitrification ponds provides the carbon source necessary to allow for partial denitrification of the effluent prior to discharge into the groundwater through the evaporation-percolation ponds. A series of monitoring wells are monitored as a means of verifying any detrimental build-up of nitrates and their migration to the river.

6. Chlorination and Disposal: Clarified effluent flows to either the denitrification ponds or to the evaporation-percolation ponds with effluent chlorination provided at flow control box Number 3 before final disposal. This box directs effluent flow from the denitrification ponds to either of the two evaporation-percolation ponds. Evaporation-percolation ponds are provided to help stabilize the effluent as well as perform their primary purpose of effluent disposal and storage.

   Tables 1, 2, and 3 summarize the design criteria and physical dimensions of the major plant units.

TABLE I

DESIGN FLOWS FOR FISHING BRIDGE WWTP

Average Daily Flow (ADF)	0.6 mgd
Macimum Peak Flow (3 x ADF)	1.8 mgd
Minimum Peak Flow (.25 x ADF)	0.15 mgd
Design Flow (1.3 x ADF)	.78 mgd

TABLE II

DESIGN CRITERIA FOR FISHING BRIDGE WWTP

Constituent	Influent Average mg/l	Influent Design lbs/day	Effluent From Clarifier mg/l	Effluent From Denitrification Ponds, % Removal
BOD	250	1625	15 - 25[a,b]	--
Suspended Solids	140	910	15 - 30[b]	--
Ammonia Nitrogen	25	163	--	--
Nitrite Nitrogen	0	--	--	--
Nitrate Nitrogen	0	--	15 - 25	20 - 25[c]
				40 - 45[d]
				60 - 95[e]

a - Typical BOD removal in excess of 90 percent

b - Each year there will be a 2 to 4 week period during plant start-up that the effluent will be of lower quality than shown.

c - Estimated nitrogen removal for the existing uncovered denitrification ponds without mixing.

d - Estimated nitrogen removal for a hypalon covered, unmixed pond

e - Estimated nitrogen removal for a denitrification system complete with pond covers, mixing and solids separation with recycle

TABLE III

ADDITIONAL DESIGN INFORMATION FOR FISHING BRIDGE WWTP

UNIT	SIZE
Headworks	
Parshall Flume, In.	9
Oxidation Ditch	
Number of basins	2
Volume (total), gallons	810,000
Water depth, ft.	5
Width of channel, ft., top	36
" " " ", bottom	24
Hydraulic detention time, hrs. (at 0.78 mgd 0% sludge return)	24.8
Loading Rate	
lb BOD/1000 cu.ft./day	15
F/M ratio, lb BOD/lb MLVSS/day	.05-.15
Maximum MLSS concentration, mg/l	3,000-6,000
Mean cell residence time, days	30
Aeration Equipment	
Number of aerators (rotor assemblies)	4
Length of rotor assembly, ft.	20
Blade diameter, in.	27.5
Submergence, in.	
Average design	6
Maximum (at peak flow)	10
Unit rpm	85
Horsepower, each aerator	25
Total horsepower	100
Clarifier	
Number	1
Diameter, ft.	41
Surface area, sq.ft.	1,300
Side water depth, ft.	10
Volume, gallons	97,500
Weir Length, ft.	116
Surface loading rate, gpd/sq.ft.	
Design flow	600
Peak flow (3.0 x ADF at 0% sludge return rate)	1,385
Weir loading rate, gpd/lin. ft.	
Design flow	6,720
Peak flow (3.0 x ADF)	15,000
Detention time @ design flow, hrs.	3.0

Unit	Size
Sludge Handling Facilities	
Estimated sludge load, lb. dry solids/day	600
Sludge lagoons	
Number	1
Volume, cu.ft.	25,000
Sludge drying beds	
Number	2
Surface area (total), sq. ft.	3,500
Loading rate. lb/sq.ft./year	26
Denitrification Pond	
Number	2
Total volume, cu.ft.	380,000
Side water depth, ft.	9
Detention time, days (at 0.78 mgd)	3.6
Average methanol dosage	75 mg/l (70 gal/day)
Evaporation-Percolation Ponds	
Number	2
Total area, acres	7.3
Evaporation-percolation rate, ft./day	.25
Water depth @ 15 day detention time, ft.	3

V. OPERATIONS EVALUATION

Operational considerations of a wastewater treatment plant are dependent on three general conditions. The first condition is that the plant be designed appropriately to provide the degree of treatment that is necessary. The second condition is that the sewage characteristics are compatible with plant design and that the plant equipment perform as the designer intended. Thirdly, the operations staff have an adequate process control plan and that they have the expertise, laboratory support and budgetary support to perform the operational duties.

In evaluating and assisting in plant operations at Yellowstone National Park, various deficiencies were noted pertaining to each of the three general conditions just identified. It is important that the three categories be identified and kept in mind and in perspective when corrective action is implemented in order for these actions to be effective. For example, process control on denitrification can only be administered to a limited point because the design of the unit is so limiting. Consequently, the major corrective emphasis needs to be placed at identifying the design limitations and then, correcting or eliminating the design limitation.

A. PROCESS CONTROL

Process Control is one area of concern at Yellowstone. Generally, the Park operators are seasonal help and are inexperienced in plant operations. Part of the assistance that the Environmental Protection Agency provided was to train Park personnel in operational conditions and to implement a Process Control Plan. Written as well as verbal guidelines were provided the Park Service staff on Process control. The seasonal operating situation and the extensive use of seasonal personnel dictates that Process Control procedures be as straight-forward as possible and that operating procedures be developed into well defined routines. One of the major recommendations that this report gives is that a thorough review of operating procedures and process control techniques be given to the operational staff each year, just prior to start-up of the treatment facilities.

A second recommendation is that emphasis be put on giving to plant operators instructions on the need to keep detailed daily logs of operating conditions and trend charts depicting process performance. These are normal considerations for efficient plant operations; but they are especially important for the situation at Yellowstone, where several facilities have to be operated for short seasonal uses. Efficient use of trend charts should greatly help the Park Environmental Engineer to quickly observe and evaluate operating condition over any given period of time.

B. TREATMENT UNITS - HEADWORKS

Considerable miscellaneous problems were experienced with headwork systems. The flow controller system did not work properly which caused hydraulic surges in the treatment units. The flow recording instrument was not operable which made it difficult to assess plant loadings and plant hydraulic characteristics. The chlorinator and the methanol feed systems were also limited as they were designed to be paced to the influent flow through the flow monitoring system.

All flow measurements were consequently made by visual observations of the staff gage in the parshall flume. This as well as other problems adds an additional work load to the operators. The full extent of the headwork problems was not within the scope of this study but these problems do need to be evaluated and resolved.

SECONDARY TREATMENT

Secondary treatment is provided by two oxidation ditches. The key parameters which significantly affect secondary treatment performance are dissolved oxygen (D.O.), mixed liquor suspended solids (MLSS), return sludge (RS) and clarification.

DISSOLVED OXYGEN (D.O.)

Generally, D.O. levels should be about 2.0 mg/l in order to provide an adequate aerobic environment. D.O. is controlled by changing the immersion of the aerators in the mixed liquor. The change in liquid level is accomplished by raising or lowering the mixed liquor overflow weirs at the end of each ditch. Proper D.O. levels are especially important at the Fishing Bridge Plant in order to maintain an adequate number of the highly sensitive nitrifying bacteria. Several times during the summer the operators noted a complete absence of D.O. in the system. Although no real supportive data is available, this lack of D.O. could be caused by periods of extensive nitrification. However, other factors which could produce this same effect are short periods of high organic loading, periods of high nitrogen loading, or possibly an operational change which could affect the activity of the micro-organisms. In order to properly analyze this an extensive montroing program needs to be maintained to monitor such parameters as organic loading, nitrogen loading, and oxygen uptake rates of the activated sludge.

MLSS

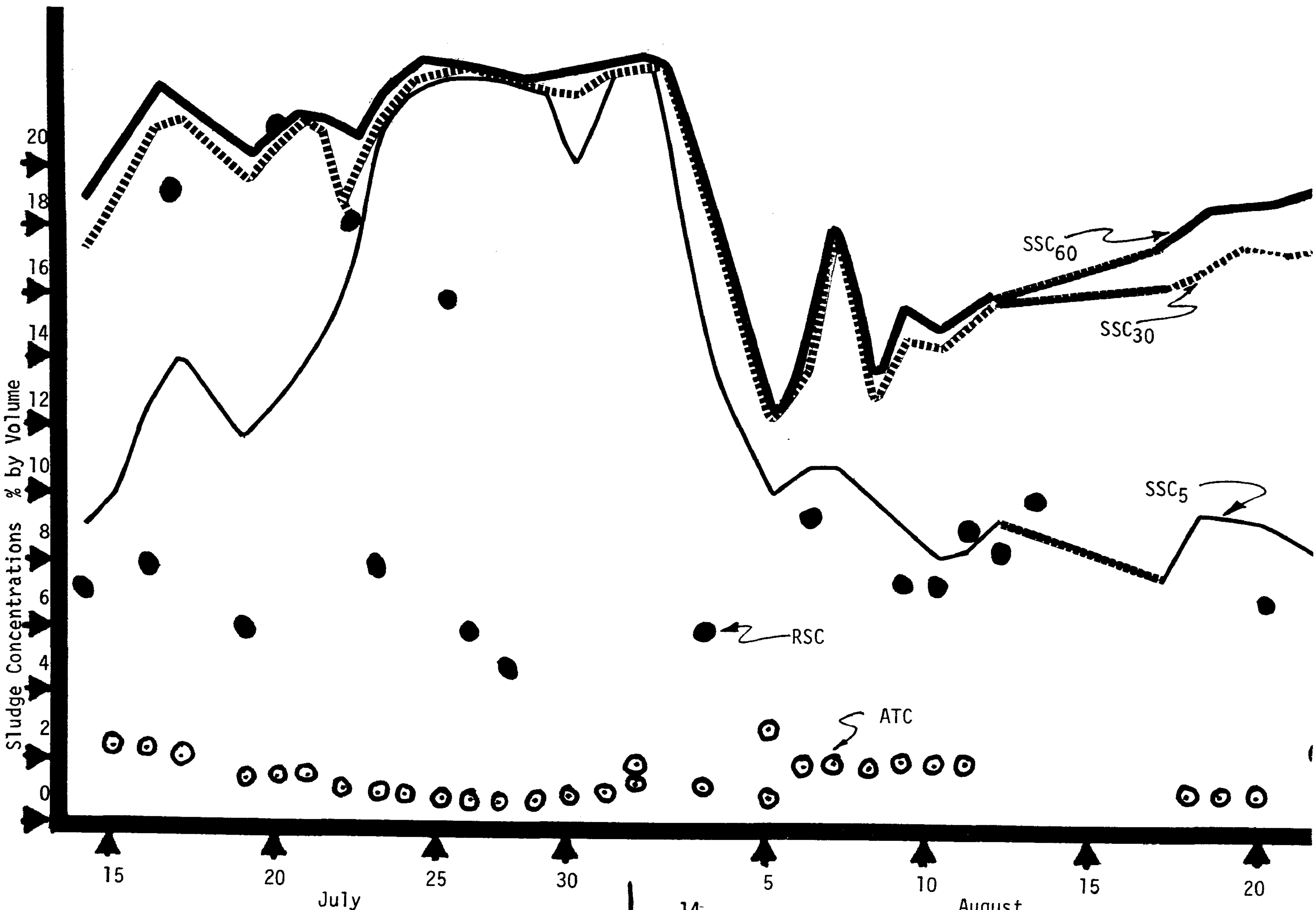
Mixed Liquor Suspended Solids is a mass measurement of the quantity of micro-organisms in the aeration tank. The function of the micro-organisms is to biologically remove soluble and colloidal organic matter from the wastewater. Since MLSS measures only the mass of the micro-organisms, the operator still needs a process control system which evaluates the quality of the activated sludge. The process control system which was introduced to the Park Service staff provides this control.[1, 2] Settleometer trends on Figure 3 provides some insight to the system's ability to adequately control MLSS. The plotted curves represent sludge settling concentrations (SSC) for a given period of time (5 minutes, etc.) in a Mallory settleometer. The other values shown are the return sludge concentration (RSC) and the aeration tank concentration (ATC). All concentration values on this graph are measured in terms of percent by volume.

The first characteristic this graph shows is that in the latter part of July a significant change in sludge settling characteristics occurred. The exact reason for this change is not known but the operators did observe the appearance of gasoline in one lift station on at least two occasions. The introduction of toxic substances such as gasoline could easily produce this response, a deterioration of sludge quality. Park Services employees identified one instance of gasoline contamination and initiated steps to prevent it from recurring. During future operating seasons, Park Service employees will need to make very careful checks on lift station operation to ensure that such incidents do not recur. The presence of gasoline in the collection system is also very hazardous and could result in the formation of explosive vapors. Numerous explosive incidents have occurred in other systems because of gasoline in the collection system.

After EPA's arrival the sludge settling characteristics improved dramatically. The major reason was probably due to the elimination of gasoline from the sewage, but at the same time closer attention was provided to the plant operations due to the increased manpower that was then available. Consequently, more responsive process control was provided and timely changes were made in plant operations. This example illustrates the needs for maintaining efficient process control aids such as the trend chart shown in Figure 3.

Another problem with controlling the MLSS was discovered at the end of the EPA technical assistance period. At that time all the sludge from one oxidation ditch was transferred to the remaining ditch. This was done in an attempt to provide a more optimum food-to-micro-organism ratio in hopes of improving nitrification. However, the MLSS measurements, as found at the overflow weir, did not correspond with the anticipated results. Further checking revealed that some solids separation was occurring in the ditch. It also appeared that this separation occurred only after the MLSS rose above 2000 mg/l as no discrepencies in MLSS data were observed

Figure 3 Settlometer Data - Fishing Bridge - 1976



at values below this level.

Examination of the plans revealed that a potential dead zone appeared at the outlet structure from the ditch. The design of the outlet structure, therefore, could have caused the solids separation problem.

Another potential reason for the solids separation problem may be attributed to the placement of the flow direction baffle. This baffle is located horizontially in front of the rotors and its purpose is to change the direction of the velocity gradient in order to prevent solids from separating. In either case this problem needs further evaluation during the next operating season and the assistance of the equipment manufacturer and the design engineer will probably be needed to correct this problem.

Sludge wasting is the primary operational tool for ultimately controlling MLSS levels. The Fishing Bridge plant was provided with both sludge drying beds and sludge lagoons for dewatering sludge. Due to the short operating season there was no limitation experienced with sludge wasting. The Park Service is cautioned, however, that because the wasted sludge has a high percentage of volatile solids odors from the sludge drying beds and sludge lagoons may be present each Spring.

CLARIFIER OPERATION

Final clarification in an activated sludge plant has the dual objective of separating solids from the treated sewage and concentrating activated sludge so it may be returned to the aeration tank. The hydraulic design characteristics of the clarifier meet established criteria, yet significant problems were still experienced with solids carry over.

The most significant problems were experienced during the periods of poor sludge settling quality, as shown in Figure 3 and, therefore, were not attributed to clarifier design. But problems were still encountered after significant improvement in sludge settling was obtained. These problems were attributed directly to denitrification and indirectly to the efficiency of sludge removal from the clarifier. The clarifier system used at Fishing Bridge requires that activated sludge be scraped to a center well and from which it is pumped back to the aeration system. This type of sludge removal system minimizes the ability to rapidly remove sludge which has settled in the outer portions of the clarifier and consequently, makes the clarifier system very susceptable to denitrification. Once the sludge denitrifies there is an uncontrolled loss of solids because there are no surface skimmers on the clarifier. There is very little the operators can do about this problems, except to maintain a close watch on the solids inventory in the clarifier and try to keep it to a minimum. If the problem persists then surface skimmers may be required to collect the floating solids.

Another problem encountered with the clarification system was with the rim feed and scum removal system. Scum that entered the feed channel did not move around the periphery to the scum collector. Consequently, scum collected in the channel, went anaerobic and produced odor and other nuisance problems. Either a water spray system or a mechanical scum scraper system should be installed.

RETURN SLUDGE SYSTEM

Returning activated sludge to the aeration tank is necessary in order to provide sludge residence times greater that the hydraulic detention time of the system. The return sludge system has to be flexible and highly efficient in order to minimize any adverse effects from the low oxygen concentration environment of the clarifier and to counter changes in sludge settling characteristics.

As discussed previously, the sludge collection system is somewhat limited in its ability to efficiently remove sludge from the clarifier, and also has limited flexibility. Since there are two aeration tanks, there are times that the return sludge should be split to each tank independent of the raw sewage flow split. This was not possible with the plant design. A flow control box was constructed and placed in the headworks channel to provide temporary return sludge control flexibility. It is recommended that a permanent structure be constructed to provide additional flexibility and also to facilitate the measurement of return sludge flow. Any permanent structure should have the capability to regulate and measure return sludge to each basin independently of the other basin. Sliding V-notch gates have been shown to be very effective for this.

SECONDARY PERFORMANCE

The primary objective of secondary treatment is to remove BOD and total suspended solids from the wastewater. Figures 4 and 5 respectfully show influent and effluent trends of BOD and total suspended solids from the summer operating period. Data, based on composite samples, shows that influent BOD strength increased steadily until July, where it leveled out at about 150 - 175 mg/l.

The effluent BOD_5 stayed below 30 mg/l until about July 10. At this time the effluent quality deteriorated very rapidly. This period coincides with the previously discussed disruption in sludge settling and is attributed to the gasoline that was found in the sewer system. Problems continued for the rest of July but by August 12, the effluent BOD was reduced to 34 mg/l. Due to manpower limitations no more BOD_5 data was taken after this time.

Figure 5, as stated, shows weekly averages of the total suspended solids at the plant. Influent total suspended solids values increased much faster than the BOD_5 values and also exhibited a very high degree of variability.

The total suspended solids effluent values were also quite good until July 10. The effluent total suspended solids climbed to over 100 mg/l as the plant performance deteriorated. Unlike the BOD, however, the effluent suspended levels never did return to expected ranges despite the improved settling characteristics of the sludge. The poor suspended solids capture in August coincide with a fairly active nitrification process in the oxidation ditches, so it is suspected that the solids carry over was from denitrification in the final clarifier. The floating solids also had the gray-brown color that is associated with denitrifying sludge.

Except for the denitrification problems, the oxidation ditch effluent BOD_5 and total suspended solids level are expected to be much better than were found. Elimination of toxic substances from the sewer system and improvement in operations should ensure that the plant does significantly better next summer. As recommended earlier, if denitrification cannot be controlled then surface skimmers may need to be installed on the final clarifier.

Figure 4 BOD Performance

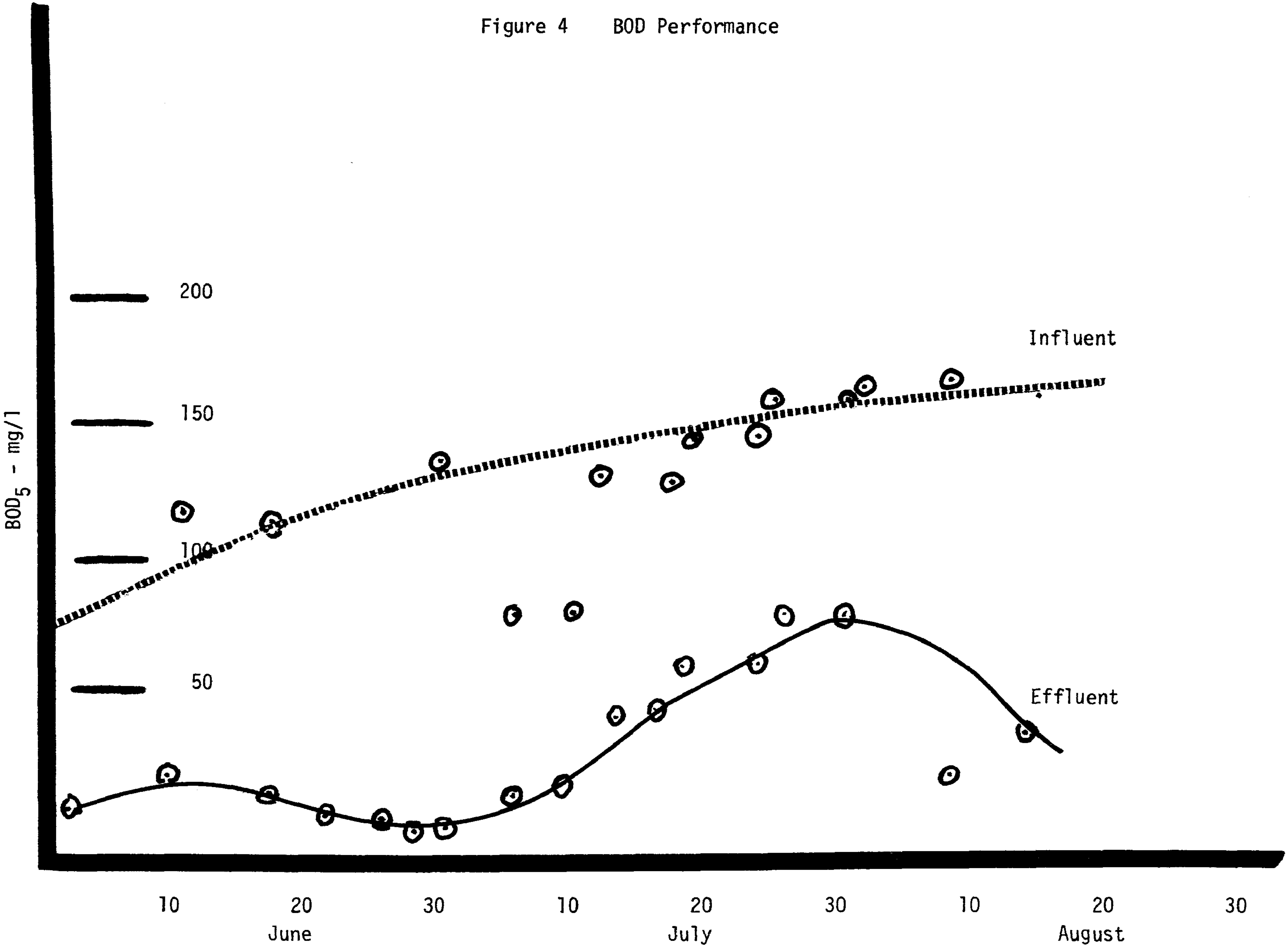
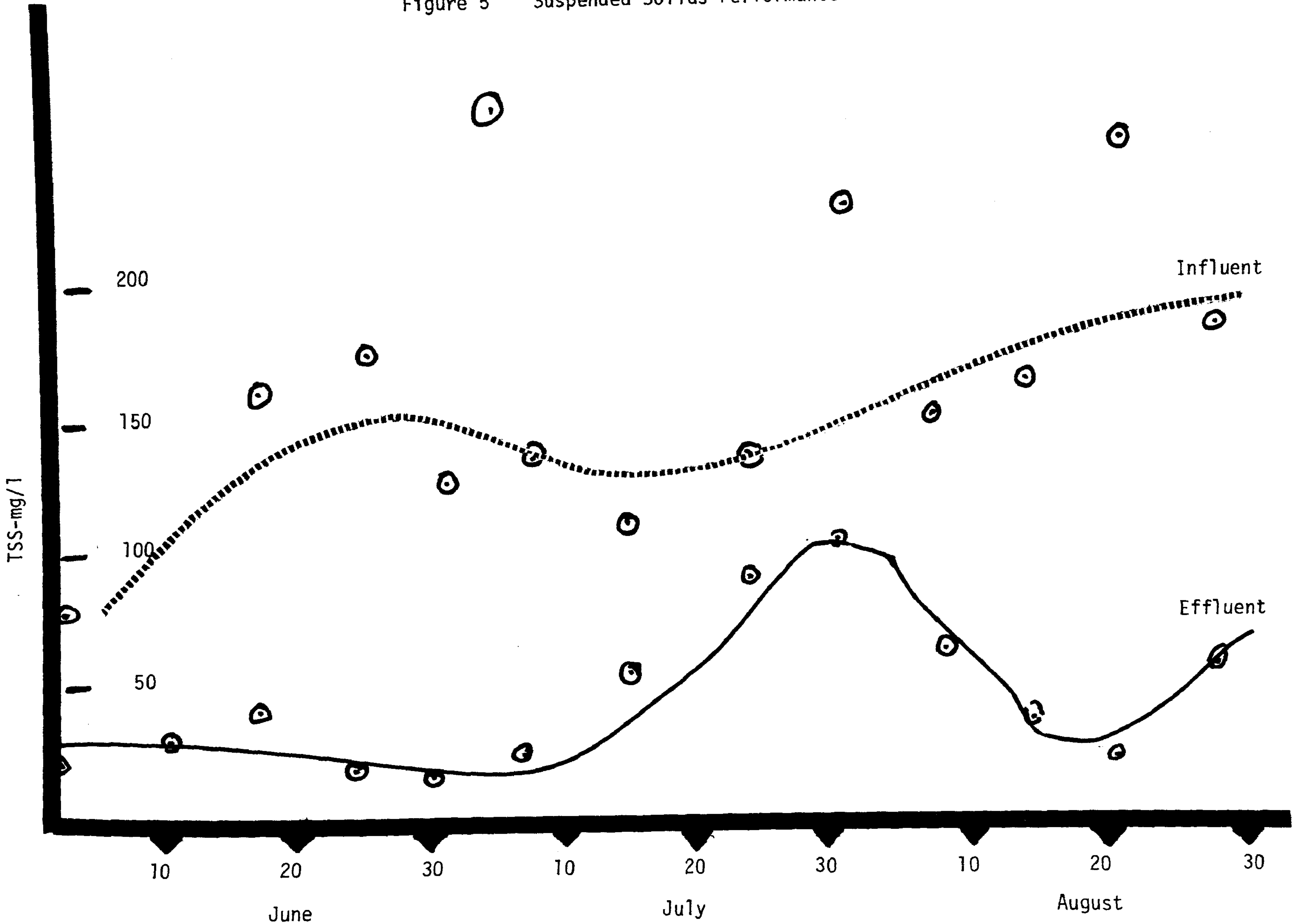


Figure 5   Suspended Solids Performance



LABORATORY CONTROL

Appropriate laboratory facilities are important to provide good information for process control, process performance, and for any special plant evaluations. The lab at the Fishing Bridge plant was spacious and fairly well supplied with necessary glassware and equipment. The major deficiency found was the inability to measure total organic nitrogen. Kjeldahl equipment was purchased for the purpose but it did not arrive in time to be useful.

The second problem was with the manpower available for doing extensive monitoring. The operator was essentially responsible for both operations and laboratory work, so extensive laboratory work was not possible due to other important duties.

The limited manpower is also compounded by the use of seasonal employees and by the start-up and shut-down operations each year. These conditions necessitated the need for very systematic operations, pre-training of new and returning employees and considerable planning before plant start-up commences.

NITRIFICATION

Nitrification is the bacterial process of converting ammonia (NH_3) to nitrate (NO_3^{-2}). Specific bacteria are needed for this process and the "principal genera of importance in biological nitrification are Nitrosmonas and Ntirobacter."[3] Nitrification wastewater treatment plants utilizing biological nitrification have to be specifically designed to provide an environment suitable for these specific bacteria. Specific limits are required for such parameters as temperature, pH, alkalinity, and dissolved oxygen. The nitrifying bacteria are generally considered as very sensitive to changes in environmental conditions. A slight deviation from an ideal condition may produce a significant change in process performance.

Levels of nitrification achieved at the Fishing Bridge plant averaged 70% during the month of August. More critical, however, is the observation that the apparent percent of nitrification ranged from a low of 14% to a high of 92%. Factors which cause this range in efficiencies, are not totally understood, but the following discussion attempts to analyze these factors.

Sewage influent temperatures ranged from 10 - 17 degrees Celsius during the summer. The rate of nitrification is very sensitive to temperature and reaction rates reduce quite appreciably as temperatures are reduced. It would appear, however, the long detention times afforded by the extended aeration process minimized any temperature related problems. Dissolved oxygen has, likewise, been reported as being very critical for nitrification. Generally, it is felt that D.O. levels of at least 2.0 mg/l are needed to support nitrification. Nitrification can occur at lower D.O. levels but again, it is believed long detention times limit any adverse effect on reaction rates of low D.O. levels.

The operators reported that at times the D.O. fell to 0 mg/l. This is unacceptable for maintaining any degree of nitrification. The reason for the total depletion of D.O. is not clearly understood. The operators attempted to regulate the D.O. levels by adjusting the immersion level of the rotors, but this was not always successful. Part of the problem may be attributed to excessive loadings of total nitrogen and BOD_3. Due to the nature of the facilities served, it is possible that very strong wastes were received periodically.

pH is another parameter which influences nitrification reaction rates. Generally, it has been found that pH's of 7.0 to 8.5 are needed to support nitrification. Occasionally nitrification has been observed at a pH of 6.5, but if the pH drops much lower nitrification may be drastically reduced.

pH control is not generally a problem unless there are industrial loads to the facility or unless the wastewater has very little alkalinity. When low alkalinity water is encountered, careful control has to be exerted because for every milligram of ammonia oxidized, 7.14 milligram of alkalinity is removed.

Figire 6 is a profile of the pH data and alkalinity data taken at the Fishing Bridge facility. As can be seen when the plant first started up the plant influent pH and effluent pH were nearly the same. However, by July, when the plant was in full operation, the effluent pH fluctuated quite significantly from the influent values and by late July the effluent pH appeared to be cycling from high of 7 to a low of 6.

Since pH is a function of the alkalinity in the water it is important to look at this parameter. It is especially important considering the stoichimetric requirement of alkalinity in the nitrification process. The alkalinity data noted in Figure 6 shows a similar pattern as the effluent pH, in that at high alkalinity values the pH is not suppressed, but at low alkalinity values the pH drops off very quickly. This data strongly supports the contention that alkalinity is limited in the natural water to such an extent that the buffering ability of the wastewater is lost.

Figure 7 shows the effluent pH data for July and August with the percent ammonia removal superimposed. This data shows quite clearly that within a few days after the pH was suppressed the nitrification efficiency dropped off very rapidly. Likewise, when the pH returned to a much more acceptable range of 6.5 - 7.0 the nitrification efficiency climbed to 90%.

Figure 6 pH and Alkalinity Profiles

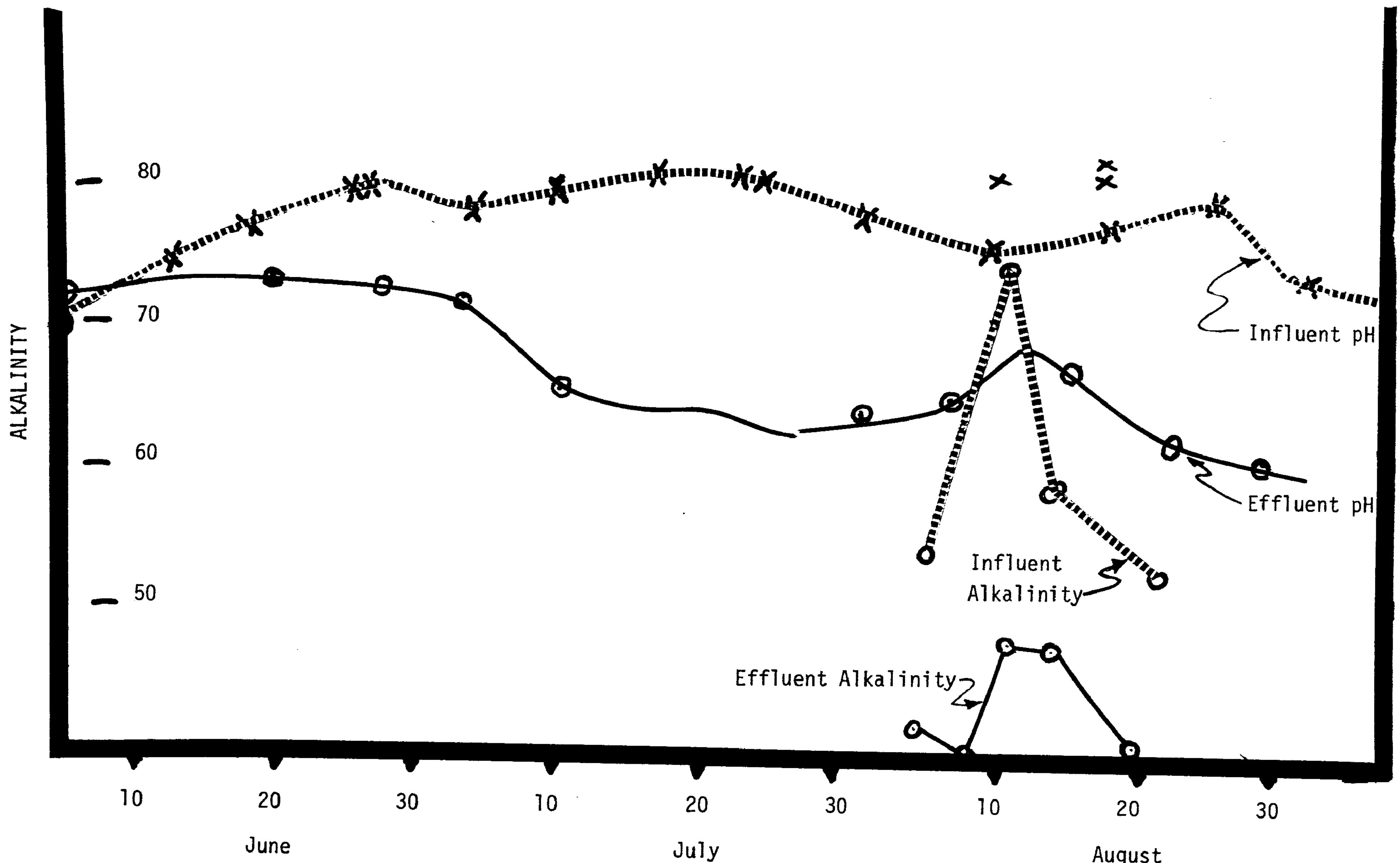
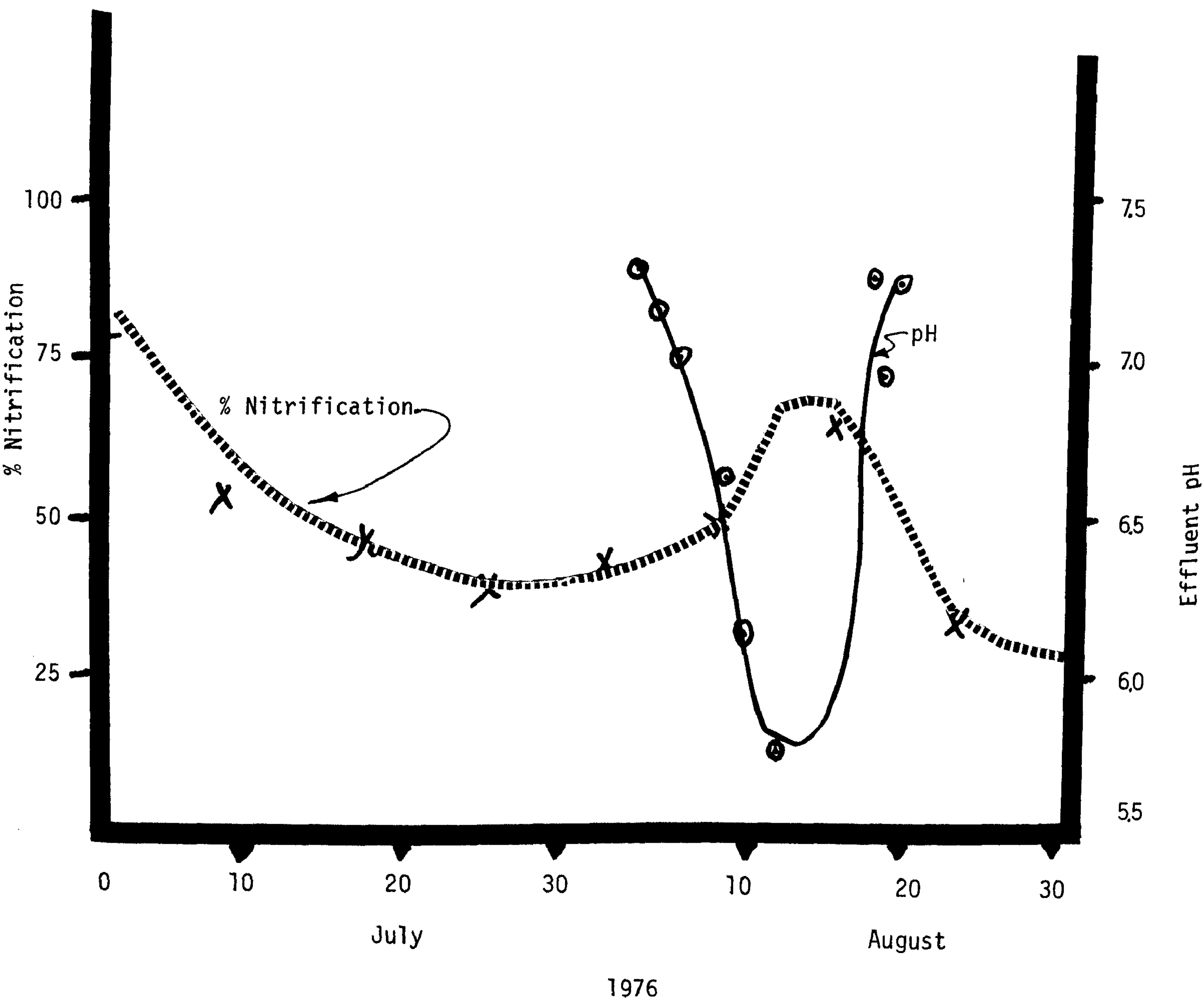


Figure 7   Nitrification as
Influenced by pH



It is recommended, therefore, that the Park Service initiate plans to add alkalinity to the wastewater in order to maintain the nitrification efficiency at optimum levels. Alkalinity additions usually involve adding lime, sodium hydroxide or sodium bicarbonate. Liquid sodium hydroxide is probably the easiest to handle but it is probably more expensive than lime. Sodium bicarbonate is also more expensive than lime but it would require less chemicals and would be relatively easy to handle.

It is recommended that extensive monitoring be maintained on nitrogen loading to the plant. The conclusions drawn from this evaluation are limited to some degree because a nitrogen blance cannot be made due to the unavailability of organic nitrogen data and because the alkalinity data is very limited.

DENITRIFICATION

The denitrification process is the bacterial reduction of nitrates (NO_3) to nitrogen gas (N_2). In order for this process to proceed sufficient numbers of appropriate bacteria are necessary and an environment free of dissolved oxygen must be available. The denitrification process at the Fishing Bridge plant utilizes two covered lagoons.

During the month of August nitrate reduction averaged 38%. As is shown in Figure 8 this reduction was not achieved consistently. Part of the problem was obviously related to the fluctuating nitrification process. However, a critical look must also be given to the facilities available for nitrification. At no time was the D.O. found to be less than 0.5 mg/l in the effluent from the denitrification ponds. This is significant because as was stated earlier, denitrification can only occur in the absence of D.O.

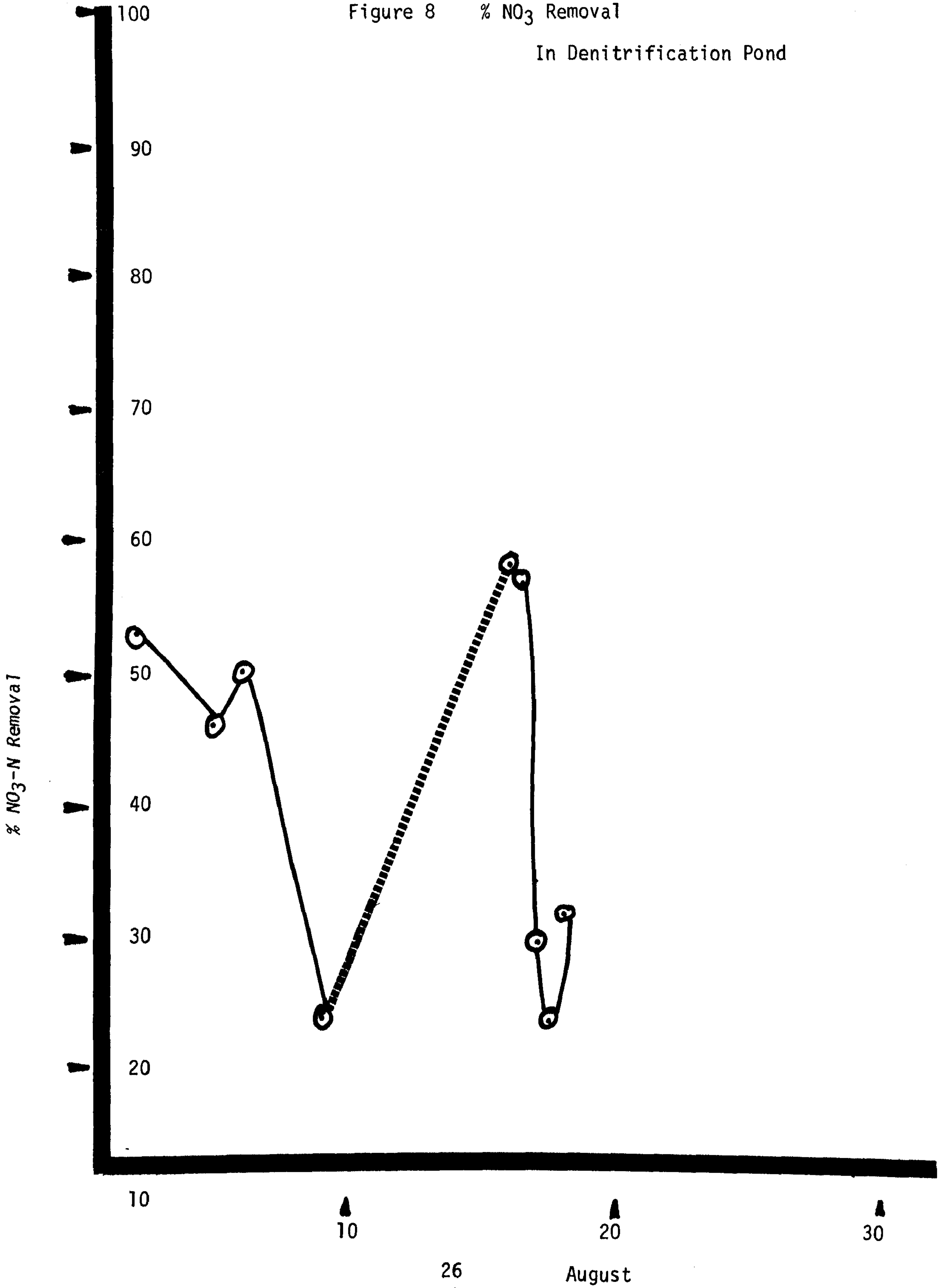
The inability to provide a D.O. free environment can probably be attributed to several reasons. The instability of the preceding nitrification process certainly would not lend to a stable denitryfying process and the cold sewage would inhibit denitrification. However, since both BOD and D.O. were available, there should have been sufficient aerobic activity to deplete the dissolved oxygen. In fact, the BOD leaving the ponds was always so high that no attempt was made to add methanol to the ponds. Since the dissolved oxygen was not depleted it was suspected that the ponds had either significant short circuiting or that the design was not adequate to maintain a sufficient population of denitrifying micro-organisms.

One possible solution, or at least an improvement over the existing system would be to recycle pond effluent back to the pond influent structure. This would have the effect of providing a continuous seed of organisms to the pond influent and thus add to the population of organisms and possibly enhancing the growth rates of the organisms. This solution would not be expected to provide much more than a 10 - 20% increase in NO_3 removals but it also should act as a way to make the denitrification performance more consistent.

Another possible solution would be to fill the ponds with some inert material such as rock, redwood, or plastic to convert the system to a fixed growth denitrification process. This modification would be significantly more expensive, but if designed properly, it should be very effective in converting all the nitrate to nitrogen gas.

Figure 8 % NO_3 Removal

In Denitrification Pond



It is recommended that Park Service employees or their consultant fabricate a pilot plant to operate and study fixed growth denitrification. Oil drums and rock could be used to simulate the environment that would be expected in the ponds. Key parameters that need to be studied and related to the existing ponds would be hydraulic detention time (measured without media), volumetric loading rates (pounds NO_3-N/1000 ft.^{3} of media), surface loading rates (pounds NO_3-N/ft.^{2} of media), recycle rates, temperature effects, and methanol feed rates.

PERCOLATION PONDS

The two evaporation-percolation ponds were designed to dispose of final effluent without a direct discharge to the Yellowstone River. The critical parameters for effective performance are a design based on reliable percolation rates and the ability to maintain the percolation rates at optimum conditions.

Recommended operating practices call for periodically drying of the cells to ensure an aerobic environment. Slime layers on the bottom of the cell when the cells are dry can be removed or rototilled into the soil.

One major problem found at Fishing Bridge was that early spring infiltration completely filled both ponds faster than the water was being percolated into the soil. Later, when the infiltration subsided, water did not percolate fast enough to keep up with the incoming sewage. Consequently, the ponds filled to the point where sewage was backing up into the plant and the dikes were in danger of being flooded. Because the cells never were able to operate as intended (with a drying period) an accurate assessment of the percolation rates was not available. However, having only two cells does not provide much operational flexibility.

The Park Service, decided by the end of the summer to construct an additional cell and to initiate major correction activities of the infiltration problem. Both activities should greatly improve the operability and reliability of the percolation system.

The Park Service, also has a contract with the U. S. Geological Survey to monitor the groundwater around the ponds.

The groundwater monitoring was initiated prior to the operation of the ponds and continued through the first operating season. Results from this study should reveal information about the impact of the pond operation on the level and quality of the groundwater.

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16. ABSTRACT

The National Park Service (NPS) has recently constructed several new wastewater treatment facilities at the Yellowstone National Park. These facilities represent a major commitment by the Park Service to ensure that the high quality of water in the Park is not degraded by the presence of man.

To ensure that their new facilities perform as expected, the Superintendent of Yellowstone National Park requested assistance from the EPA to train Park personnel in process control procedures and to provide performance evaluations of treatment facilities. Specific technical assistance was requested for the nitrification-denitrification facility located at Fishing Bridge. Limited additional assistance was provided at the Old Faithful facility. Two weeks of troubleshooting on-site technical assistance was conducted in August 1976 and extensive follow-up through telephone calls continued for the remainder of the operating season.

17. KEY WORDS AND DOCUMENT ANALYSIS

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