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# Assessment Of The Biolac Technology

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United States Environmental Protection Agency
Office of Municipal Pollution Control

# ASSESSMENT OF THE BIOLAC$^{R}$ TECHNOLOGY

Contract No. 68-C8-0023

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## ACKNOWLEDGEMENT

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## NOTICE

CONTENTS

FIGURES

TABLES

# SECTION 1

## INTRODUCTION

The Environmental Protection Agency (EPA) has supported the application of new technologies to municipal wastewater treatment in order to encourage the development of better and more efficient treatment technologies. This often involves support of the full scale application of a technology on a widespread scale without the benefit of long term field demonstration and evaluation, with acceptance of the potential risk of O&M and/or process problems due to the lack of experience.

The Office of Municipal Pollution Control (OMPC) evaluates specific technologies to determine performance capabilities and to identify weaknesses, limitations in terms of use, maintenance shortcomings and cost effectiveness. Where an evaluation addresses a technology with which there have been problems, they need to be defined in order to correct them or to clearly indicate the limitation of a technology for further consideration and support. Where technologies are successful and show beneficial applications, the EPA is interested in providing current information to encourage their use.

This report addresses the Biolac[R] Wastewater Treatment System. Biolac, which stands for BIOLogical Aeration Chains is a registered trademark of the Parkson Corporation, Fort Lauderdale, Florida manufacturers of the system. It utilizes oscillating, diffused air aeration chains in extended aeration and aerated lagoon treatment processes.

The first full scale installation in the United States was at Fincastle, Virginia in 1986. Little information has been available regarding system operation and experience, except for an assessment report(1) prepared for the EPA in 1986 that relied primarily on the manufacturer's literature. With the startup of several plants since then, an evaluation of the system was recommended in order to investigate any problems that may have been identified with the process, and to determine if the technology was appropriate for application to municipal wastewater treatment.

SCOPE OF WORK

The overall objective of this evaluation was to determine the status of Biolac systems within the United States with regard to equipment configurations, process design and performance, operation and maintenance experiences, equipment and process related problems, and problem resolutions. Based on this evaluation, the USEPA would assess if the technology is appropriate for continued application to municipal wastewater treatment and would define system limitations, if any, that may need to be addressed with new systems.

The scope of work relied on the collection of existing data and contact with operating plants. Information was received from the EPA, the Regional offices, the manufacturer and treatment plant operators through telephone interviews and several site visits. Data regarding the Biolac equipment, treatment system design parameters, and operating conditions were compiled, and problems that were identified with the operation, maintenance and process performance of the systems were defined. Modifications that have been made to the equipment in existing systems or are planned for new plants were reviewed with the plant operators and the manufacturer, particularly as they relate to reported problems.

This report describes the Biolac treatment system and presents information on the present status of installations. The current approach to the design of the treatment system and an evaluation of the equipment and associated problems are included, as well as plant performance and cost information.

# SECTION 2

## SUMMARY AND CONCLUSIONS

The Biolac Treatment System uses the process technology of either extended aeration or flow-through lagoons for the treatment of wastewaters. The key component is the aeration device, which is assembled as a floating aeration chain. A series of diffuser assemblies are suspended from a "chain" of floats stretched across the basin surface. Located near the basin bottom, the rising air bubbles from the diffusers cause the aeration chains to oscillate across the surface. These moving fine bubble diffusers provide sufficient oxygen and keep the mixed liquor solids in suspension. The Biolac-R configuration incorporates an integral clarifier and sludge return and the Biolac-L is a simple flow-through lagoon and polishing basin.

The Biolac System was developed in Europe during the mid 1970s with the manufacturer reporting over 200 installations worldwide. By late 1989, there were greater than 50 Biolac systems operating or in the design/construct stage in the United States. Forty-five of these are municipal facilities, of which 32 are Biolac-R and 10 are Biolac-L configurations (the other three are modified systems). Most operating plants are the R configuration (19 of 27 operating plants). These also have longer operating histories, with the first facility going on-line in 1986.

Operating experience is limited because the technology is relatively new to the United States and most plants have only recently come on-line. The long term reliability of system components and performance could not be fully evaluated within the context of this report.

The systems are sized conservatively relative to conventional extended aeration and flow-through lagoons. Loadings to the Biolac-R extended aeration system are typically 7 to 8 lbs BOD/d-1,000 $ft^3$, with an F/M ratio of 0.03 to 0.1 lbs BOD/lb MLVSS; the hydraulic residence time is typically 24 to 48 hours.

The flow-through Biolac-L lagoon systems are designed for a hydraulic residence time of 6 to 20 days.

Greater than half the plants have design flows between 0.5 and 2.0 mgd. Only two plants have a design flow greater than 2 mgd (both are 4.0 mgd). The remaining are less than 0.5 mgd design capacity. Most plants are located in the South, with 14 of the 27 operating in Arkansas and Alabama.

Operating plants are consistently meeting permit requirements. Of 13 plants for which performance data were available, average effluent BOD ranged between 5.1 and 20.8 mg/L., representing removals of 91 to 98 percent. The TSS effluent levels ranged between 6.7 and 34.8 mg/L, with removals of 86 to 96 percent. Most plants were accomplishing full nitrification.

A major claimed advantage of the systems, low cost operation due to low power requirements for mixing, appears to be realized based on an average reported horsepower for aeration of 45 HP/million gallons of basin volume. This is significantly less than required by conventional fixed aeration systems. Whereby aeration horsepower in extended aeration systems is generally set by mixing requirements for fixed aeration systems, the Biolac aeration system sizing is set by oxygen requirements, resulting in significantly less power input than conventional systems.

Problems that have been encountered with the Biolac system have related primarily to equipment materials, installation and maintenance. Various problems which centered on materials of construction and hardware design resulted in corrosion failures, excessive wear, and clarifier return sludge clogging problems. These appear to have been adequately addressed and solved by replacement, repair, and/or redesign.

The fine bubble diffusers have operated well. Where problems have been noted, these were limited and generally due to improper installation (clamp materials and adequate fastening), and clogging/failure of the diffuser sheath. Proper, routine flexing of the diffusers appears to be an essential maintenance task to assure the performance and life of the diffusers.

Total capital construction costs, based on data (received from the manufacturer) for 13 plants averaged approximately $1.30/gpd design capacity with a range of $0.84 to $2.11/gpd for plants greater than 0.5 mgd. This excluded the cost of land.

Overall, the Biolac system, installed in the Biolac R and L configurations, is a reliable, effective wastewater treatment process. The aeration chain system and integral clarifiers are cost effective because of low power and operation and maintenance requirements, and are appropriate to the application of extended aeration process technology.

# SECTION 3

# RECOMMENDATIONS

The Biolac Wastewater Treatment system should be considered a viable, cost effective, alternative extended aeration or flow-through lagoon process for application to municipal wastewaters.

Application of the Biolac technology should incorporate several elements that affect its performance and O&M requirements. These include effective screening of coarse solids, routine flexing of the diffusers, skimming devices in the integral clarifier (although the need for this may be influenced by the size of the plant and the acceptable level of operator attention), use of corrosion resistant materials (coal tar epoxy painted steel or stainless steel) for appropriate metallic parts that contact the water, sludge withdrawal systems to minimize the potential for clogging (addressing air lift pipe sizing, suction line hole sizes and spacing), and effective design of the blower systems for noise control and air filtration.

Continued evaluation of O&M requirements and experience is recommended. Current experience is limited because most plants are only recently installed. Attention should be paid to the long-term operation and the demonstrated unit life of the Wyss diffusers in the Biolac treatment system applications. The overall operation and maintenance costs for the system, and winter operational reliability should be assessed as experience is gained with the systems.

An evaluation of one modified Biolac system, the wave oxidation modification for biological nutrient removal, is recommended. The apparent low power requirements for the system suggests that it may be a viable alternative nitrogen removal system. Particular attention should be paid to system control and process stability.

# SECTION 4
# DESCRIPTION OF THE BIOLAC SYSTEM

## INTRODUCTION

Biolac stands for Biological Aeration Chain systems. Manufactured by the Parkson Corporation of Fort Lauderdale, Florida, the system utilizes a moving fine bubble aeration device and earthen basin construction, in the application of low loaded extended aeration and aerated lagoon process technologies. There are more than 200 systems reported in operation, primarily in the United States and Europe.

The basic Biolac process layout consists of a basin or lagoon equipped with floating aeration chains. A polishing basin following the aeration basin is optional, but is generally recommended by Parkson when designing a new facility and assuming land is available. This may reduce operator requirements and will provide greater process stability, particularly in cases where stringent effluent limits are imposed. The polishing basin may be aerated, unaerated or split into aerated and unaerated zones. The process goal is direct discharge of clarified effluent of secondary quality or better. Nitrification can be accomplished and a process option is available for nitrification-denitrification.

The innovative aspects of the Biolac system lie in the approach to aeration and mixing. The key component is the floating aeration chain. This is a series of diffuser assemblies that are suspended from a "chain" of floats stretched across the basin surface. The chains oscillate across the basin surface, propelled by the rising bubbles from the diffusers; this moves the diffusers through the liquid, thereby mixing and aerating the wastewater simultaneously. When the chain moves to full tension in one direction, the diffuser assemblies swing slightly and cause the chain to move in the opposite direction, repeating the oscillation cycle. The chains typically move laterally 8 to 30 feet (for activated sludge applications) under normal operating conditions, mixing the volume of water in the traversed path and maintaining the mixed liquor solids in suspension. In cases where less mixing is required (e.g. flow-through lagoons) the chain spacing will be wider, with greater lateral movement.

The reported advantages of the system lie primarily in the lower energy requirement, when compared to conventional extended aeration systems, to maintain mixing. Additionally, the systems are relatively stable due to low organic loadings and long hydraulic retention times. Long solids retention times in the extended aeration system will require smaller quantities of well digested sludge to be handled, simplifying this part of the plant. Low maintenance is also suggested for the blowers, diffuser assemblies, and integral clarifier components.

This section presents a description of the system configurations, and the elements of the unit operations that comprise the system. A discussion of the status of Biolac facilities in the United States is presented, addressing the types and size of facilities currently in operation.

## SYSTEM CONFIGURATIONS

Alternate configurations of the Biolac system are applied, dependent upon the site requirements. The Biolac-R system is an extended aeration/activated sludge process, and the Biolac-L system configuration is an aerated flow-through lagoon system. A third configuration that has very recently been developed is known as the Wave Oxidation Modification; it operates under a modified aeration pattern to achieve anoxic zones for denitrification. Floating aeration chains have also been installed in existing lagoon systems as a retrofit, replacing existing fixed aeration equipment.

### Biolac-R System

Figure 1 illustrates the typical Biolac-R arrangement. It is an extended aeration activated sludge process, generally designed more conservatively than

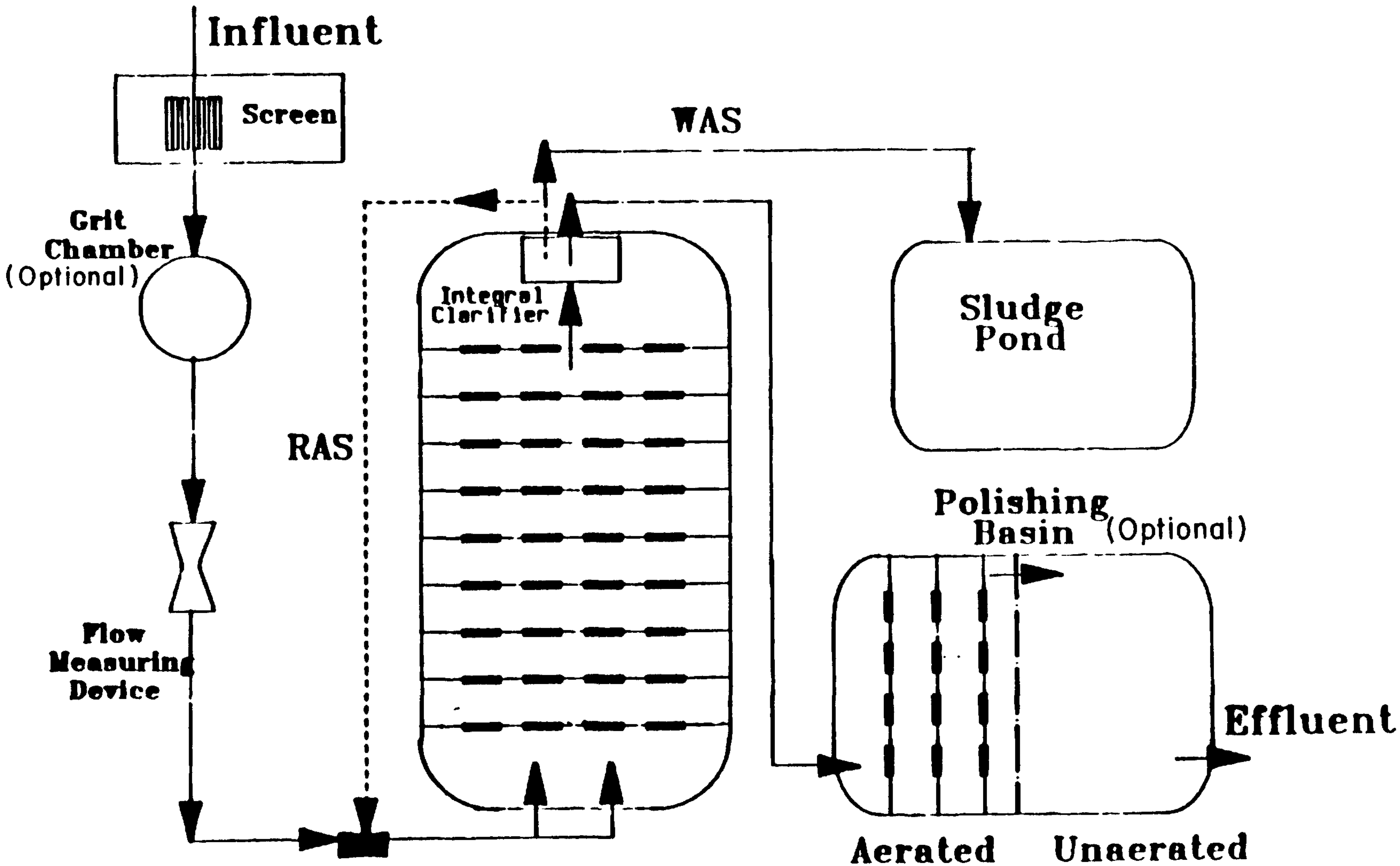



FIGURE 1. TYPICAL BIOLAC-R FLOW DIAGRAM.

a conventional extended aeration system. Preliminary and primary treatment are not components of the system, although, as will be discussed later, effective screening can contribute to successful operation and lower maintenance of the Biolac system, as with any secondary treatment plant. It is generally recommended by the manufacturer.

Lagoon/basin depths range from 8 to 20 feet. Depths on the lower end of the range are generally designed in cases where deep basin construction is impractical for hydraulic, geologic, or cost reasons. Depths on the higher end of the range are typically used, since oxygen transfer efficiency by fine bubble aeration is greater with the increased diffuser submergence. Basin side slopes are engineered based upon soils and construction considerations. For the Biolac-R basin, in which high mixed liquor solids are maintained, sidewall slopes in the order of 1.5 to 1 (horizontal to vertical) are optimum to minimize the required mixing energy.

Clarification and sludge return are provided to maintain appropriate mixed liquor solids levels. Integral clarifiers are used in most systems, although existing external clarifiers may be used with older systems where lagoons were retrofitted with the Biolac aeration systems. A waste sludge pond is also provided with the Biolac-R system; this is generally small because of the limited sludge production in these low loaded systems. Digestors, or other sludge conditioning processes, would generally not be needed due to the stability of the waste sludge.

A polishing basin is optional, but would be located after the aeration basin. Although not required, it is recommended by the manufacturer for additional stability affecting effluent polishing and additional solids settling. This is particularly the case when there is little operator attention, restrictive effluent standards, and/or high hydraulic variability that may influence the integral clarifier performance. The polishing basin is usually divided by a floating curtain wall, with aeration in the first section and quiescent settling in the second section.

Biolac-L System

The Biolac-L system operates as an aerated flow-through lagoon. Its configuration is as shown on Figure 1, except that it does not have clarification and sludge return, and a waste sludge pond is not needed. A polishing basin is required for the Biolac-L, with two to four days HRT (based on average flow) and storage capacity for sludge. As with the Biolac-R system, the polishing basin can be divided into aerated and unaerated sections.

Wave Oxidation Modification

The Wave Oxidation Modification is a combined carbon oxidation, nitrification-denitrification process. The process employs a Biolac-R system operated at low (0.5 mg/L or less) dissolved oxygen levels (0.5 mg/L or less through the entire basin) and automatic control of each aeration chain's air flow. Air is throttled back to progressively alternating groups of aeration chains. This sets up a situation in which several oxic and anoxic zones alternate in the aeration basin as illustrated on Figure 2. After a period of time (approximately 15 minutes), the air flow is redistributed and the low air flow chains receive high air flow, maintaining the mixing requirement for the mixed liquor solids. A dynamic moving "wave" of alternating oxic and anoxic zones is formed.

The Wave Oxidation Modification has been employed in more than a half dozen wastewater treatment facilities in Europe. There is one plant operating in the United States, located in Decatur, Arkansas. It handles a combined domestic and poultry waste high in organic nitrogen. The plant has been operating since mid 1989 and has reported good performance.

OTHER APPLICATIONS OF BIOLAC FLOATING AERATION CHAINS

The Biolac floating aeration chains have also been used outside the application of a specifically designed R or L system, primarily in retrofitting existing aeration systems. In Ellsworth, Kansas, for example, floating chains

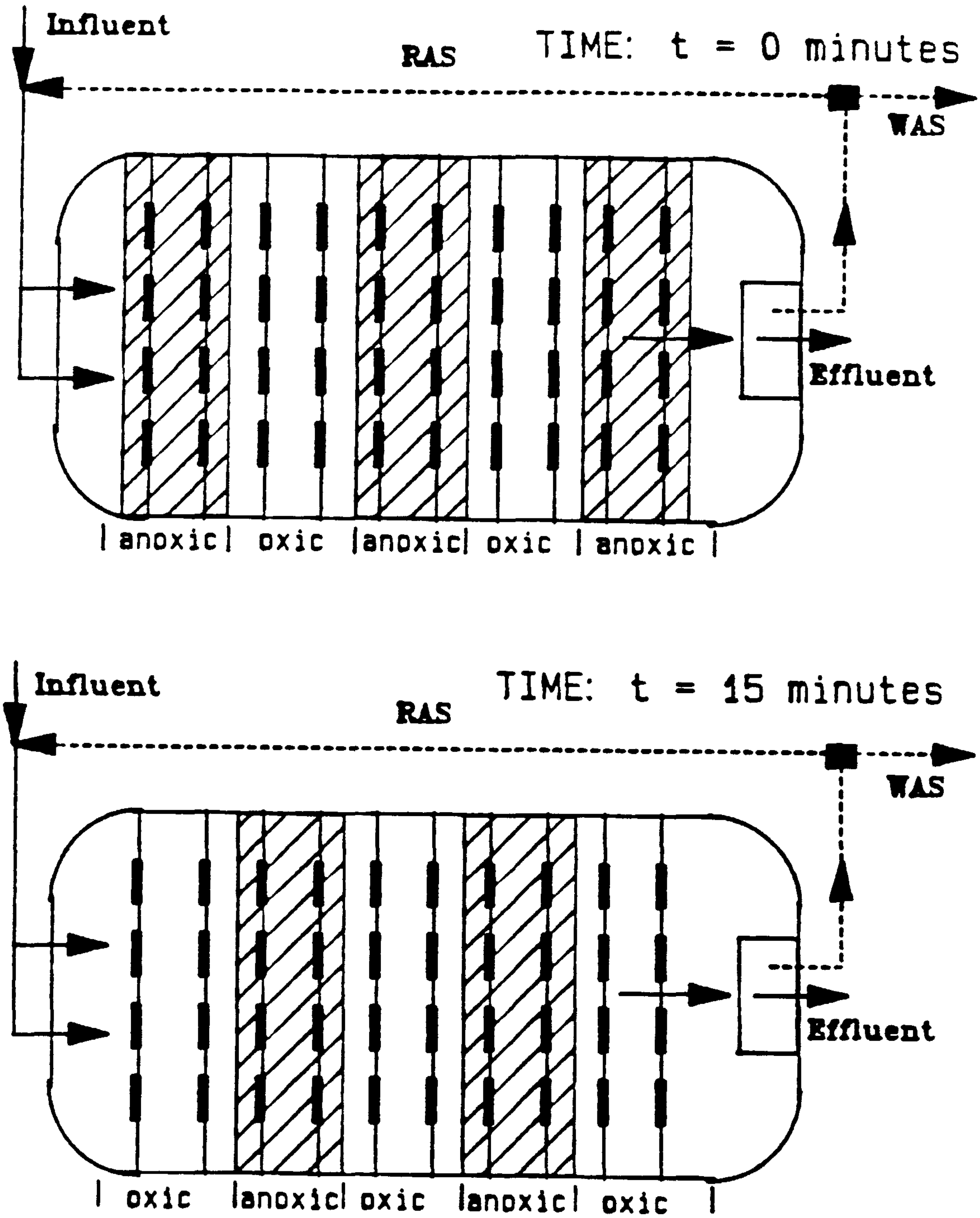



FIGURE 2. WAVE OXIDATION MODIFICATION OF THE BIOLAC-R SYSTEM.

have been used in an aeration basin prior to stabilization pond treatment. Aeration chains have also been retrofitted to an existing aerated lagoon treatment facility in Excelsior Springs, Missouri, where the aerated lagoon is followed by an overland flow treatment system. The Biolac aeration chains have been in operation in a previously existing plant at Durant, Oklahoma for over a year and a half; the aeration chains replaced the fixed aeration equipment in the first one-third section of two basins operated in parallel. A polishing basin with aeration chains was also added to the system. These changes allowed this plant to meet discharge permit limits. Several Biolac equipped aeration basins are currently being planned to provide nitrification of a trickling filter plant effluent at the 55 mgd wastewater plant in Witchita, Kansas.

## UNIT OPERATIONS

The major components of the Biolac systems are the aeration equipment and the clarification/solids handling elements. The following discussions present a description of these unit operations.

### Aeration System

The aeration system consists of the floating aeration chains and diffuser assemblies and the blowers and air piping manifold.

#### Aeration Chains and Diffuser Assemblies

The heart of the Biolac system is the floating aeration chain assembly. A schematic of this assembly is shown on Figure 3. A restraining chain connects the end floats of the aeration chain with a hook to an anchor post mounted on the basin bank. Tension adjustment is made by simply increasing or decreasing the length of chain between the last float and the anchor post. Flexible hose connects the air header to the air pipe of the float assemblies. The hose is a multi-layered construction with inner and outer layers made of PVC, with fiber reinforcement for strength. The outer layer is also impregnated with plasticizers and U.V. inhibitors.

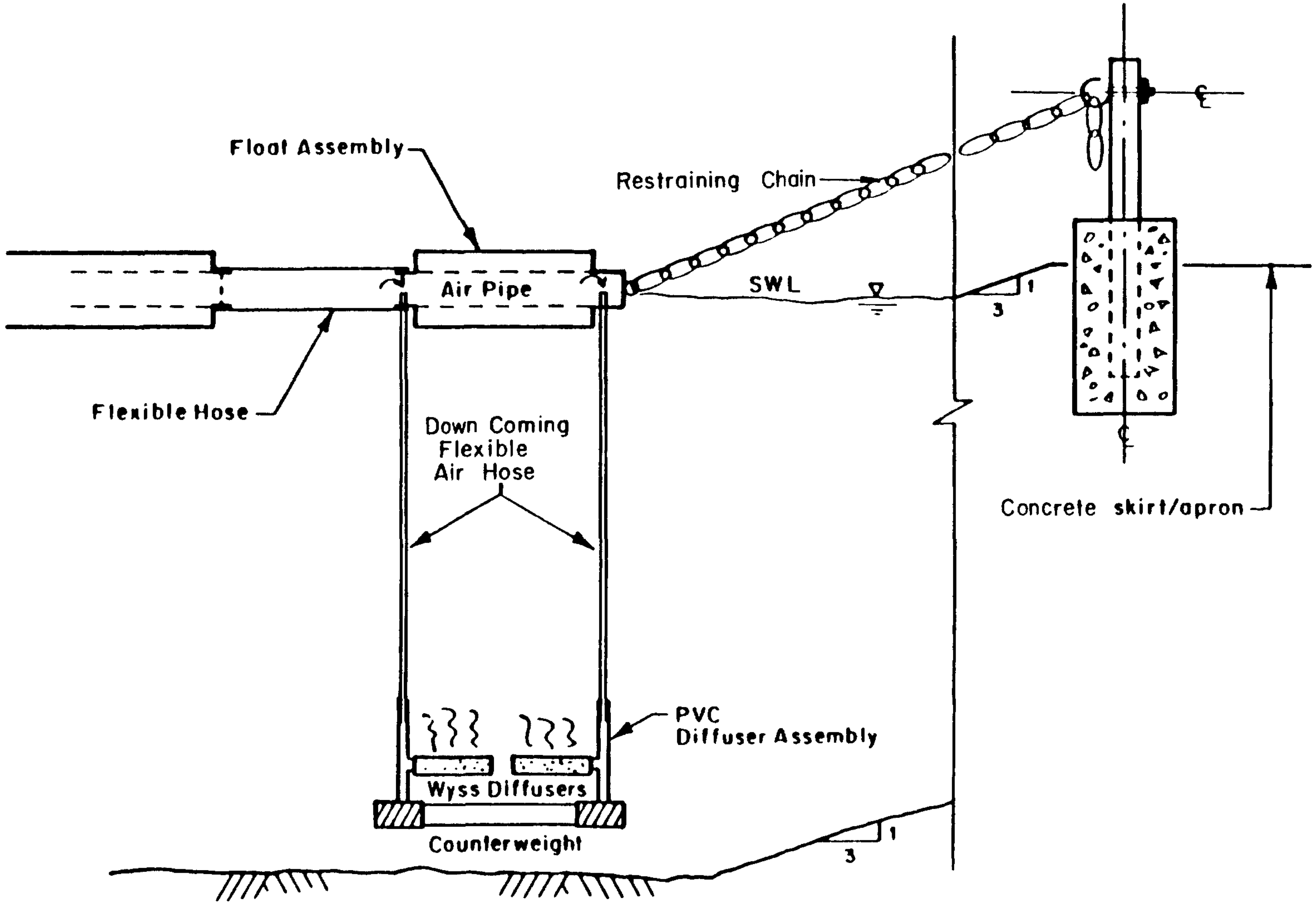



FIGURE 3. BIOLAC AERATION CHAIN DETAIL.

The float assembly consists of the float, air pipe, two downcoming air tubes and a fine bubble diffuser/counterweight assembly. The float is a polyethylene shell filled with closed-cell polyurethane foam. The float is designed to remain buoyant, even in the event that the entire chain becomes filled with water. The float shell material contains inhibitors to resist ultraviolet deterioration.

The air pipe runs through the center and extends out of the ends of each float. Hose connection points are located at both ends of the float for joining the air pipe to the downcoming air tubes. The air pipe and connections for new systems are made of polyethylene and fastened with stainless steel clamps.

The downcoming air pipes are connected to the diffuser/counterweight assembly; clearance between the basin bottom and the diffuser centerline is typically one foot. The diffuser/counterweight assembly is constructed of PVC, and supports either two, four or six diffusers. The counterweight keeps the assembly submerged when the diffusers are charged with air.

Wyss® Flex-A-Tube® diffusers (manufactured by Parkson) are used, consisting of a plastic frame, diffuser sheath, retainer pad, backflow check valve and stainless steel fastening hardware. The diffuser sheath is composed of modified PVC soft plastic material. When air is introduced to the diffuser, the flexible sheath expands and thousands of tiny aperatures open, each releasing a jet of fine bubbles. When air flow to the diffuser is disrupted, the liquid head collapses the sheath and closes the apertures, preventing fouling from backflow of solids. When air flow to the diffusers is re-established, any solids, slime or carbonate build-up on the surface are displaced by the flexing action of the sheath.

The EPA has studied[2] the Wyss® diffusers and classified them as fine bubble diffusers. However, the manufacturer notes that the air bubbles can approach medium size when the diffusers are fully charged with air. The operating range for each diffuser is from 1 to 5 scfm with a typical operating air flow of 3 scfm. Parkson estimates a diffuser life expectancy of five years under normal conditions with recommended maintenance. Maintenance consists of weekly to bi-weekly diffuser flexing, a procedure by which the aeration chain air flow is shut off, the air remaining in the chain is bled off (by opening a ball relief valve on the air header), and the chain is then recharged with air.

Blowers and Air Manifold

Positive displacement rotary type blowers, designed for continuous service, are generally supplied. For larger systems, multistage centrifugal machines may be economical and are considered. In most designs, three blowers, each capable of handling 50 percent of the air requirement, are provided; thus, two blowers will be in service at capacity, with one on standby. The blowers are fitted with an inlet filter and silencer, a discharge silencer, a pressure relief valve, a discharge check valve, an isolation butterfly valve and a discharge pressure gauge.

Connection between blower discharge and the aeration chains is through the air piping manifold. The pipe is normally laid adjacent to the basin, running perpendicular to the aeration chains. A header pipe off the manifold is located at the point of connection to each aeration chain. Each header contains a butterfly valve to isolate each aeration chain on the air piping manifold for maintenance and a pressure relief valve for depressurization of the aeration chains. Each header pipe is supported by a concrete thrust block and a flexible hose is used for header to float connections.

Clarification and Solids Removal

The Biolac-R and Biolac-L systems provide for solids/liquid separation. An integral clarifier is typically incorporated with the R system, while a quiescent zone is provided in the polishing basin of the L system.

Integral Clarifier

The integral clarifier section is defined by two concrete walls, and a floating partition wall which separates the clarification zone from the aeration zone. Figure 4 presents a cross-sectional view of the clarifier. The rear wall of the aeration basin serves as the back wall, and the two parallel concrete walls extend out into the basin. The floating partition wall which separates the aeration basin and the clarification zone, is fixed across the open end between the two sidewalls.

The partition wall is fixed to the sidewalls to permit flow to enter the clarifier only under the length of the partition, minimizing short- circuiting. A flocculating rake, which moves along the length of the clarifier sludge trough, is provided for sludge concentration and distribution. Sludge is withdrawn by an air lift pump. Overflow weirs are provided for effluent discharge to the polishing basin. The weir design loading rate is typically less than 10,000 gpd/lineal foot of weir length at average flow.

The air lift sludge removal system consists of an air blower (or air from the main aeration blowers is used), air piping, sludge suction piping, gravity flow sludge trough, and an RAS/WAS sludge control valve or gate. A positive displacement blower supplies the required air to lift sludge from the hopper bottom to a concrete gravity flow sludge trough into a sludge flow control box. The suction pipe, typically made from PVC, has holes spaced appropriately along its length for removal of the sludge. Two gravity flow pipes from the sludge control box convey the settled sludge to either the sludge pond or back to the head of the plant to be mixed with the plant influent. An electrically activated and time controlled sludge gate directs sludge flow to either the RAS or WAS pipe.

Biolac-L Settling Basin

A minimum of one day detention time in the unaerated section of the polishing basin is typically provided. The volatile solids (about one-half the

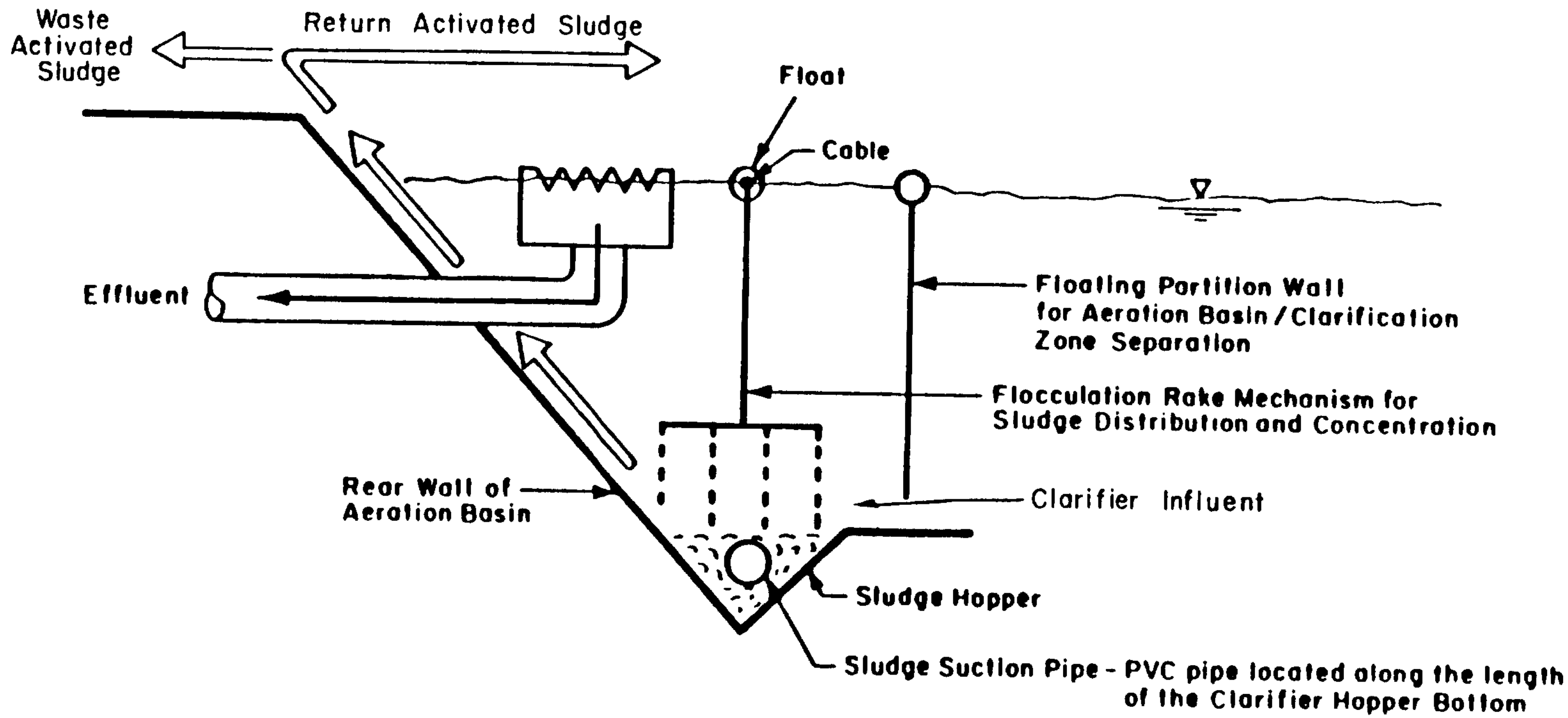



FIGURE 4. SCHEMATIC INTEGRAL BIOLAC-R SYSTEM CLARIFIER.

total solids) settling in the basin are further degraded by about 40 to 60 percent under anaerobic conditions that develop in the settled sludge zone at the bottom of the basin. The polishing basin is sized to provide up to one to two decades of sludge storage within this zone. At the time when it becomes necessary to remove the sludge, one of various methods can be selected to remove sludge, including a floating dredge, dewatering and bulldozing, etc.

## STATUS OF THE BIOLAC SYSTEM

The Biolac Treatment System was developed in Europe in the mid-1970s; by 1985, there were approximately 100 installations throughout Europe and around the world. The Biolac system was first introduced to the United States in 1985 with a pilot test at the Miami Conservancy District located in Franklin, Ohio. The first full-scale floating aeration chain system was started in January 1986 for the treatment of a dairy waste; approximately one month later the first Biolac domestic wastewater treatment plant was put into service at Fincastle, Virginia. These two installations, as well as many other early U.S. installations, were retrofits of existing plants.

Recent Parkson information(3) lists approximately 200 Biolac installations operating in the U.S., Europe and other parts of the world. There were 59 domestic and industrial U.S. installations either on-line, under construction or in the design phase as of September 1989. Recently (March 1990), Parkson has reported selling an additional 12 systems for domestic applications and two for industrial clients. The 59 installations are spread among 20 states, with most located in the eastern half of the U.S. Figure 5 locates the U.S. municipal installations.

### Municipal Biolac Treatment Systems

A listing of municipal plants is presented in Appendix A. A description of the system and a discussion of the operations and performance of each plant is included. This list is based on information compiled from telephone interviews, site visits, or discussions with the manufacturer. Table 1

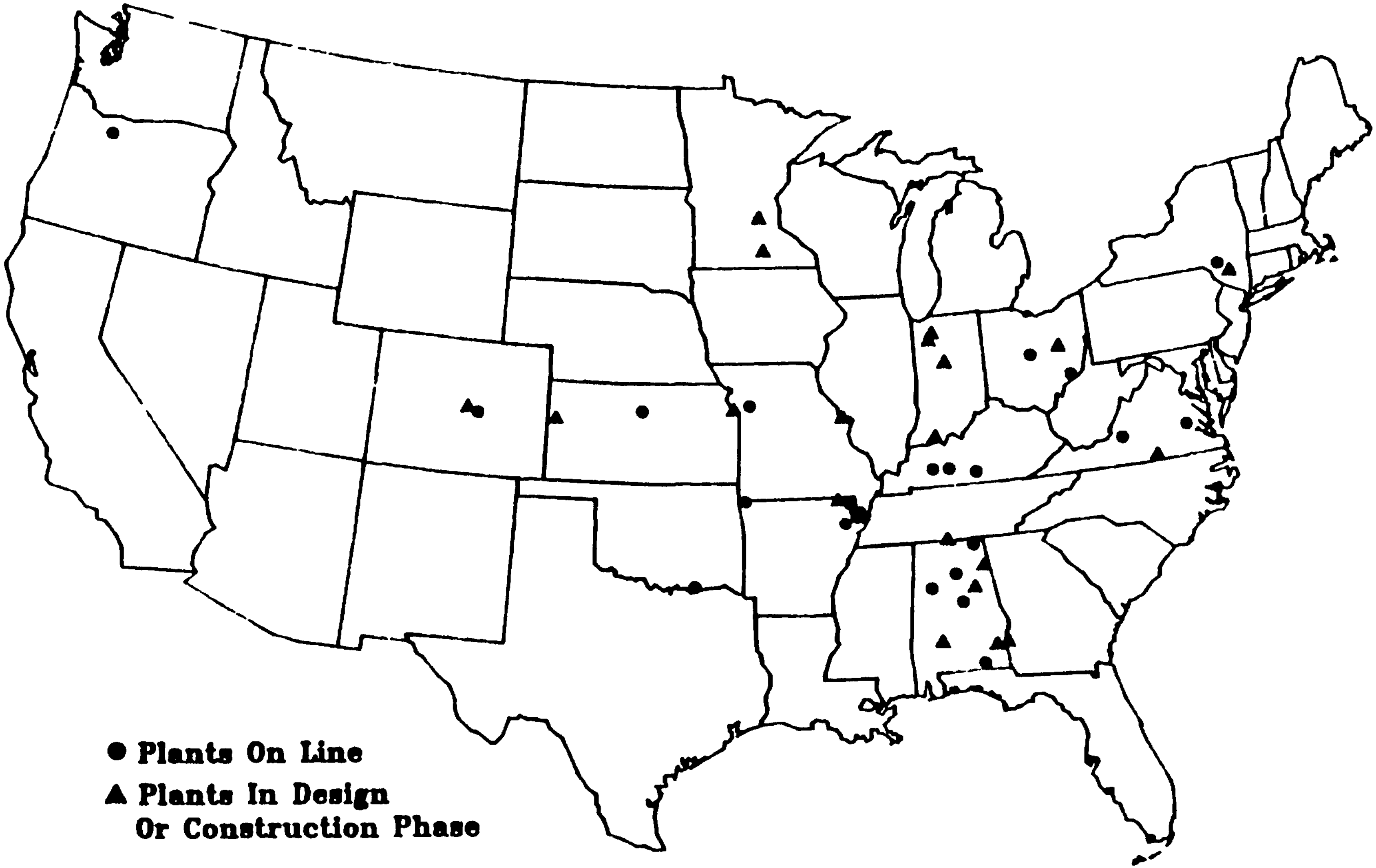



FIGURE 5. BIOLAC TREATMENT SYSTEM - U.S. INSTALLATIONS (MUNICIPAL WWTP'S ONLY).

TABLE 1. SUMMARY LISTING OF MUNICIPAL WASTEWATER PLANTS WITH BIOLAC

| Plant | Design Flow (mgd) | Plant Type | Status | Startup |
|---|---|---|---|---|
| Alabama (10) | | | | |
| Ardmore | 0.35 | R | D/C | March 1990 |
| Berry | 0.15 | R | O | August 1989 |
| Camden, North | 0.22 | R | O | August 1990 |
| Cedar Bluff | 0.30 | R | O | April 1990 |
| Clayton | 0.40 | R | O | May 1990 |
| Columbiana | 0.75 | R | O | April 1989 |
| Hanceville | 0.57 | R | O | March 1989 |
| New Brockton | 0.18 | R | O | Summer 1987 |
| Oxford | 1.0 | R | D/C | June 1990 |
| Stevenson | 0.75 | R | O | Summer 1987 |
| Arkansas (7) | | | | |
| Bay | 0.15 | R | O | March 1989 |
| Blytheville, North | 0.80 | R | O | April 1989 |
| Blytheville, West | 1.50 | R | O | April 1989 |
| Blytheville, South | 1.40 | R | O | April 1989 |
| Decatur | 1.35 | W | O | Summer 1989 |
| Maynard | 0.06 | R | D/C | February 1990 |
| Piggott | 0.60 | R | O | April 1989 |
| Colorado (2) | | | | |
| Colorado Springs | 0.9 | L | O | March 1989 |
| Monument | 1.3 | L | D/C | July 1990 |
| Georgia (1) | | | | |
| Quitman | 1.3 | L | D/C | January 1990 |
| Indiana (4) | | | | |
| Ferdinand | 0.47 | R | D/C | Spring 1990 |
| Remington | 0.28 | R | D/C | Spring 1990 |
| Rensselaer | 1.2 | R | D/C | Summer 1990 |
| Cambridge City | 0.8 | R | D/C | Summer 1990 |
| Kansas (3) | | | | |
| Ellsworth | 0.5 | L* | O | April 1988 |
| Wellsville | 0.18 | L | D/C | Spring 1990 |
| Witchita | 54.4 | ** | D/C | Summer 1990 |
| Kentucky (3) | | | | |
| Edmonton | 0.51 | R | O | April 1989 |
| Greenville | 0.75 | R | O | April 1988 |
| Morgantown | 0.50 | R | O | Summer 1988 |
| Minnesota (2) | | | | |
| LeSueur | 0.9 | R | D/C | May 1990 |
| Wells | 0.55 | L | D/C | November 1989 |

TABLE 1. SUMMARY LISTING OF MUNICIPAL WASTEWATER PLANTS WITH BIOLAC (Continued)

| Plant | Design Flow (mgd) | Plant Type | Status | Startup |
|---|---|---|---|---|
| Missouri (2) | | | | |
| St. Louis | 4.0 | L | D/C | November 1989 |
| Excelsior Springs | 2.4 | + | O | 1985 |
| New York (2) | | | | |
| Livingston Manor | 0.8 | R | O | 1986 |
| Rock Hill | 0.22 | R | D/C | Fall 1990 |
| Ohio (4) | | | | |
| Coalton | 0.046 | R | D/C | Fall 1990 |
| Miami Conservancy | 4.0 | R | O | October 1989 |
| Frazeysburg | 0.18 | R | D/C | Fall 1990 |
| Lowell | 0.054 | R | O | January 1989 |
| Oklahoma (1) | | | | |
| Durant | 1.7 | L | O | April 1988 |
| Oregon (1) | | | | |
| Canby | 1.15 | R | O | 1986 |
| Virginia (3) | | | | |
| Chase City | 0.6 | R | D/C | Fall 1990 |
| Fincastle | 0.08 | L | O | 1986 |
| Winchester | 0.28 | L | O | 1988 |

R Biolac-R
L Biolac-L
W Biolac-R - Wave Oxidation Modification
* Stabilization Ponds
** Nitrification of Trickling Filter
+ Pre-aeration
O Operating
D/C Design Construct

presents a summary listing of municipal Biolac wastewater plants, current through December 1989. A total of 45 plants are listed, of which 42 are R or L configurations. The first of the three other plants (Decatur, Arkansas) is a Biolac-R plant with the Wave Oxidation Modification for nitrogen removal. The second (Excelsior Springs, Missouri), uses the Biolac aeration chains for preaeration prior to an overland flow wastewater treatment system. The third (Witchita, Kansas), will use the aeration chains for second stage nitrification of a trickling filter effluent.

Of the 42 Biolac plants, 10 are L configurations, and 32 use the R arrangement. Only 5 of the Biolac L systems are currently in operation, with the earliest startup in April 1988; the remaining are in the design/construct stage. Thirteen of the 32 R plants are in the design/construct stage. Of the 19 operating plants, most have been brought on-line in the past two years, with the earliest startup in 1986 (Livingston Manor).

Most plants are relatively small, based on the design flow. This is summarized as follows for the 42 (operating and in the design/construct phase) Biolac R and Biolac L plants.

| Design Flow | Number of Plants | |
|---|---|---|
| (mgd) | Biolac R | Biolac L |
| < 0.1 | 3 | 1 |
| 0.1 - 0.5 | 11 | 2 |
| 0.5 - 1.0 | 12 | 3 |
| 1.0 - 2.0 | 5 | 3 |
| 2.0 - 5.0 | 1 | 1 |

As shown, greater than 50 percent of either R (53 percent) or L (60 percent) plants have design capacities within the range of 0.5 to 2 mgd. Only one of each has a design flow greater than 2 mgd (both are 4.0 mgd). The remaining are less than 0.5 mgd design capacity.

Geographically, most plants are located in the south and midwest, distributed among 14 states. Alabama and Arkansas have 17 of the 45 listed plants, all of which are Biolac-R configurations. Of the 27 operating plants, 14 are in Arkansas and Alabama. Six of the remaining 12 are located in moderate climate states (Kentucky, Oklahoma and Virginia). Six plants are operational in winter climate conditions (Colorado, Kansas, Missouri, New York and Ohio), and only three (Livingston Manor, New York; Excelsior Springs, Missouri; and Ellsworth, Kansas) have experienced more than one winter operation. Thus severe winter operating experience is limited at this time.

Unit Operations Associated with the Biolac System

A review of the plant descriptions listed in Appendix A indicates the range of unit operations included in the process trains of Biolac treatment plants. Parkson recommends influent screening, which is normally included as part of the Biolac System scope. Grit removal systems are optional and can be included if a large quantity of grit is anticipated. Both unit operations are shown in the "typical" system flow schemes (see Figure 1).

A summary of unit operations associated with the Biolac system is presented in Table 2 (based on municipal plants only). Four plants have no preliminary treatment, while thirty-eight plants provide some form of pretreatment;

| | |
|---|---|
| Bar Rack Only | 2 plants |
| Bar Rack/Screening/Grit Removal | 1 plant |
| Bar Rack/Comminution/Grit Removal | 2 plants |
| Bar Rack/Comminution/Grit Removal and Primary Clarification | 1 plant |
| Screening Only | 15 plants |
| Screening/Comminution | 5 plants |
| Screening/Grit Removal | 4 plants |
| Screening/Primary Clarifiers | 2 plants |
| Comminution/Grit Removal | 1 plant |
| Grit Removal | 1 plant |

Twenty-seven of the plants have screening, eleven of which are traveling screens. Nine plants practice some type of comminution/grinding. Ten plants

TABLE 2. SUMMARY OF UNIT OPERATIONS WITH BIOLAC SYSTEMS
(MUNICIPAL BIOLAC PLANTS)

| | | Pretreatment | | | | | | | | Post-Treatment | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | Clarification | | | Polishing | | | |
| Plant | Type | Bar Rack | Bar Screen | Traveling Screen | Static Screen | Grinders | Grit Chamber | Primary Clarifier | None | Integral | External | None | Aerated | Non-Aerated | Aerated/ Non-Aerated | None |
| Ardmore, AL | R | X | | | | | | | | X | | | X | | | |
| Berry, AL | R | | | X | | | | | | X | | | | | X | |
| Camden, AL | R | | X | | | | | | | X | | | X | | | |
| Cedar Bluff, AL | R | | | X | | | | | | X | | | | | X | |
| Clayton, AL | R | | | | X | | | | | X | | | X | | | |
| Columbiana, AL | R | | X | | | | X | | | X | | | X | | | |
| Hanceville, AL | R | | | X | | | | | | X | | | | | X | |
| New Brockton, AL(1) | R | X | | | | | | | | X | | | | | | X |
| Oxford, AL | R | X | | X | | | X | | | X | | | | | X | |
| Stevenson, AL | R | | | X | | | | | | X | | | | | X | |
| Bay, AR | R | | X | | | | | | | X | | | | | X | |
| Blytheville, AR-N | R | | | X | | X | | | | X | | | | | X | |
| Blytheville, AR-W | R | | | X | | X | | | | X | | | | | X | |
| Blytheville, AR-S | R | | | X | | X | | | | X | | | | | X | |
| Maynard, AR | R | | X | | | | | | | X | | | | | X | |
| Piggott, AR | R | | | X | | | | | | X | | | | | X | |
| Colorado Springs, CO | L | | X | | | | | | | | | X | | | X | |
| Monument, CO | L | | X | | | | X | | | | X | | | | | X |
| Quitman, GA | L | | | | | | | | X | | | X | | X | | |
| Ferdinand, IN | R | | | | | X | X | | | X | | | | | X | |
| Remington, IN | R | | X | | | X | | | | X | | | | | | X |
| Rensselear, IN | R | | | | | | X | | | X | | | | | | X |
| Cambridge, IN | R | | X | | | | | | | X | | | | | | X |
| Ellsworth, KS | L | | X | | | | X | | | | | X | | X | | |
| Wellsville, KS | L | | | | | | | | X | | | X | | X | | |
| Edmonton, KY(2) | R | | X | | | X | | | | X | | | X | | | |
| Greenville, KY | R | | X | X | | | | | | X | | | | | | X |
| Morgantown, KY | R | | | X | | | | | | X | | | | | | X |
| LeSuer, MN | R | | X | | | | X | | | X | | | | | | X |
| Wells, MN | L | | | | | | | | X | | | X | | | | X |
| St. Louis, MO | L | | | | | | | | X | | | X | X | | | |
| Livingston Manor, NY | R | X | | | | X | X | | | | X | | | | | X |
| Rock Hill, NY* | R | | | | | | | | | | | | | | | |
| Coalton, OH | R | | X | | | | | | | X | | | X | | | |
| Miami, OH | R | | X | | | | | X | | | X | | | | | X |
| Frazeysburg, OH* | R | | | | | | | | | | | | | | | |
| Lowell, OH | R | X | | | | X | X | | | X | | | | | X | |

TABLE 2. SUMMARY OF UNIT OPERATIONS WITH BIOLAC SYSTEMS
(MUNICIPAL BIOLAC PLANTS)
(Continued)

| | | Pretreatment | | | | | | | | Post-Treatment | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | Clarification | | | Polishing | | | |
| Plant | Type | Bar Rack | Bar Screen | Traveling Screen | Static Screen | Grinders | Grit Chamber | Primary Clarifier | None | Integral | External | None | Aerated | Non-Aerated | Aerated/ Non-Aerated | None |
| Durant, OK | L | X | | | | X | X | X | | | | X | X | | | |
| Canby, OR* | R | | | | | | | | | | | | | | | |
| Chase City, VA* | R | | | | | | | | | | | | | | | |
| Fincastle, VA* | L | | | | | | | | | | | X | | | | |
| Winchester, VA | L | | X | | | | | | | | | X | | | X | |

(1)Wetland treatment follows aeration basin.
(2)Final discharge to aquaculture pond.

have grit removal, with two primary clarification plants (these were retrofits of existing plants).

None of the ten L systems have separate mechanical clarifiers. Two R plants have external clarification; the remaining have integral clarifiers. Nine Biolac-R plants do not have polishing lagoons. Of those that do, six use fully aerated basins, while the remaining polishing basins are split into aerated and non-aerated sections. When the polishing basin is used, the trend is to have this aerated/non-aerated configuration with new Biolac-R systems (with integral clarifiers), unless they are to be followed by a land treatment process (wetlands, overland flow, etc.).

# SECTION 5

# ASSESSMENT OF THE BIOLAC SYSTEM

This section presents an evaluation of the Biolac wastewater treatment system. The discussion focuses on the process design considerations for the system based on in-field observations; performance data for selected plants; an assessment of the system components and related Operation and Maintenance (O and M); and the costs associated with the installation of the system.

Note that the system is relatively new; earlier discussions indicated that the majority of facilities have come on-line in only the last one to three years. As such, there is limited experience, particularly with respect to O and M and hardware reliability aspects that are influenced by long-term operations. This also applies to operating costs, which were not estimated within the context of this report. The principal focus is on the Biolac-R configuration since this system is most common and is typically the preferred system for new installations.

## PROCESS DESIGN CONSIDERATIONS

As discussed earlier, the approach to sizing the extended aeration or flow-through lagoon system is somewhat conservative when compared to conventional systems. Table 3 compares the design parameters generally found for extended aeration systems and the Biolac-R process.

The aeration basin for the Biolac-R system is sized to yield an average Hydraulic Retention Time (HRT) of 24 to 48 hours and a Solids Retention Time (SRT) of 30 to 70 days. These are greater than conventional design, in particular with regard to the SRT. Food to microorganisms ratios are low, ranging between 0.03 and 0.1, somewhat lower than typically used. The volumetric BOD loading is 6 to 18 lbs $BOD_5$/d- 1,000 $ft^3$, with a typical loading of 7 to 8 lbs BOD/d- 1,000 $ft^3$. Figure 6 presents actual design loading data

TABLE 3. MANUFACTURER'S RECOMMENDED DESIGN CRITERIA FOR BIOLAC-R SYSTEM IN COMPARISON TO CONVENTIONAL EXTENDED AERATION SYSTEMS

| Parameter | Extended[a] Aeration | Biolac-R[b] |
|---|---|---|
| Hydraulic Residence Time (HRT), hours | 18 to 36 | 24 to 48 |
| Solids Retention Time (SRT), days | 20 to 30 | 30 to 70 |
| F/M, (lbs $BOD_5$/d-lb MLVSS | 0.05 to 0.15 | 0.03 to 0.1 |
| Volumetric Loading (lbs $BOD_5$/d - 1,000 $ft^3$ | 10 to 25 | 6 to 18 |
| MLSS (mg/L) | 3,000 to 6,000 | 1,500 to 5,000 |
| Basin Mixing (HP/MG of Basin Volume) | 80 to 150[c] | 12 to 15[d] |

(a)Reference 3
(b)Reference 4
(c)Mechanical aeration
(d)Manufacturers data for mixing only

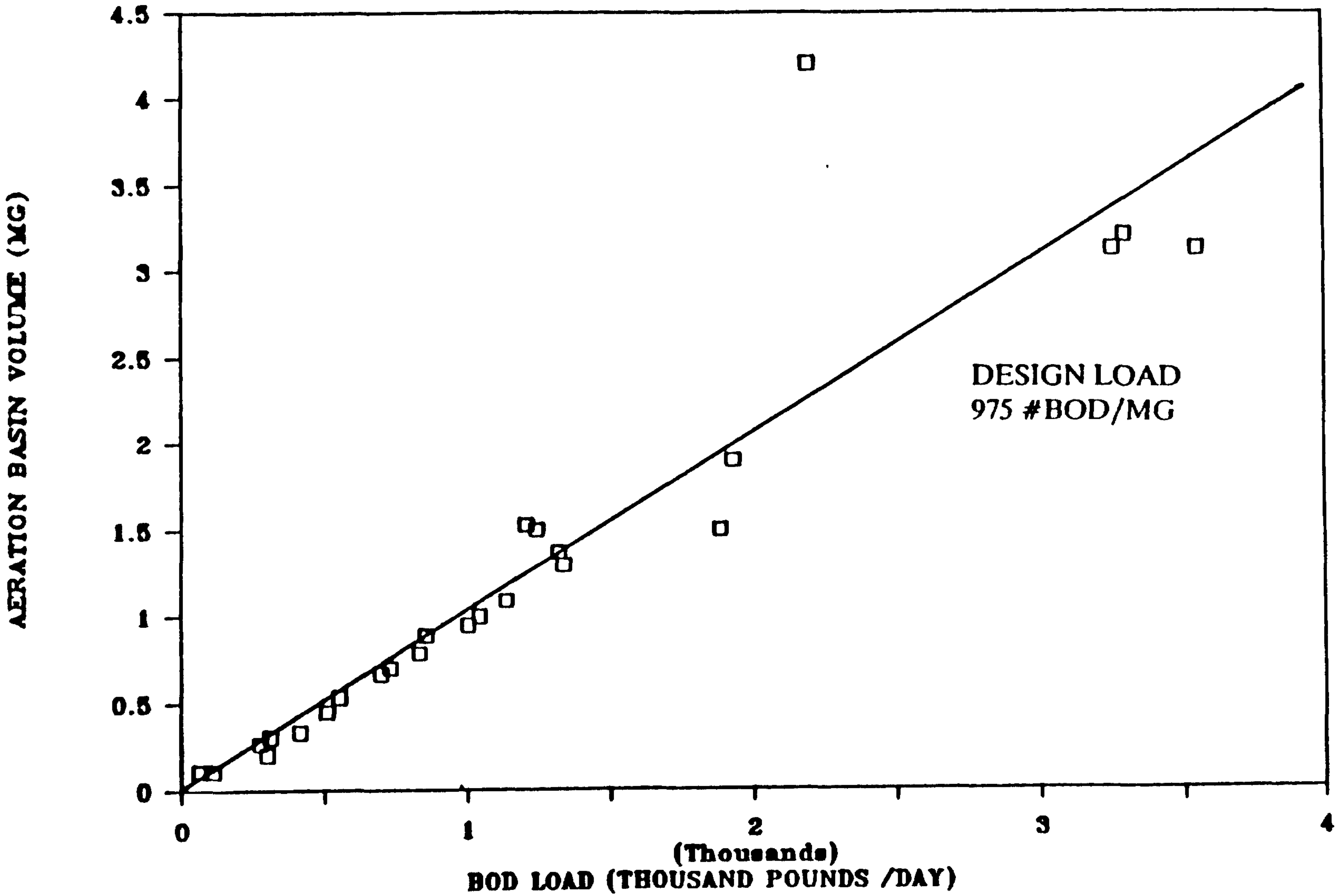



FIGURE 6. BIOLAC-R PLANT DESIGN - AERATION BASIN LOADING.

for 25 Biolac-R plants; the mean design loading was 975 lbs BOD/d-MG equivalent to 7.3 lbs BOD/d - 1,000 $ft^3$. The polishing basin of the R system is typically sized for an HRT of 12 to 24 hours.

Design sizing for the flow-through lagoon system (Biolac-L) is typically based on hydraulic residence time. An HRT of 6 to 20 days is used, whereas conventional design sizing would use a 3 to 10 day HRT. The Biolac-L polishing basin is typically designed to provide an equivalent loading of 0.5 to 1.8 lbs BOD/d - 1,000 $ft^3$, which generally results in an average HRT of one to two days, and greater than 10 years capacity for sludge.

The Biolac aeration system sizing is based on the assumption that full nitrification will be accomplished. The manufacturer recommends 1.5 lbs oxygen per pound of $BOD_5$ removed and 4.6 lbs of oxygen per pound of available nitrogen. The rated transfer capacity for the Wyss diffusers under standard conditions, in clean water is between 4 and 5 lbs $O_2$/hp-hr.

At the typical design loading, the air required to satisfy oxygen requirements is higher than that required for mixing. Thus the aeration system can be turned down during nightime, weekends, and/or the initial years of operation at lower loadings, while still maintaining mixing. This provides a large degree of flexibility and energy savings with this type of system when compared to conventional fixed aeration equipment.

The total number of diffusers is determined by dividing the required air flow by the normal design air flow per diffuser. This is typically 2 to 4 scfm/diffuser for the Wyss units. The number of aeration chains, floats per chain, diffusers/float are then determined for the specific application. A typical aeration chain spacing of 8 to 30 feet for Biolac-R plants and up to 30 to 50 feet for Biolac-L plants is used, above an unsloped basin bottom. Parkson recommends keeping all diffusers at the same elevation for the simplest installation and operation. Figure 7 presents a summary of the actual number of diffusers used for the design of 25 Biolac-R plants. The mean was 385 diffusers per million gallons basin volume. This is equivalent to an air flow of 1,350 scfm/MG at 3.5 scfm per diffuser.

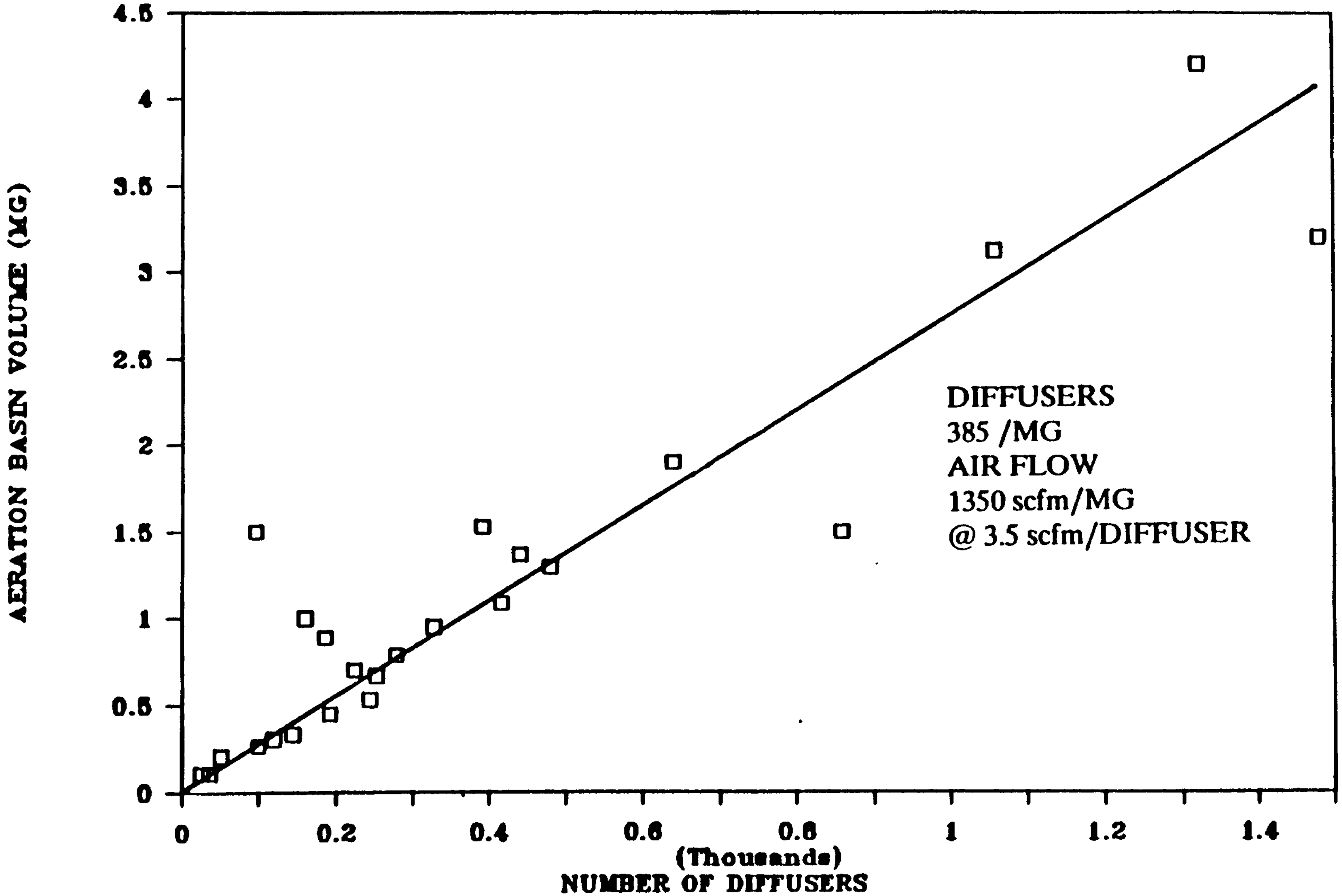



FIGURE 7. BIOLAC-R PLANT DESIGN - DIFFUSERS/AIR FLOW.

The minimal requirement for mixing and effective solids suspension is approximately 3 to 4 scfm/1,000 $ft^3$ of basin volume using the Biolac aeration chains. This is equivalent to approximately 12 to 15 HP/million gallons. Figure 8 presents data showing actual operating HP at 25 Biolac-R plants. The mean was approximately 45 HP/MG; note that these plants were typically at 50 to 70 percent of their design loading. This still compares favorably with conventional fixed aeration systems which require up to 100 HP/MG basin volume. Thus, whereby aeration HP in extended air systems is generally set by mixing requirements for fixed aeration systems, the Biolac aeration system sizing is typically set by oxygen requirements, resulting in significantly less power input than required for conventional systems.

For the R system, an integral clarifier is normally provided to effect solids settling, and an optional aerated/unaerated polishing basin can be provided. The polishing basin is not considered a requirement to achieve secondary effluent limits, but can provide additional polishing for solids removal. Clarifier design rise rates (overflow) range between 200 and 800 gpd/$ft^2$, with 400 gpd/$ft^2$ being used most often. For the L system, solids settling is accomplished in the quiescent settling zone established in the unaerated section of the polishing basin. The design is typically for a 24 hour detention time in this zone. This is common for the aerated lagoon process.

BIOLAC SYSTEM TREATMENT PERFORMANCE

Most Biolac plants have been operating a relatively short time and as yet have not reached design flows or loads. Additionally, many plants are small and permit sampling requirement are not extensive, thus minimal data has been collected. The response to a request for data was good; approximately 75 percent of the domestic plants on-line responded with information. In many instances, however, the data were limited, often representing monthly or twice/month sampling. Additionally, several plants do not monitor the influent, and the 24 domestic plants that were on-line, only 9 were on-line longer than one year.

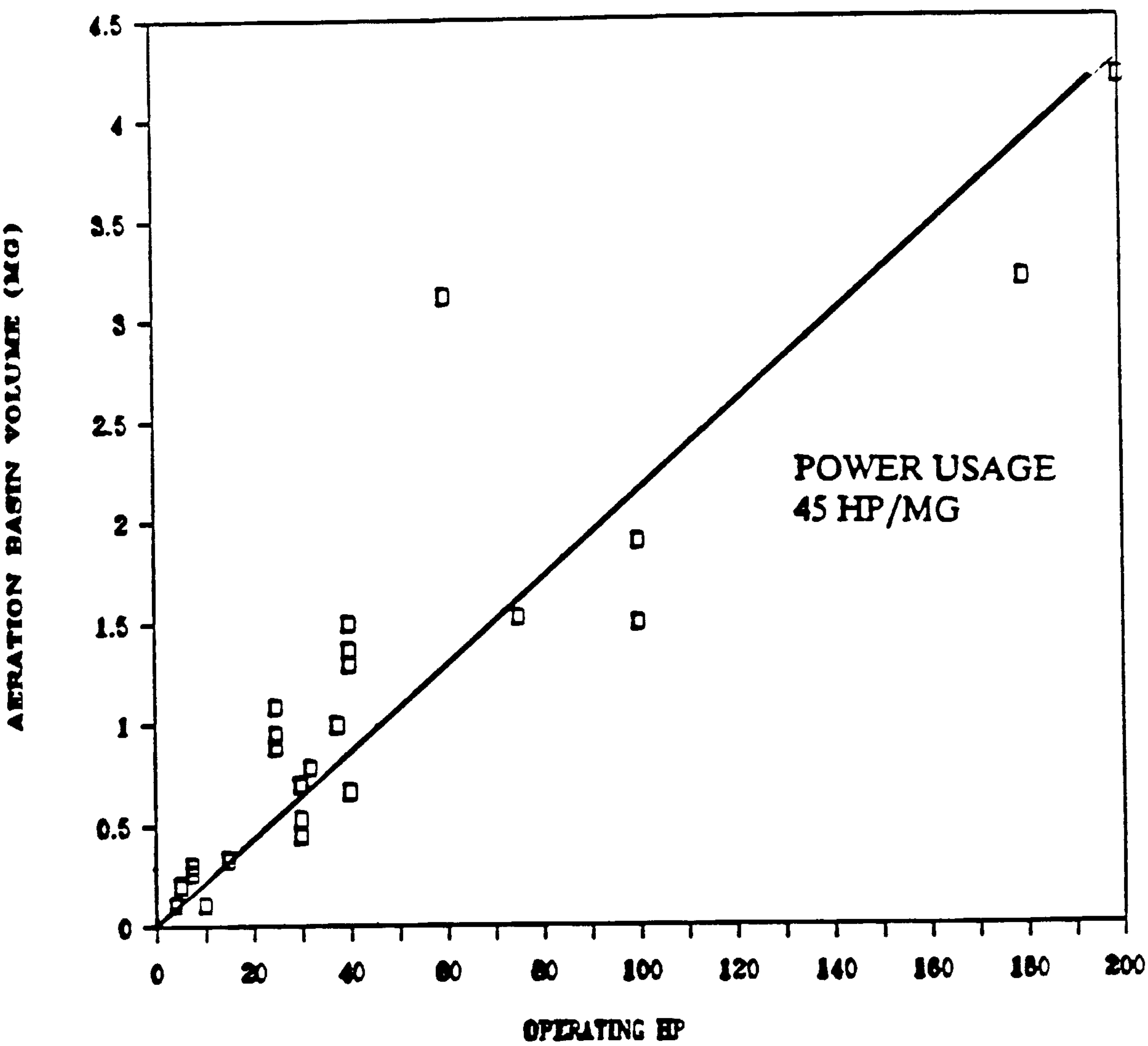



FIGURE 8. OPERATING BIOLAC-R PLANTS-POWER USAGE.

Performance data summaries for 13 plants are presented in Appendix B. All but one (Fincastle, Virginia) are R plants. In all cases, and in discussions with other Biolac plants, the facilities were in full compliance with their permit requirements. Table 4 summarizes these data, presenting the averages for the different performance periods at each plant. Note that the initial months of start-up data were excluded from these averages. The average effluent BOD ranges from 5.1 to 20.8 mg/L; the average removal (for those plants for which influent data were available) ranged between 91.1 and 97.9 percent.

The average effluent TSS concentrations ranged between 6.7 and 34.8 mg/L; the average removal ranged between 86.3 and 95.7 percent. Ammonia levels were typically less than 7 mg/L in the effluent, except for higher levels in the Bay, Arkansas and two Blytheville, Arkansas plants. It is suggested that these were influenced by high incoming ammonia concentrations due to farm fertilization and high infiltration into the sewer collection system.

## EQUIPMENT

Since the initial installations in 1985, design and materials modifications have been made on a continuing basis, reflecting operating experience at an increasing number of plants. Problems that were identified related to hardware components and materials of construction, ineffective maintenance, and inefficiencies in operation. The following discussions summarize the problems noted by the operators and present how they have or are being addressed.

Table 5 summarizes the types of problems encountered by the various plants that were interviewed and/or visited. Plants that reported the problems are also shown, if possible. Finally, resolution of the problem, if there is one, is also discussed.

### Aeration System

The floating chain system is assembled in the field. Problems were reported primarily by early Biolac plants, and related to the diffusers,

TABLE 4. SUMMARY OF AVERAGE PERFORMANCE DATA FROM SEVERAL BIOLAC SYSTEMS

| Plant Name | Period of Performance | Type | Flow (MGD) | % Design | Influent BOD (mg/l) | Effluent BOD (mg/l) | % BOD Removal | Loading (lbs BOD/day) | Influent TSS (mg/l) | Effluent TSS (mg/l) | % TSS Removal | Effluent $NH_3$-N (mg/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Morgantown WWTP Morgantown, KY | 4/89 to 9/89 | R | 0.29 | 58.0 | 243 | 12.7 | 92.3 | 575 | 188 | 11.7 | 95.7 | 0.1 |
| Greenville WWTP Greenville, KY | 5/88 to 8/89 | R | 0.40 | 55.3 | 178 | 6.2 | 96.5 | 528 | 213 | 12.4 | 94.7 | 0.5 |
| New Brockton WWTP New Brockton, AL | 6/89 to 8/89 | R | 0.05 | 27.8 | 233 | 8.7 | 95.5 | 111.5 | 257 | 10.7 | 94.4 | 1.9 |
| Edmonton, WWTP Edmonton, KY | 7/89 to 11/89 | R | 0.2 | 39.2 | 203 | 11.6 | 91.1 | 185 | 266 | 18.4 | 89.5 | 3.2 |
| Fincastle WWTP Fincastle, VA | 9/88 to 8/89 | L | 0.05 | 62.5 | 218 | 18.6 | 91.2 | 86.9 | 190 | 21.5 | 89.7 | ND |
| Lowell WWTP Lowell, OH | 7/89 to 9/89 | R | 0.11 | 204. | 186 | 13.3 | 91.8 | 167.0 | 172.0 | 26.0 | 86.3 | 6.7 |
| Hanceville WWTP Hanceville, AL | 6/89 to 9/89 | R | 0.5 | 87.8 | 134 | 9.7 | 92.0 | 514.0 | 97.8 | 9.0 | 92.0 | 0.8 |
| Livinston Manor WWTP Rockland, NY | 6/86 to 8/89 | R | 0.5 | 62.5 | 260 | 5.1 | 97.9 | 1,062.0 | 217.0 | 8.7 | 95.3 | 1.9 |
| Blythville West WWTP Blytheville, AR | 7/89 to 10/89 | R | 0.39 | 26.0 | ND | 7.6 | - | - | ND | 14.9 | - | 2.2 |
| Blytheville North WWTP Blytheville, AR | 4/89 to 10/89 | R | 0.39 | 48.8 | ND | 13.8 | - | - | ND | 26.3 | - | 26.0 |
| Blytheville South WWTP Blytheville, AR | 4/89 to 10/89 | R | 0.60 | 42.8 | ND | 15.1 | - | - | ND | 18.1 | - | 30.9 |
| Bay WWTP Bay, AR | 6/89 to 9/89 | R | 0.27 | 180. | ND | 10.4 | - | - | ND | 6.7 | - | 11.3 |
| Piggot WWTP Piggot, AR | 6/89 to 9/89 | R | 0.35 | 58.0 | ND | 20.8 | - | - | ND | 34.8 | - | ND |

ND: No data provided

TABLE 5. PROBLEMS IDENTIFIED AT VARIOUS BIOLAC PLANTS

| Problem | Plants Reporting Problem | Comments |
|---|---|---|
| **Hardware/Materials Related** | | |
| Wear on chain restraining cables and rake cable | Excelsior Springs; Livingston Manor; Ellsworth; Morgantown | Chain material changed to stainless steel or chrome plated steel; replacement |
| Corrosion of hardware pieces (bolts, clamps, cable, connecting pieces) | Livingston Manor; Durant; Excelsior Springs; New Brockton | Materials changed from galvanized to stainless steel; replacement |
| Loosening of diffusers, other parts | Livingston Manor; New Brockton | |
| **Diffuser/Aeration System** | | |
| Diffusers blowing off frame | Livingston Manor; Morgantown | Installation; replace clips |
| Diffusers clogging | Livingston Manor; Durant | Loosening diffusers; improve clip, increase flexing maintenance |
| Reduced diffuser life | Livingston Manor; Morgantown; Ellsworth | Installation; improves flexing maintenance |
| Excessive blower noise | Blythville; Bay; Columbiana | Install in separate buildings; improve silencer design |
| Blower Filters | Blythville | Excessive dust; install screens; frequent replacement |
| **Clarifiers** | | |
| Rake motor | Hanceville; New Brockton; Decatur | Undersizing and problems relating to float over travel; replace |
| Rake limit switches and float overtravel | Berry; Hanceville; Edmonton; Morgantown; Lowell | Modify/replace switch with improved design |
| **Sludge Withdrawal** | | |
| Air lift pump clogging | Lowell; Greenville; Bay | Improve solids removal (screening) upstream; increase maintenance of lift line; improve suction line design; increase opening size |
| **Process Related** | | |
| Excessive debris/clogging and floating sludge | Lowell; Greenville; Bay; Morgantown | Improve prescreening; sludge suction line; rake cable and limit switches |
| Air distribution | Excelsior Spring; Morgantown; Livingston Manor | Relocate aeration chains; increase density of diffusers; increase maintenance (flexing); move aeration chain away from clarifier curtain |
| Excessive Oil/Grease in Clarifier | Berry; Columbiana; Hanceville; Piggot | Vacuum surface; install skimmers |

diffuser/counterweight assembly and air distribution. These centered on the corrosion of floats and anchoring cables. The floats were initially manufactured with integral galvanized air pipe and eye bolts on the end floats for cable connections. These problems have been corrected by utilizing an all polyethylene float construction.

The limited number of plants which reported float corrosion problems also commented on corrosion problems with the anchoring cables. Originally, the aeration chain was 304 stainless steel, 3/32 inch diameter, wire cable, with 6 to 8 feet of link chain at the end to allow for tension adjustment. The cables had shown excessive wear in the area where the cable dipped into the wastewater. The restraining chain has since been changed to an all link chain design of 3/16 inch diameter plated steel. Surface rusting of the new restraining chain still occurs, however, although this does not effect the structural integrity of the restraining chain. The manufacturer is considering a change to all stainless steel. The Livingston Manor WWTP has had success using nylon rope for restraining the floating aeration chains. The nylon rope is lightweight and has the ability to stretch, therefore it stays out of the wastewater. The rope remains dry and ice-free in winter.

There were relatively few diffuser problems, and overall, there was a high degree of satisfaction with the Wyss diffusers. Problems included diffuser sheaths blowing off their frames and shorter than expected diffuser life. A diffuser can come off entirely; more often it would become unseated at one end due to clamp failure, when either the clamp was improperly installed and/or tightened or the clamp corroded. Both conditions have been resolved. The clamp material must be stainless steel (which is the manufacturer's standard) and should be tightened thoroughly during installation. If the clamp is allowed too much freedom of movement it can slip as a result of diffuser flexing, causing the diffuser to unseat.

Shortened diffuser life has been reported by a few plants. The cause is not immediately apparent at each, but it can be due to several factors. If the clamps are not properly tightened, sludge can enter the diffuser and be forced into the aeration aperture, causing the sheath to clog. A diffuser will also gradually lose its effectiveness if the apertures remain enlarged for extended periods of time to the point where they can not return to their normal size when uncharged. This is due to overcharging the diffusers (i.e. operating above recommended air flow range) and can result in uneven air distribution across the diffuser. The large bubbles that result from the enlarged holes reduce overall aeration transfer efficiency. If the diffuser holes become enlarged from extended stretching of the diffuser sheaths, an additional problem can occur. When the system is not charged with air the normally closed apertures can remain open and wastewater/sludge can enter the diffuser by the pressure exerted from the liquid head.

The manufacturer suggests that a diffuser life of five years can be expected under normal conditions. The key to achieving this is regular diffuser flexing, as described in the operations manual provided for the aeration chain system. This involves shutting the air off in a chain, depressurizing the diffusers by bleeding the air and causing the diffusers to collapse. The air is then turned back on, expanding the diffuser sheaths. A one week frequency is recommended for flexing. A review of operating plant data indicates that the procedure varied, with only a third following a routine schedule.

An equally important point is that the diffusers not be overcharged. Normal operating air flow is between one and five scfm/diffuser. Increasing the air supply pressure and operating above the upper boundary continuously will likely result in enlarged apertures, if not torn diffuser sheathes. Pressure settings and relief valves on the air system can help minimize this type of problem.

Two plants reported air distribution problems unrelated to faulty diffusers. They have been noted near the clarifier and also along the diffuser chains themselves. Solutions have included utilizing side chain floats in the basin corners and locating air headers at both ends of the aeration chains. A six inch diameter aeration chain option has recently been developed. This enables a greater volume of air to be delivered at a lower pressure loss, reducing the potential for uneven air distribution to the individual chains.

Few problems were reported concerning the blowers. Excessive noise was a primary complaint. The manufacturer has addressed this by providing silencers with improved noise attenuation. Several plants do not house their blower equipment within fully enclosed structures to contain the noise. Plants in Piggot and Bay, Arkansas housed the blowers in structures which had one or more open sides. The plants are located in areas where the surrounding land is flat and largely unwooded; thus the noise is not readily contained by either the structure, or absorbed by hills and/or forested land.

Another problem was identified with regard to the silencers, and difficulties in keeping the silencer filters clean. The problem was especially difficult for plants located in farming regions. Bugs, dust and other debris from planting and harvesting operations (large quantities of cotton fiber were observed in Arkansas) clog the silencer air filters quickly. At the Blythville, Arkansas plants (North, South and West) the silencer housings were fitted with fine screens around their peripheries, resulting in greatly reduced maintenance needs for the silencer filters.

Sludge/Solids Removal Systems

Several problems were noted with the clarification and sludge removal systems in the Biolac R plants. A number of problems with the clarifiers centered on the mechanical operation of the rake drive motor, limit switches and the air lift sludge pumping system. The L systems provided sludge storage times of 10 to 20 years in the polishing basin; with only 3 plants in operation for less than 4 years, problems have not been encountered.

Figure 9 illustrates the limit switch/drive cable assembly for the integral clarifiers. A two limit switch assembly which allows the motor to slow down before starting off in the opposite direction is shown. The flocculating rake mechanism, used for sludge distribution and concentrations, is suspended from a

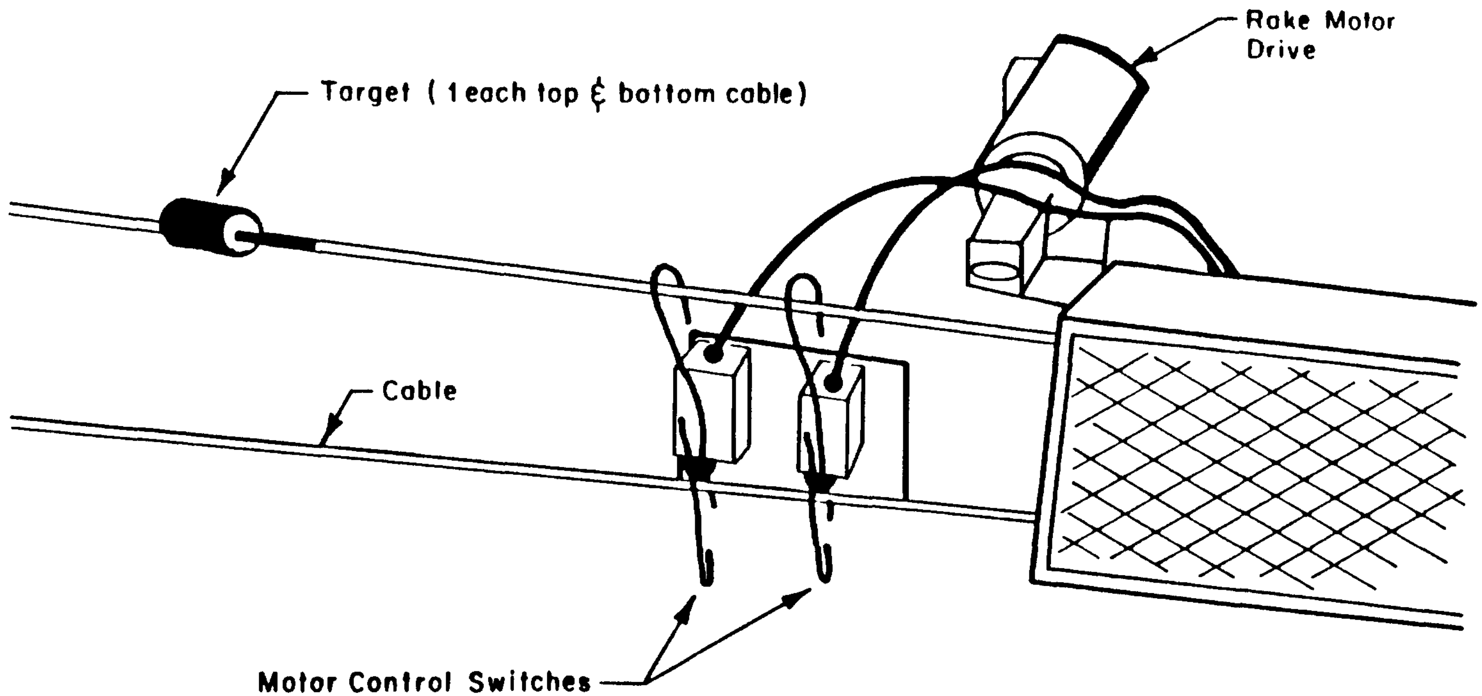



FIGURE 9. INTEGRAL CLARIFIER RAKE MOTOR AND CONTROL SWITCHES.

float similar to the floats used to support the diffuser/counterweight assembly. The rake float is attached to a drive cable which is pulled back and forth across the clarifier by the rake drive motor. Directional control of the motor is accomplished through the use of a limit switch which is tripped by a target attached to the drive cable.

Plant operators have reported difficulties due to the improper engagement of the target and the switch. When this occurs, the rake is not stopped nor sent back in the opposite direction, and the rake float eventually runs into the limit switch and drive unit, sometimes resulting in the destruction of the floats. A redesigned limit switch with modified upper and lower cable trip arms eliminates improper switch engagements; an evaluation of their use was not possible. Plant operators had reported successfully modifying the old switches; one added a PVC collar to increase the target size, while another modified the trigger arm by simply bending the trigger wire.

Another clarifier system problem was identified with the performance of the air lift sludge pumping system. This centered on clogging of the piping, resulting in a reduced sludge return rate and a solids buildup in the clarifier, with subsequent downtime for unclogging the system. Several contributing factors were identified including the lack of effective pretreatment screening at the head of the plant, lack of maintenance of the air lift system, and the air lift suction line design. The Biolac system does not include primary clarification as a standard unit operation. Without this, the plant must rely on the effectiveness of its pretreatment operation for large, potentially clogging solids removal.

Communition is not recommended because of the tendency for comminuted materials to mat together in the aeration basin, resulting in clogging problems. Nine of the plants use some form of comminution. Screening is recommended as a necessary pretreatment for most domestic applications. Screening can be accomplished by either racks or screens. The size and amount of coarse solids removed by each varies greatly. A simple bar or travelling screen can retain particles four times smaller than the typical bar rack with one inch clear openings. Generally, a review of the plants indicated that those plants without or with minimal screening encountered difficulties with clogging.

While there is no recommended approach to sludge suction line maintenance, one operator reported a program that involved flushing the line monthly to remove any debris that may have accumulated.

The manufacturer has been investigating suction line design modifications for improved sludge removal. The utilization of tapered suction line, and/or varying hole size and spacing has been studied to equalize velocities along the length of the sludge hopper. Increasing the hole size (1.5 inch is standard) would reduce clogging and with improved hole spacing would minimize dead spots where sludge can accumulate, gasify and float. A pipe is now included that extends from one end of the suction line to the surface, providing cleanout capability.

The fraying of the rake drive cables and floating sludge are two problems that can occur as a result of a malfunctioning limit switch or a clogged air-lift sludge system. The rake drive cable material has been changed from stainless steel to plastic impregnated galvanized steel to reduce cable fraying.

Floating sludge in the clarifier may be attributed to inadequate sludge removal or air leaking into the clarifier from the aeration chain closest to the integral clarifier. Breakdown of the flocculating rake or sludge removal operation will allow sludge to remain in the clarifier for an extended period of time, resulting in gasification and subsequent floating sludge. Sludge will also float to the surface if air from the aeration basin enters the clarifier. This is prevented by locating the last aeration chain a sufficient distance from the clarifier curtain wall and limiting the chain oscillation range. Air flow to this chain may also be throttled back.

Operators have reported the need to manually skim floating sludge and greases in the integral clarifiers. The manufacturer is currently designing a mechanical skimmer and incorporating scum baffles for most new Biolac systems. Better platform access across the clarifier is also being provided.

Rake drive motor troubles resulted from undersized motors or the lack of delay timers. Larger motors have replaced undersized units and delay timers have been installed on the rake drive motor which allows the motor to slow down before changing its direction of rotation, and reduces the strain on the motor.

Polishing Basins

The polishing basin provides additional BOD and TSS removal, and acts as a backup for additional solids removal when high hydraulic variability is encountered, reducing the efficiency of the integral clarifiers. Plant operators have reported significant algae growth in the basins, resulting in large swings in polishing basin dissolved oxygen, poor basin appearance, excess effluent suspended solids and reduced performance of the disinfection operation. One plant reduced the algal discharge by submerging the effluent intake pipe two to three feet below the water surface. In response to these concerns, the hydraulic retention time in the polishing basins has also been reduced from 36 to 48 hours to 12 to 24 hours so that proper operation will be maintained, even at lower than designed flow rates.

System staging has recently been utilized by Parkson, in which two or more smaller sized aeration basins are installed, as opposed to one large basin. This can be beneficial in cases in which the initial flow or loading will not approach design capacity for some time. The second basin can be by-passed or operated at a low aeration rate, thus reducing the operating costs.

BIOLAC COSTS

Data received from the manufacturer on total capital construction cost for several Biolac plants are presented on Table 6. Cost of land, which can vary considerably and is a key consideration in selecting the aerated lagoon/extended aeration treatment technology, is not included. Equipment

TABLE 6. BIOLAC SYSTEM CONSTRUCTION COSTS

| Project | Bid Date | Design Flow (gpd) | Design BOD (mg/L) | Contract Price | $/gpd |
|---|---|---|---|---|---|
| Stevenson, AL | September 1986 | 750,000 | 400 | $680,000 | 0.90 |
| Blytheville, AR (3 Plants 1.5, 1.4, 0.8 mgd) | November 1987 | 3,700,000 | 250 | 3,048,000 | 0.84 |
| Greenville, KY | July 1987 | 740,000 | 350 | 977,000 | 1.32 |
| Columbiana, AL | November 1987 | 750,000 | 200 | 1,100,000 | 1.46 |
| Camden, AL | June 1988 | 220,000 | 225 | 355,000 | 1.61 |
| Hanceville, AL | February 1988 | 570,000 | 175 | 1,019,000 | 1.78 |
| Oxford, AL | July 1988 | 2,000,000 | 225 | 2,193,000 | 1.10 |
| Camden, AL | July 1989 | 540,000 | 225 | 799,000 | 1.48 |
| LeSeur, MN | October 1989 | 900,000 | 440 | 1,900,000 | 2.11 |
| Goodwater, AL | November 1989 | 150,000 | 200 | 640,000 | 4.25 |
| Cedar Bluff, AL | December 1988 | 500,000 | 220 | 695,000 | 1.39 |

costs, including the Biolac aeration chains, integral clarifier and air blowers and piping are approximately 20 percent of the total cost for plants greater than 0.5 mgd, and up to 30 percent or more for smaller plants. An average estimated capital cost for plants greater than 0.5 mgd is in the range of $1 to $1.5 per gallon per day of design flow for a typical municipal wastewater. The smaller plants have a somewhat higher cost rate, as do plants with higher concentrations of BOD (due to industrial wastes). Reported costs are contractors bid prices to build the complete plant and also include pretreatment facilities, pump stations, sewers, roads and buildings which are variable with specific projects.

Operating expenses include labor, power and maintenance supplies, and will vary with prevailing rates in the plant location. As discussed earlier, aeration power can be controlled through the operation of the blowers; since basin mixing is achieved at power levels generally less than required for adequate oxygenation, basin dissolved oxygen levels can be used as a control parameter, and power usage kept to a minimum. Operation of these plants is not highly labor intensive. Depending upon plant size and monitoring requirements, it was reported that only one to two full time or part-time personnel are typically required for operation and maintenance. At this time, there is minimal data available on actual operating costs and estimates have not been made within the context of this report.

# SECTION 6

# SITE OBSERVATIONS

## INTRODUCTION

Six plants were visited to observe operations. The Livingston Manor WWTP, located in Rockland, New York was visited September 25, 1989, and five plants located in the northeast corner of Arkansas were visited November 15 and 16, 1989. These site visits provided the opportunity to inspect both old and new equipment, in retrofit and non-retrofit plants. The following discussion summarizes observations made at the plants, and includes photos appropriate to this assessment. Note that plant performance data for each facility may be found in Appendix B.

## LIVINGSTON MANOR WWTP, ROCKLAND, NEW YORK

The Livingston Manor WWTP serves a rural community located approximately 100 miles northwest of New York City. The plant treats an influent flow of 0.5 mgd. One-third of the total flow is a pretreated poultry processing waste and the remaining two-thirds is municipal waste. It was among the first plants in the United States to employ the Biolac system.

The influent flow passes through a comminutor or a set of bar racks. After screening, grit is removed prior to biological treatment. The biological treatment of the waste is accomplished in two aeration basins in series. The basins are lined earthen pits and are followed by two 40-foot circular clarifiers which provide clarification prior to discharge. Lime addition is provided at the head of the plant to maintain the alkalinity level in the biological processes.

The plant was retrofitted with the Biolac floating aeration chains in November 1986. The plant had previously used coarse bubble static tube aerators since upgrading to an activated sludge plant in 1977. The static tubes were replaced because of hardware failures which had necessitated rebuilding the aeration system in 1981, and finally replacing it with the Biolac system in 1986. The retrofit was completed in approximately one month, while the plant continued to operate as a secondary treatment facility.

The plant staff consists of the superintendent, two assistants and an administrative secretary, responsible for both the water and sewer departments. Process monitoring is performed daily. Other O & M includes routine blower maintenance/cycling and visual inspection of the aeration basins.

The retrofit of Livingston Manor WWTP proved beneficial. All effluent characteristics showed modest improvements while 60 percent less horsepower was needed. More complete nitrification was achieved after the retrofit. Studies were conducted by Parkson, which confirmed that the system, at 6000 mg/L mixed liquor suspended solids was completely mixed, at an air flow of 3 to 4 scfm per 1,000 cu ft. of basin volume. This is roughly one-fifth to one-eighth the air required with fixed diffused air systems to achieve adequate mixing. Operation at the high MLSS level causes some floating sludge in the aeration basin, although this has apparently not caused process related problems.

At the time of the site visit some of the original Biolac equipment was being replaced. These included deteriorated restraining cables and badly corroded galvanized air pipes and eye bolts. Loose and corroded clamps (stainless steel clamps had not been supplied) were responsible for improperly functioning diffuser sheathes, many of which were filled with sludge. Some of the restraining cables had been replaced by nylon rope, which appeared to function adequately. The nylon rope's ability to stretch kept it from dipping down into the wastewater during the chain's oscillation. Despite the equipment problems the system has performed well, as evidenced by the performance data presented in Appendix B. Removals have averaged 87.9 percent for $BOD_5$, 94.5 percent for TSS, 91.9 percent for TKN, and 84.5 percent for $NH_3$-N.

Livingston Manor STP/Photograph Description

Refer to Figures 10 and 11:

A. Lined earthen basin equipped with Biolac floating aeration chains. Middle aeration chain which is suspected to have diffuser problems due to uneven air distribution, as evidenced by the large areas of bubbling around the 2nd and 9th floats.

B. Two diffuser assemblies with loose air clamps. Clamp in the middle of the picture was missing its screw while clamp in the upper left hand corner was severely corroded.

C. A diffuser which was sliced open lengthwise revealed a significant accumulation of sludge within the diffuser.

D. Picture illustrates the benefit of the nylon anchoring line. Nylon (foreground) stays out of water; therefore, does not accumulate debris.

BAY WWTP, Bay Arkansas

The Bay WWTP serves the rural community of Bay, Arkansas, receiving 100 percent domestic waste flow. This is a new Biolac-R type plant. Although the design average flow is 0.15 mgd, the actual flow since start-up has been 0.27 MGD. The plant was installed adjacent to the original plant and was put on-line in March 1989 after about a one year construction period. The original plant was an unaerated flow-through lagoon, which now serves as the new plant's sludge storage pond.

At the head of the plant, influent screening is provided by a pair of bar racks with 0.5 inch openings. After screening, the influent is brought into the aeration basin via two influent pipes to affect better inlet flow distribution. The waste is then treated biologically in a 0.3 million gallon aeration basin equipped with Biolac floating aeration chains. The solids are settled in an integral clarifier. The clarified effluent is treated further in a polishing basin, with a detention time of one day at the average design flow.

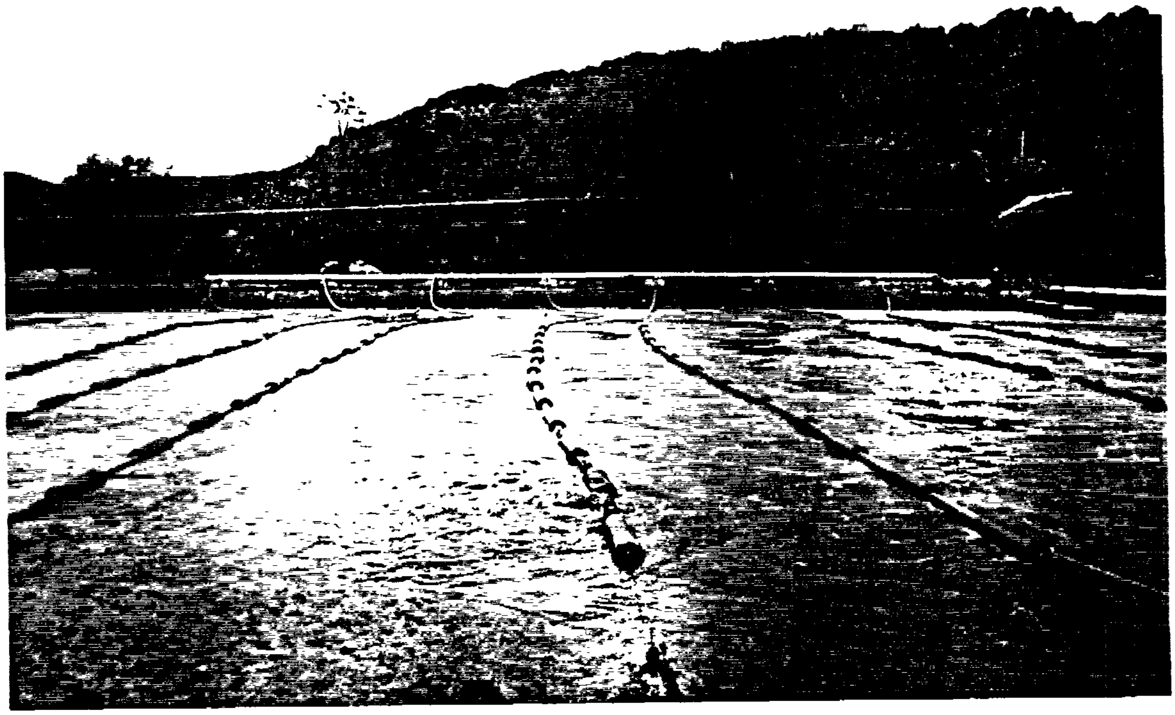
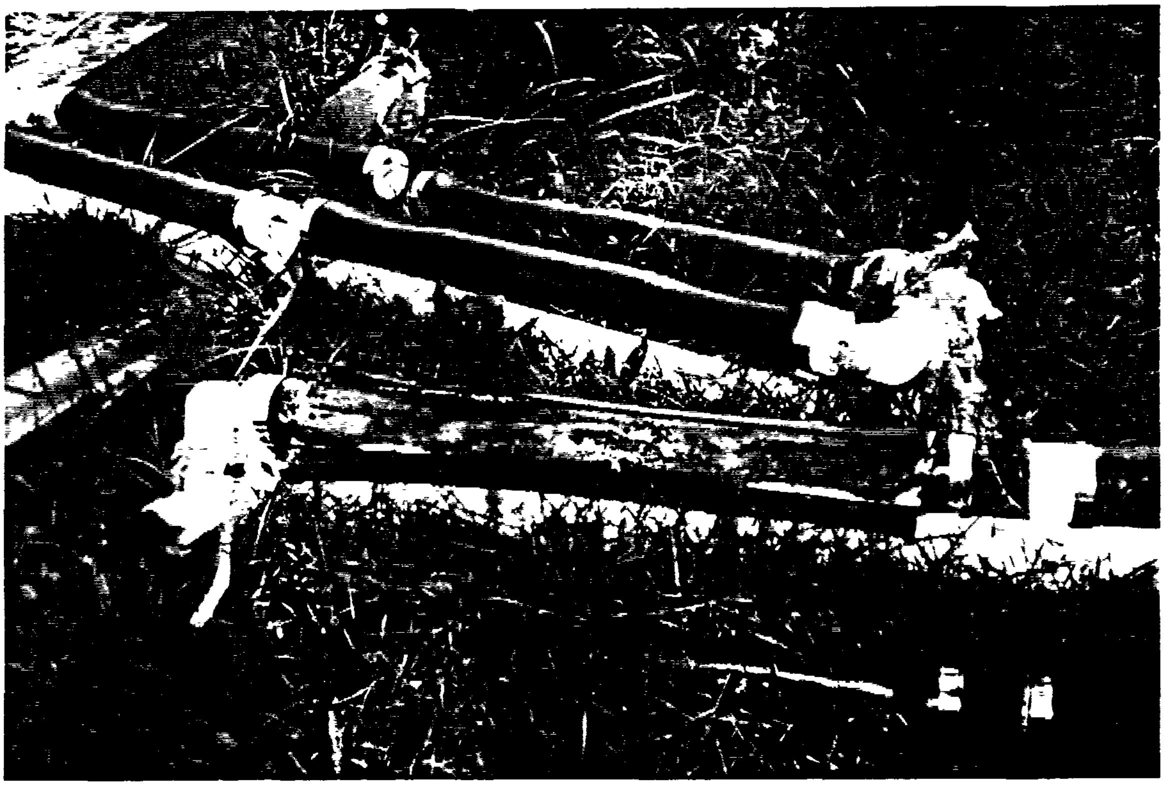


FIGURE 10. LIVINGSTON MANOR PHOTOS A AND B.



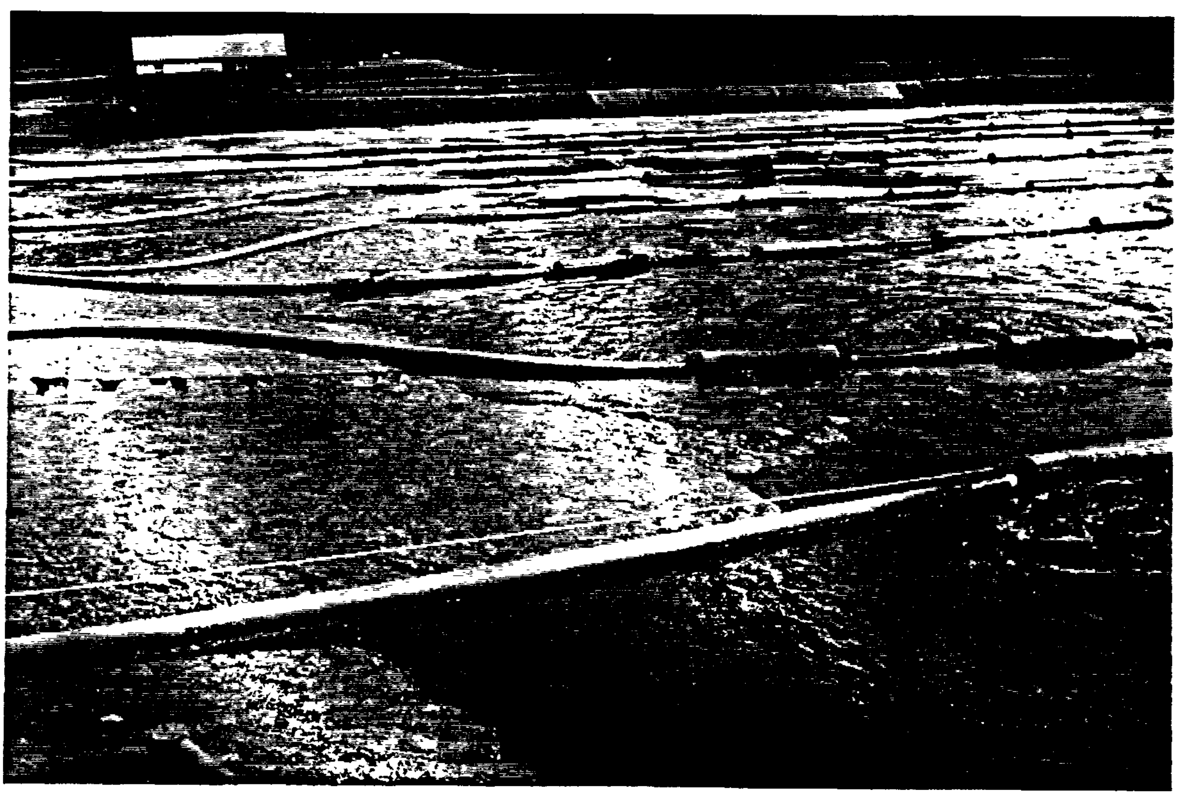


FIGURE 11. LIVINGSTON MANOR PHOTOS C AND D.

The basin is divided roughly in half by a floating curtain. The first section of the basin is aerated while the second section is unaerated. After effluent polishing, the waste is disinfected by chlorination. The plant staff consists of the plant superintendent and one assistant, while three other town employees are made available to the plant as needed.

The original plant interview revealed few problems, and all of them had been resolved satisfactorily. Problems with the rake drive motor had been resolved by the installation of an additional limit switch, which acts as a delay, allowing the motor to slow down prior to changing its direction of rotation. The plant also had floats containing galvanized air pipe. There was no visible evidence of corrosion, although the plant was on-line for only six months. The restraining chains showed signs of slight surface corrosion. Due to economic considerations, the blower assembly was not contained within a fully enclosed structure nor was a spare purchased.

Plant maintenance consists of regular blower maintenance as per specifications; bar rack cleaning twice daily; daily floatable skimming of basins and clarifiers; routine diffuser flexing; (rake) and air lift sludge system cleaning using the town sewer cleaning truck approximately every three weeks. Daily process monitoring includes dissolved oxygen, pH, chlorine residual and clarifier sludge level. August and September, 1989 effluent results show the plant to be performing very well (see Appendix B).

<u>Bay WWTP Photograph Descriptions</u>

Refer to Figures 12, 13, 14 and 15:

A. Influent to effluent view of the Biolac System. Aeration basin foreground, integral clarifier in back of the aeration basin and the polishing basin in the background.

B. Closeup of the anchoring system and header assembly. Chain length controls the aeration chain tension and subsequently the aeration chains lateral range of motion. Air header assembly includes a butterfly valve (large

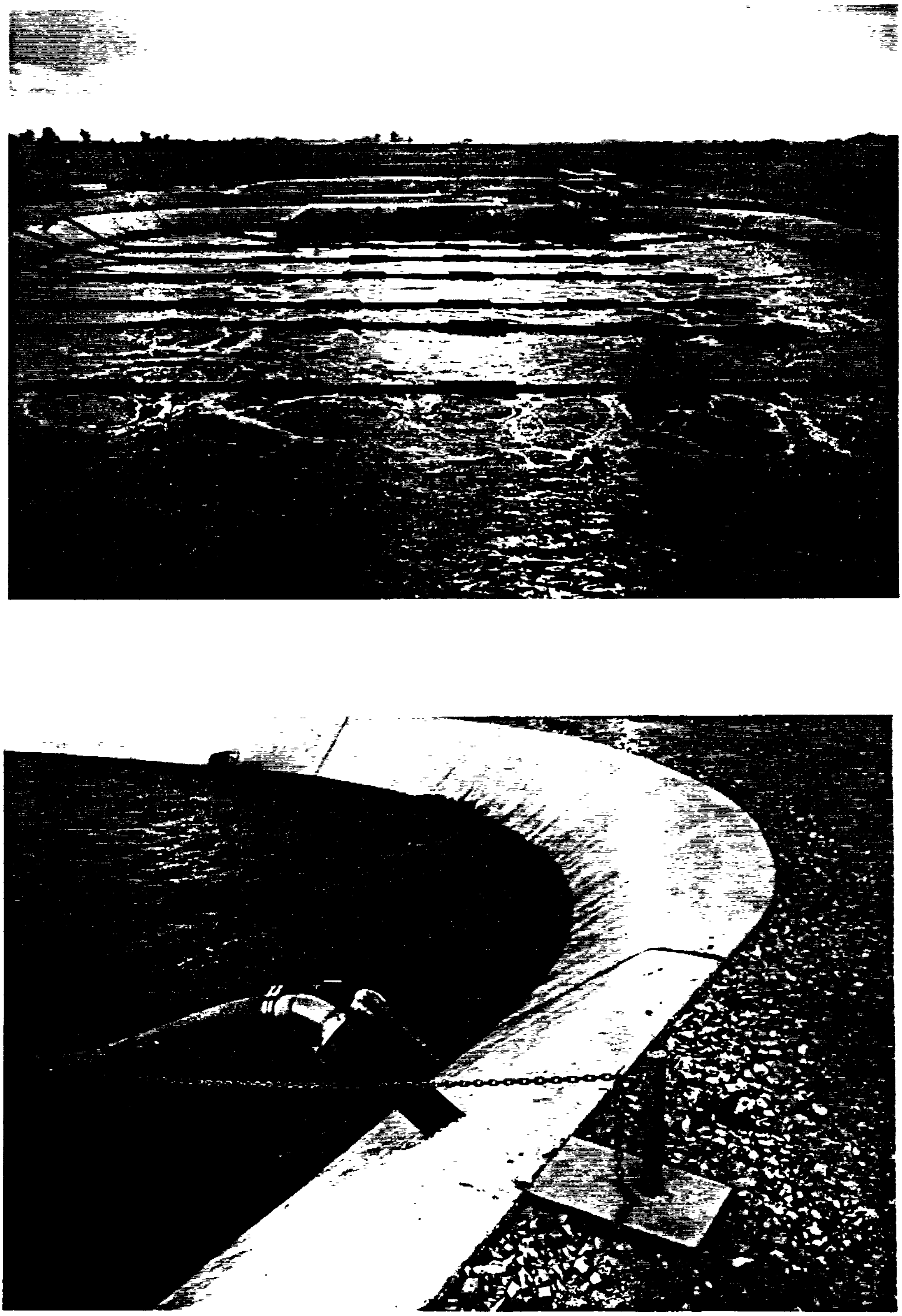
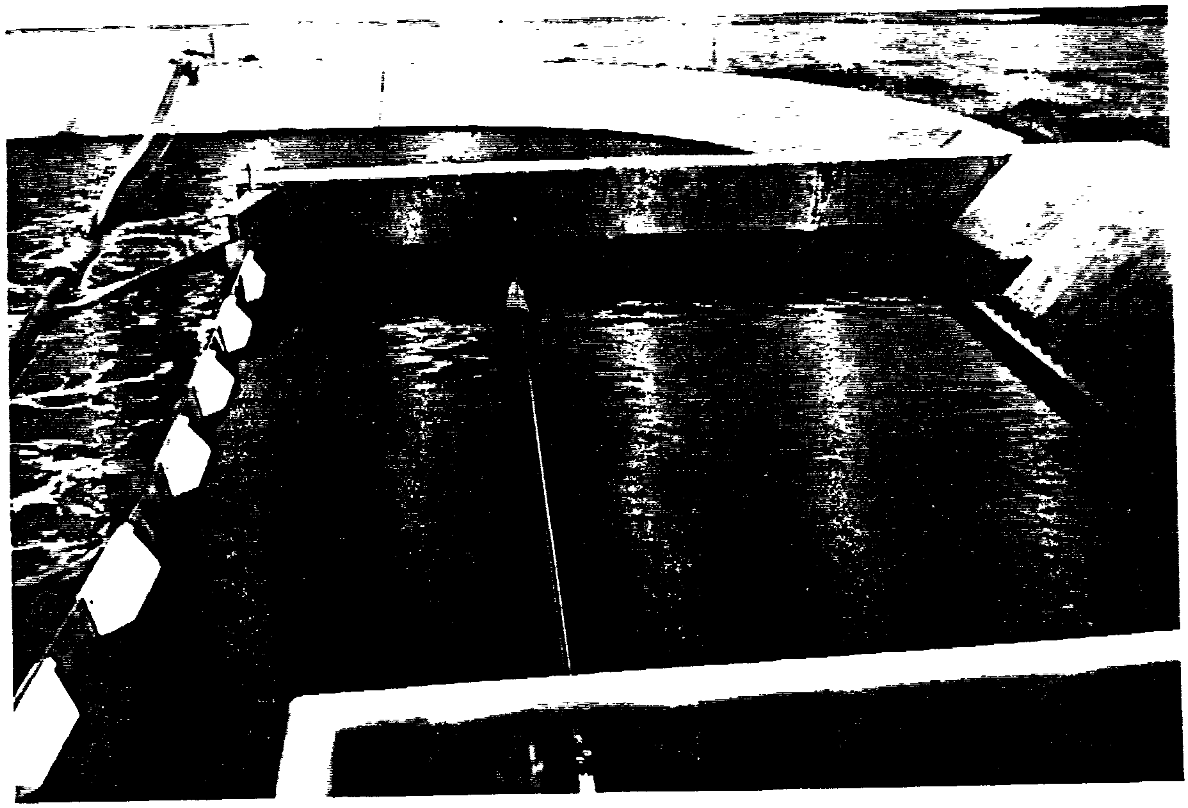


FIGURE 12. BAY, ARKANSAS PHOTOS A AND B



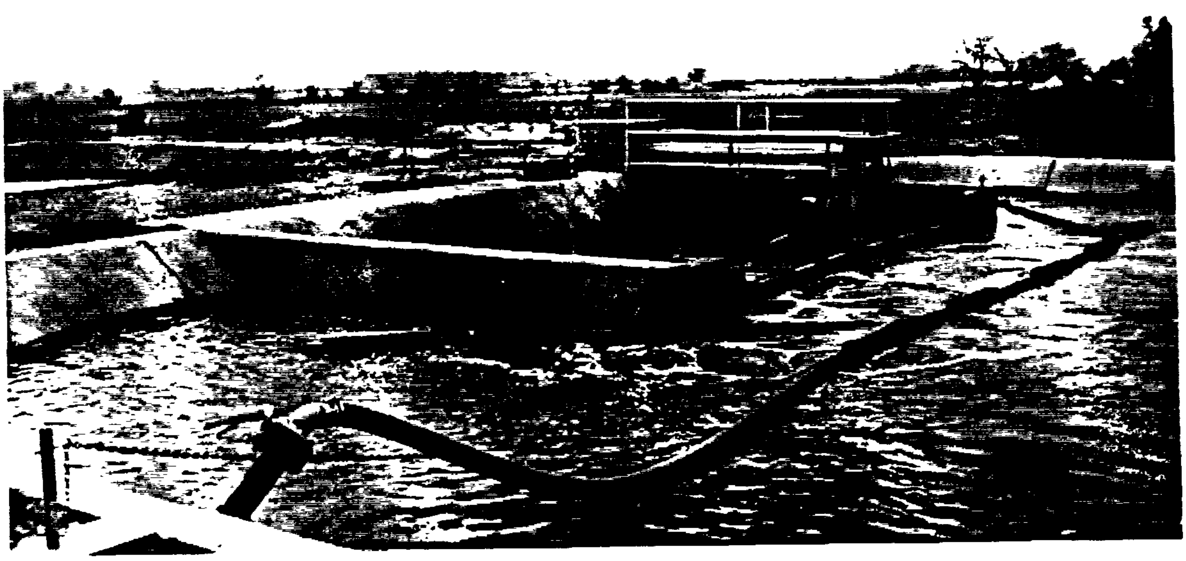


FIGURE 13. BAY, ARKANSAS PHOTOS C AND D

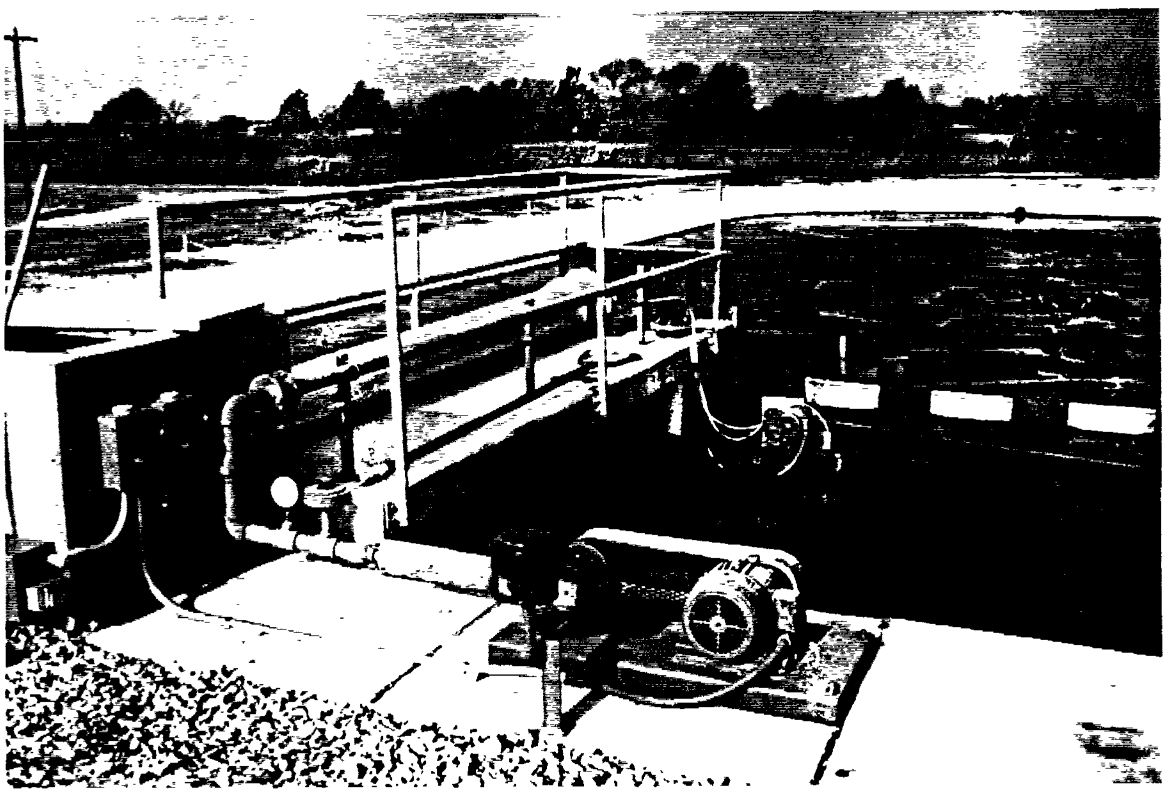


FIGURE 14. BAY, ARKANSAS PHOTO E

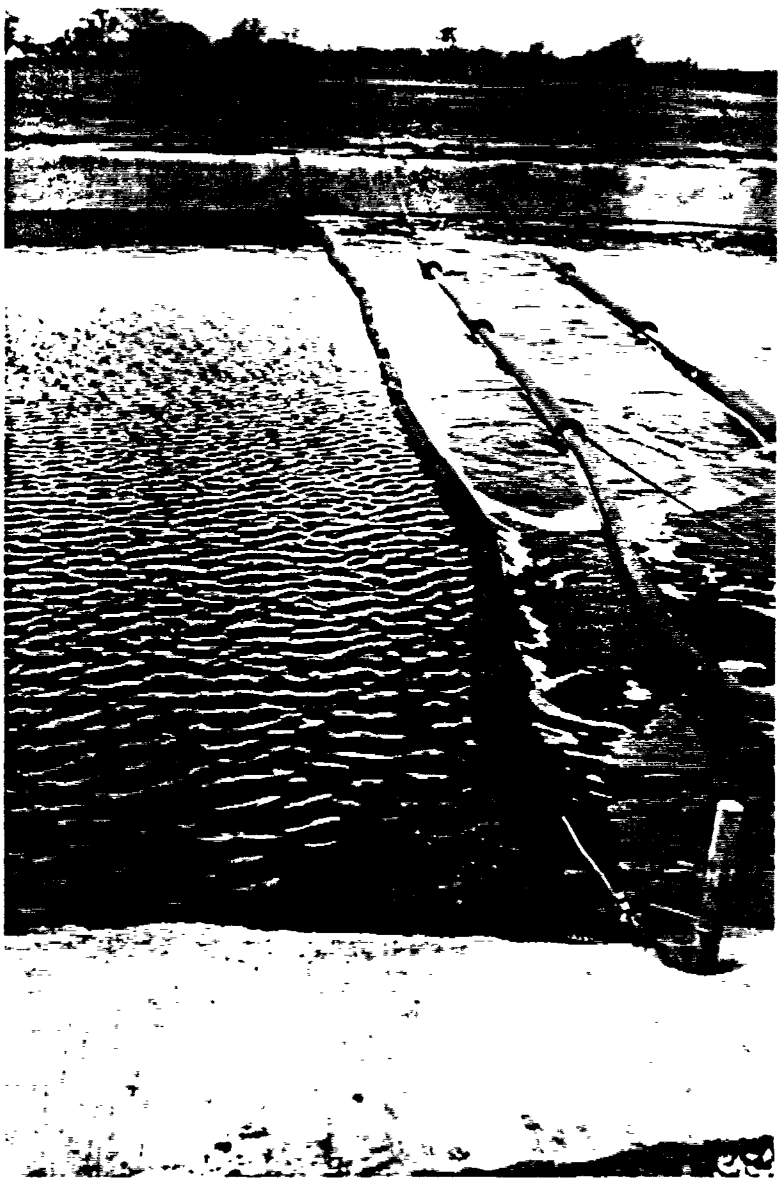


FIGURE 15. BAY, ARKANSAS PHOTO F

handle) for air flow control and an air bleed valve (smaller handle) for unchaining the aeration chain.

C. Side view of the integral clarifier consisting of 2 concrete sidewalls, concrete backwall (basin backwall) and a floating curtain on the influent side. Also note the corner float which is typical of the later designs.

D. Picture looking across the integral clarifier: baffle wall on the left; float and drive cable supporting the flocculating rake in the middle and the effluent weir on the right.

E. Picture of the airlift sludge system consisting of: air compressor (middle foreground); air lift sludge pipe (vertical pipe just to the left of the rake drive motor); gravity flow sludge line (pipe running back along the concrete walkway) and the sludge control box.

F. Picture looking across the length of the floating curtain wall in the polishing basin.

PIGGOT WWTP, PIGGOT, ARKANSAS

The Piggot WWTP in Piggot, Arkansas was designed to handle an average daily flow of 0.6 mgd. The influent is 100 percent domestic wastewater, and the flow to the plant is currently about 0.35 mgd. The plant was put on-line in April 1989 after about six months of plant construction. An unaerated flow through lagoon was previously used for treatment of the town's wastewater; this now serves as a storage lagoon for storm flow.

At the head of the plant, screening is provided by an Aquaguard™ traveling screen, manufactured by Parkson. The influent flow is then measured by a Parshall flume prior to biological treatment. Biological treatment is accomplished in a 0.95 million gallon aeration basin, followed by solids clarification in two integral clarifiers. Clarified effluent then flows into the polishing basin, with subsequent disinfection by by ultra-violet light.

The plant supervisor/operator performs essentially all plant operations and maintenance. One helper is available about one-third of the month to assist with plant chores, and an additional town employee is provided to perform weekend systems checks. A visual inspection of all systems is performed daily. The screening device is cleaned automatically and the screenings are disposed of as needed. The clarifiers are skimmed daily of floatables and blowers are checked twice per week. The UV system is cleaned weekly while other miscellaneous maintenance (i.e. spraying down equipment) is performed as needed. Diffuser flexing has been performed on a weekly basis. Process monitoring is performed three times per week and includes basin MLSS and SVI, effluent TSS, basin and effluent pH. Basin and effluent dissolved oxygen is measured daily.

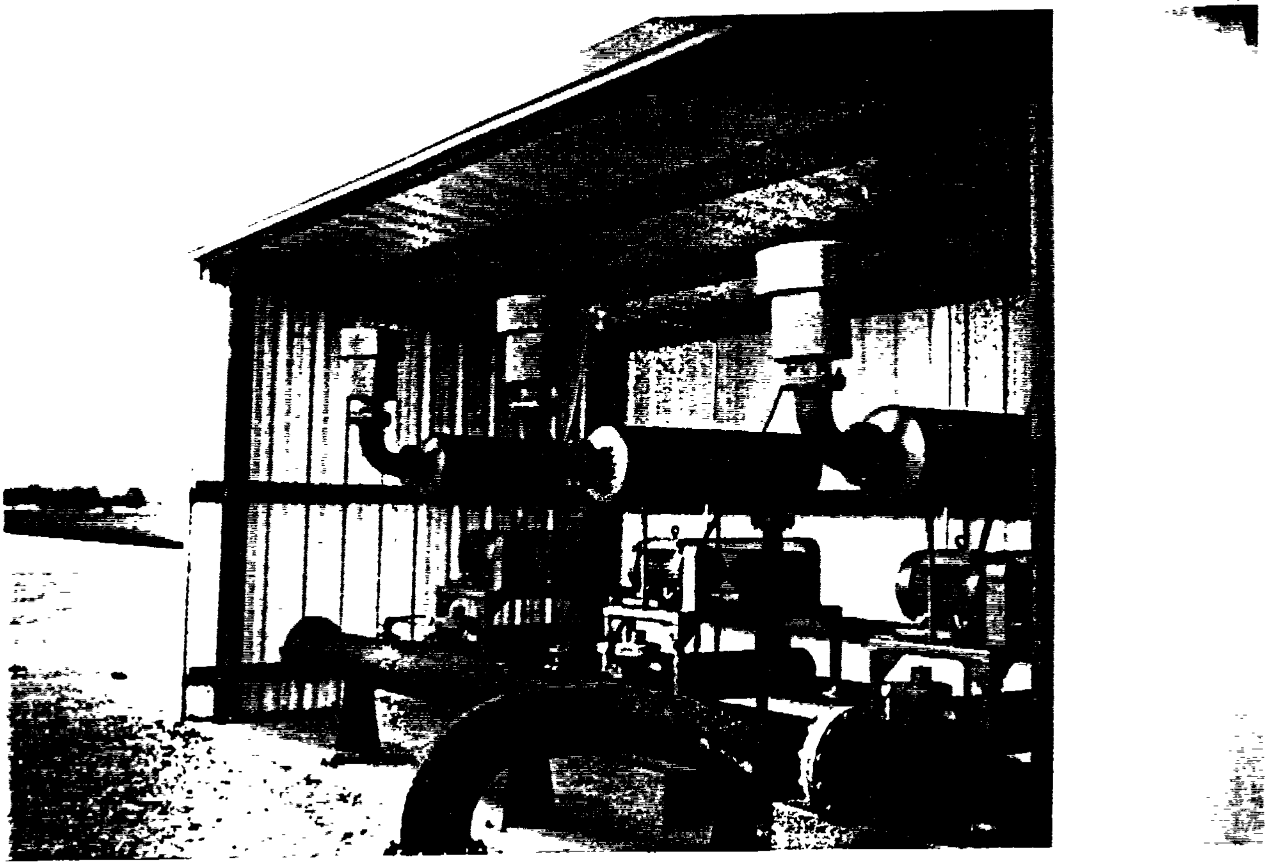
The plant has had problems maintaining the mixed liquor suspended solids at the recommended operating level. The plant effluent is meeting permit requirements. Effluent concentrations are at or a bit above 20 mg/l for BOD and TSS (See Appendix B), which will likely improve results with increased MLSS. A rake drive cable had frayed but was replaced with a plastic impregnated cable. Blower equipment is protected by a roofed three sided structure made of corrugated aluminum panels. It offers weather protection but does little for noise reduction. Otherwise the plant has experienced few problems.

Piggot WWTP/Photograph Descriptions

Refer to Figures 16 and 17:

A. Blower setup consisting of 3 to 20 HP blowers, two of which are on full-time. Blowers are housed in a lightweight aluminum structure with one open side which provides some noise reduction.

B. Flocculating rake drive control system equipped with dual limit switches. First switch slows down the motor while the second reverses the motor collation and returns it to correct operating speed.



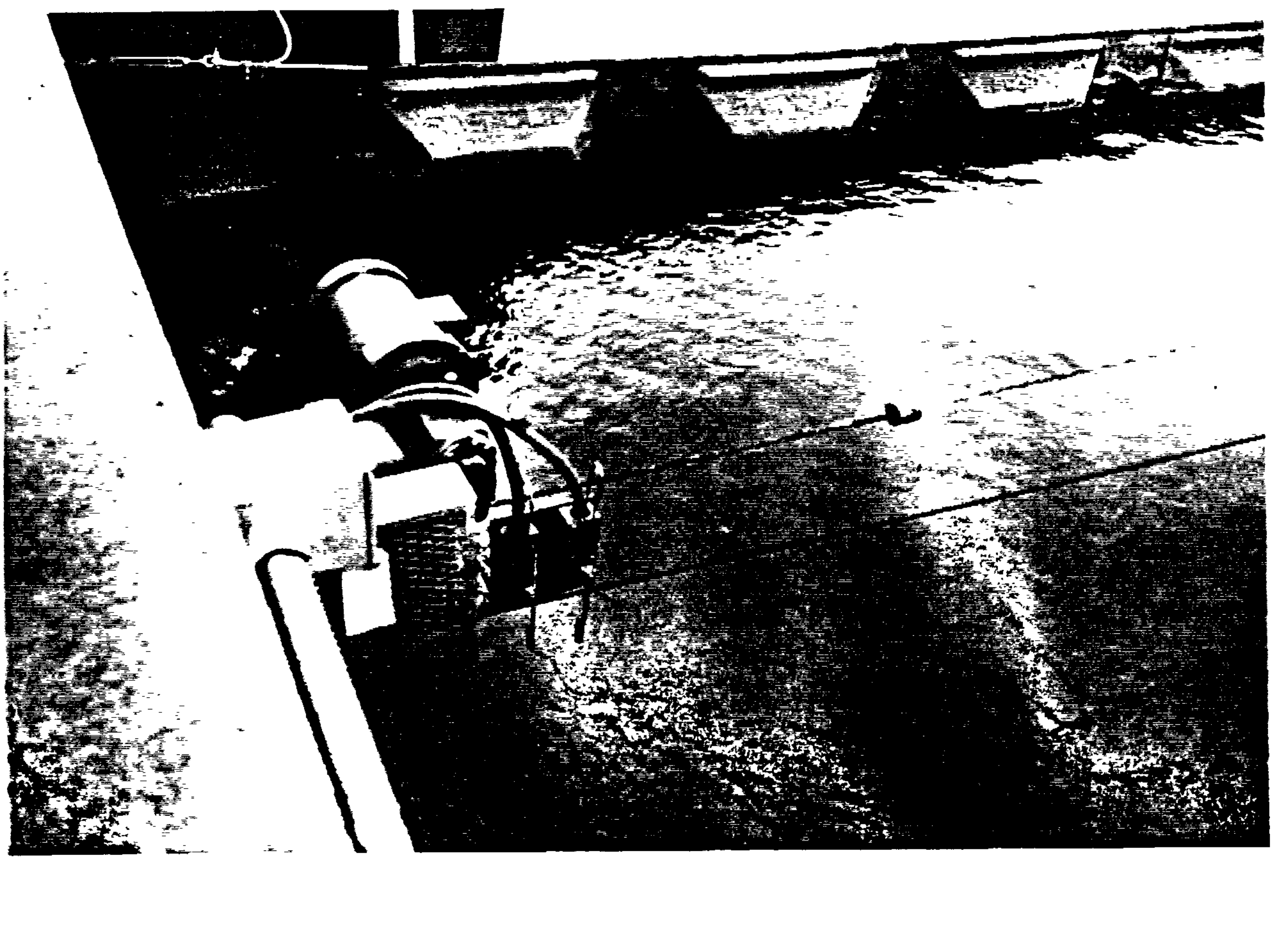
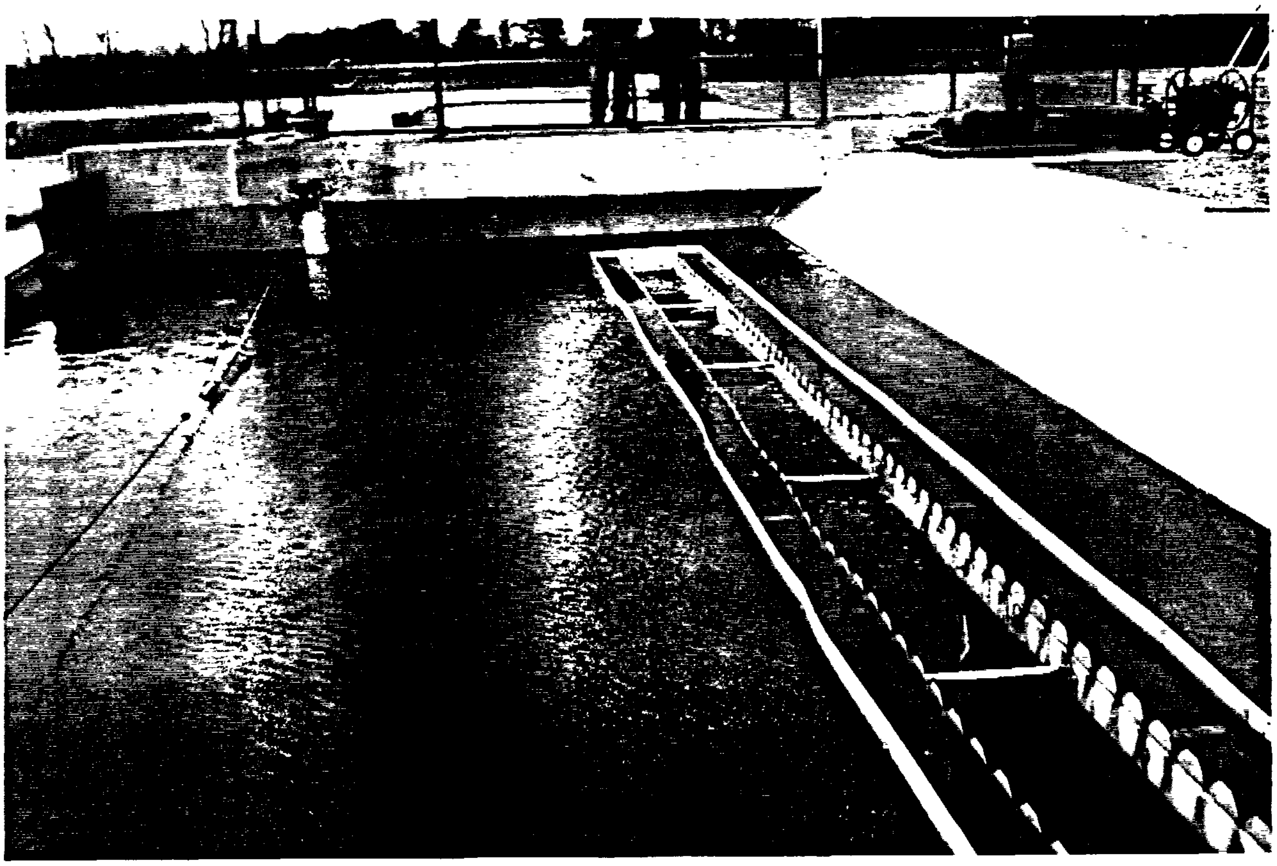


FIGURE 16. PIGGOTT, ARKANSAS PHOTOS A AND B



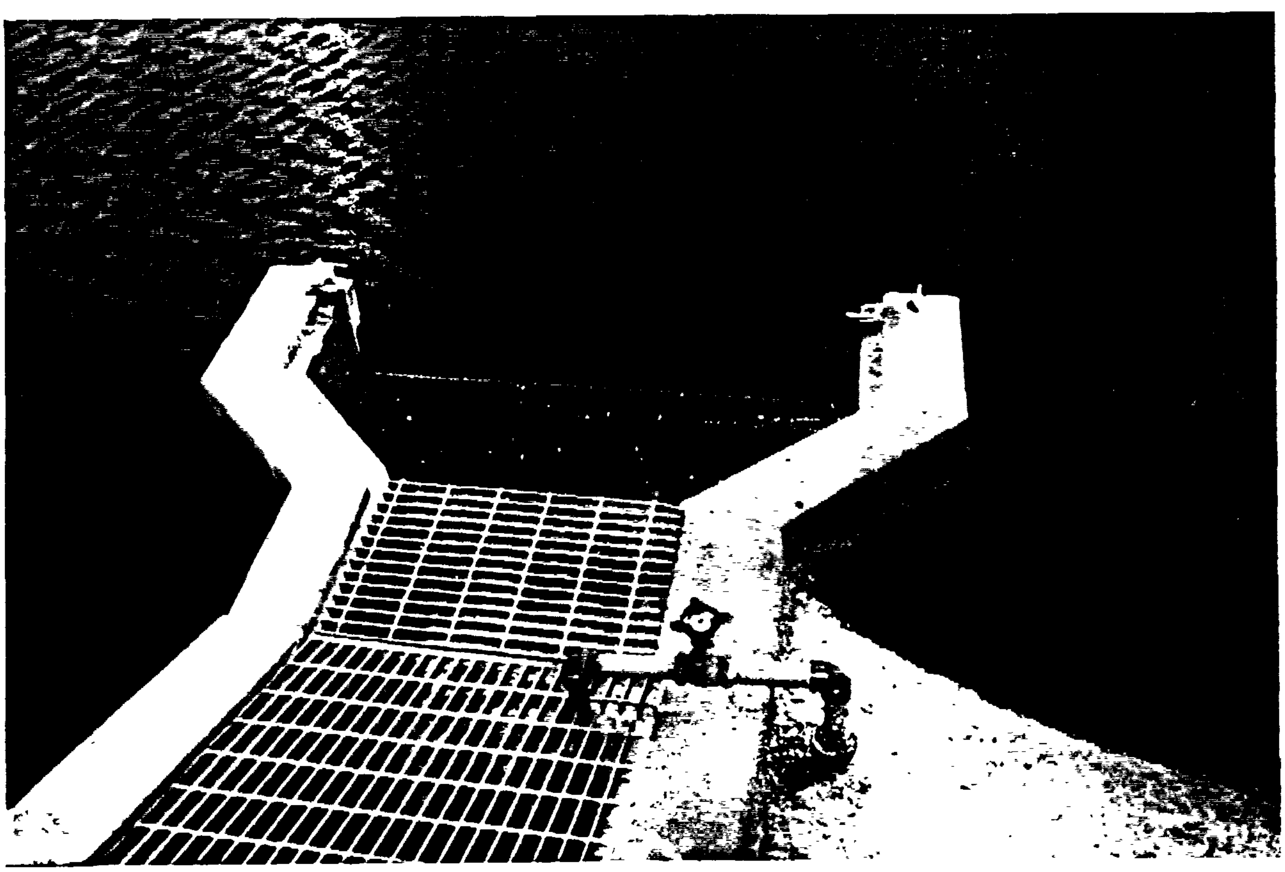


FIGURE 17. PIGGOTT, ARKANSAS PHOTOS C AND D

C. Effluent trough equipped with scum baffles.

D. Effluent weir from polishing basin. Discharges to the U.V. disinfection channel.

BLYTHEVILLE WEST, NORTH AND SOUTH WWTPS, BLYTHEVILLE, ARKANSAS

The City of Blytheville, with a population of 25,000, is one of the larger cities in Mississippi County, Arkansas. It is located approximately 185 miles northeast of Little Rock and 70 miles north of Memphis, Tennessee. Blytheville is primarily a farming community, growing cotton and winter wheat. The majority of the wastewater flow is domestic. The Blytheville plants are identical in design, differing in size only. The North plant is the smallest, and is designed to handle an average flow of 0.8 mgd. The South plant is designed for 1.4 mgd and the West plant for 1.5 mgd. Each plant was built adjacent to former unaerated flow-through lagoons. Although the City's original goal was to build one large plant to handle all the flow, this concept was dismissed because of the major sewer system re-routing and renovation which would be required. The plants were started in April 1989.

Each plant provides influent screening using an Aquaguard™ traveling screen. Grinder pumps are used for volume reduction of the screenings prior to disposal. The wastewater is biologically treated in the aeration basins which incorporate solids settling in integral clarifiers. Clarified effluent is treated further in polishing basins which have both aerated and unaerated sections. The effluent is disinfected using an ultra-violet light system.

The combined staff for the three plants consists of the superintendent, maintenance supervisor, a plant operations supervisor, three operators and an administrative assistant.

Visual inspections of all equipment is performed daily. The clarifiers and weirs are sprayed down weekly and the aeration basins and clarifiers are skimmed as needed. Blower inlet and noise filters are cleaned weekly. The two larger plants are sampled for permit requirements three times per week while the other plant is sampled for permit requirements three times per month. Additionally, process monitoring is performed daily.

The South plant has had trouble maintaining the desired operating mixed liquor suspended solids level due to a significant underloading at the plant. A two sided cinder block enclosure has been installed around the air lift sludge blower to minimize the noise. The West plant developed a crack in the concrete sludge trough due to soil settlement. The three plants had installed screening around all noise filter housings to minimize silencer maintenance due to debris accumulation. The three plants experienced high effluent ammonia levels during the start up spring months which may have been caused by farm fertilization operations and/or limited nitrification development. All these plants were performing well, in subsequent months through October 1989, as shown in the data in Appendix B.

Blytheville WWTPS Photograph Descriptions (North, South and West Plants)

Refer to Figures 18, 19, 20 and 21:

A. Blower silencers. Screens were installed to reduce filter clogging. Metal mesh filters are used; these are brushed and washed regularly (North).

B. Integral clarifier. Note the curtain and rake drive cable (North).

C. Effluent trough and rake drive enclosure (installed by plant) (North).

D. Last aeration chain in basin; closest to 3 integral clarifiers (West).

E. One of three integral clarifiers at the West plant. Steel angle bracing was installed to minimize lateral movement of the long effluent trough.

F. Aeration chain. Localized boiling indicated diffuser problem (West).

G. Structure used for air lift pump blower noise control at the South Plant.

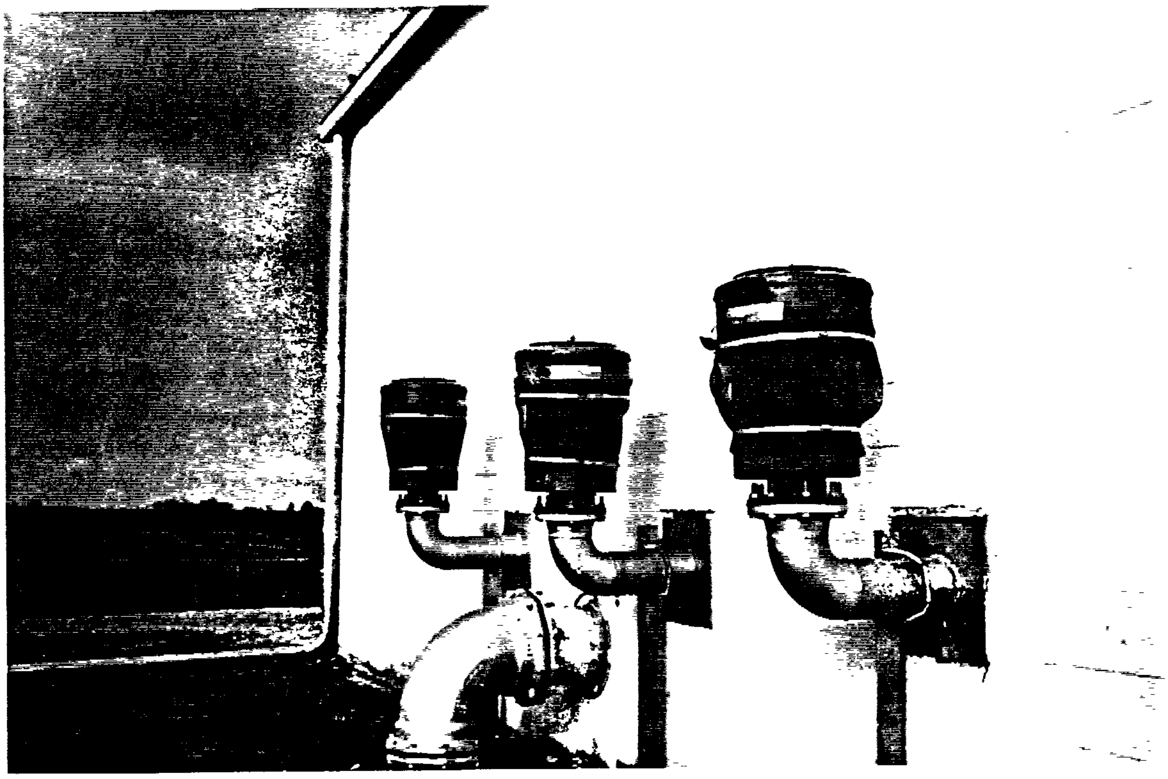
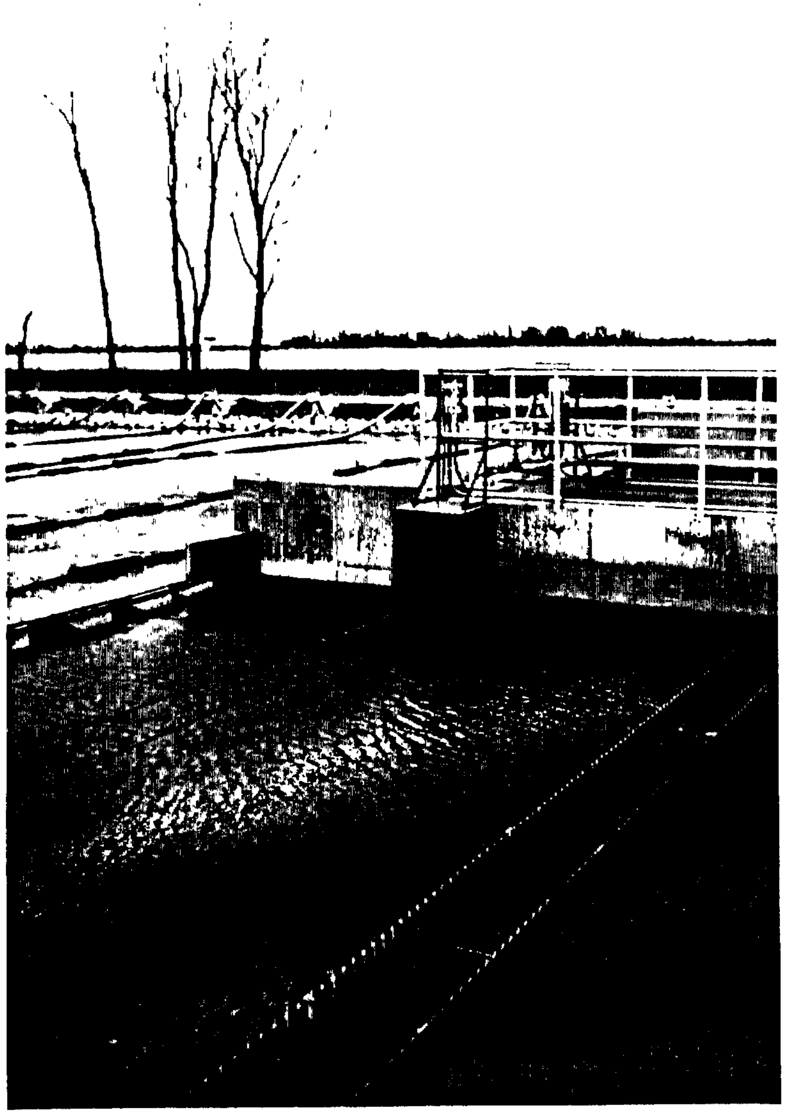
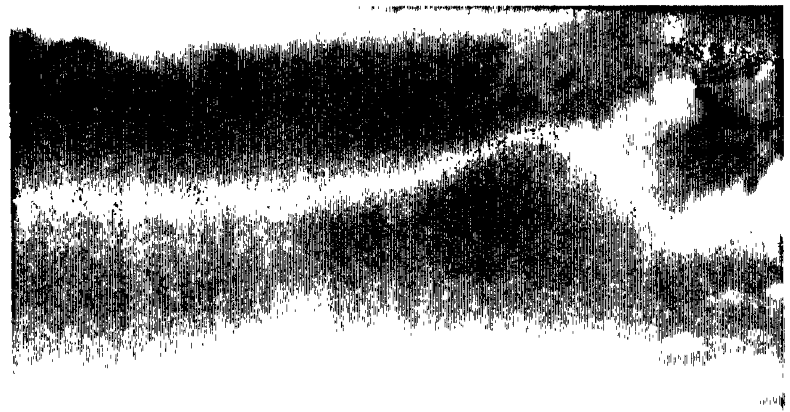


FIGURE 18. BLYTHEVILLE, ARKANSAS PHOTOS A AND B





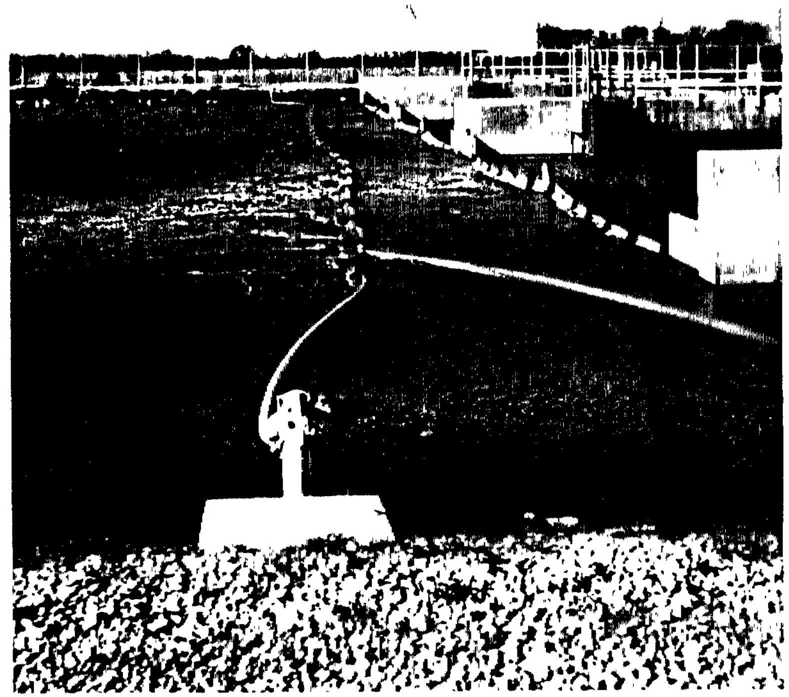
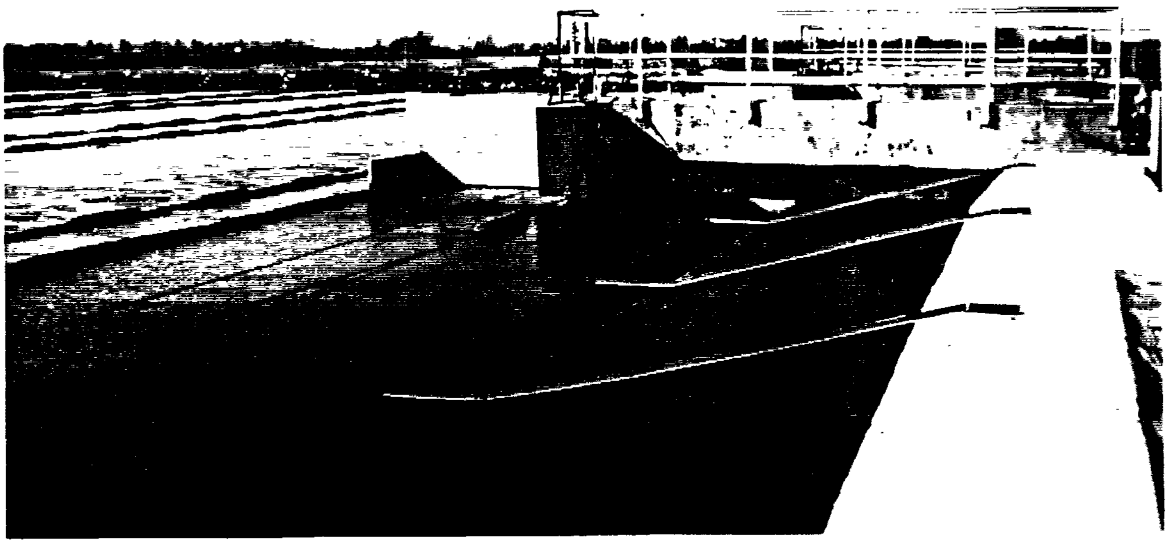


FIGURE 10 - BLYTHEVILLE, ARKANSAS PHOTOS C AND D



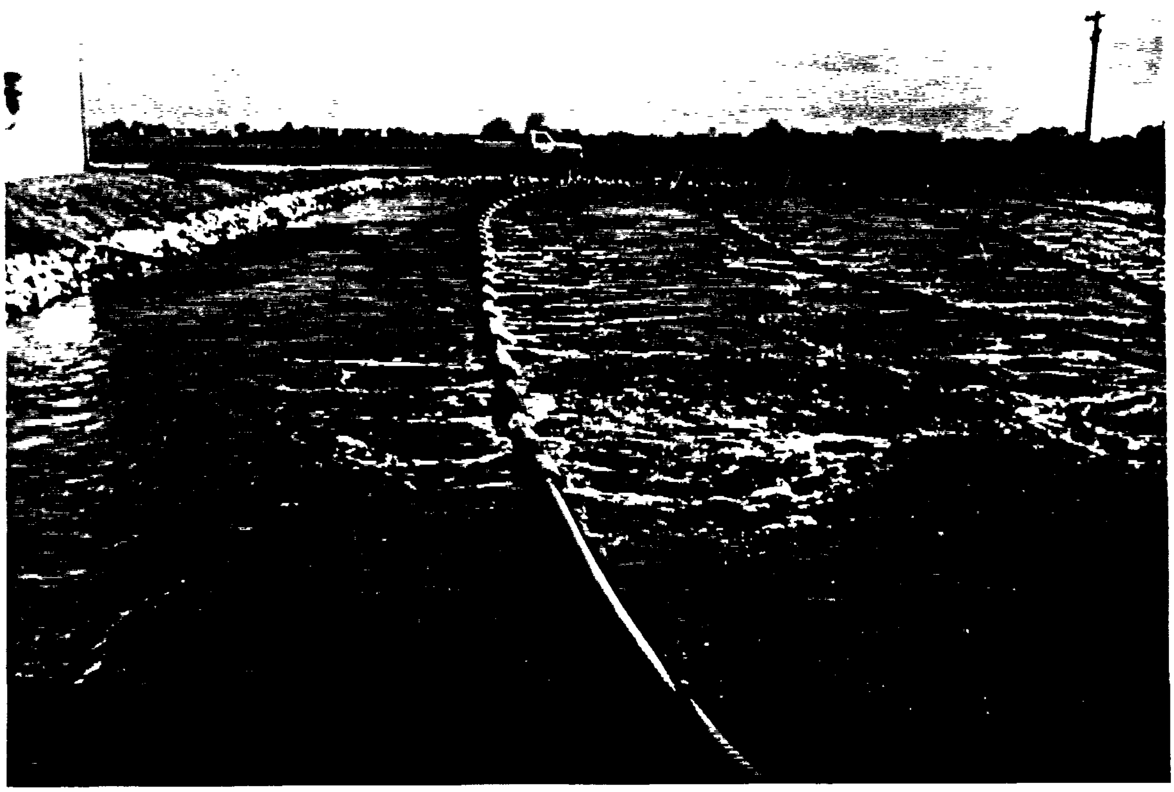


FIGURE 20. BLYTHEVILLE, ARKANSAS PHOTOS E AND F

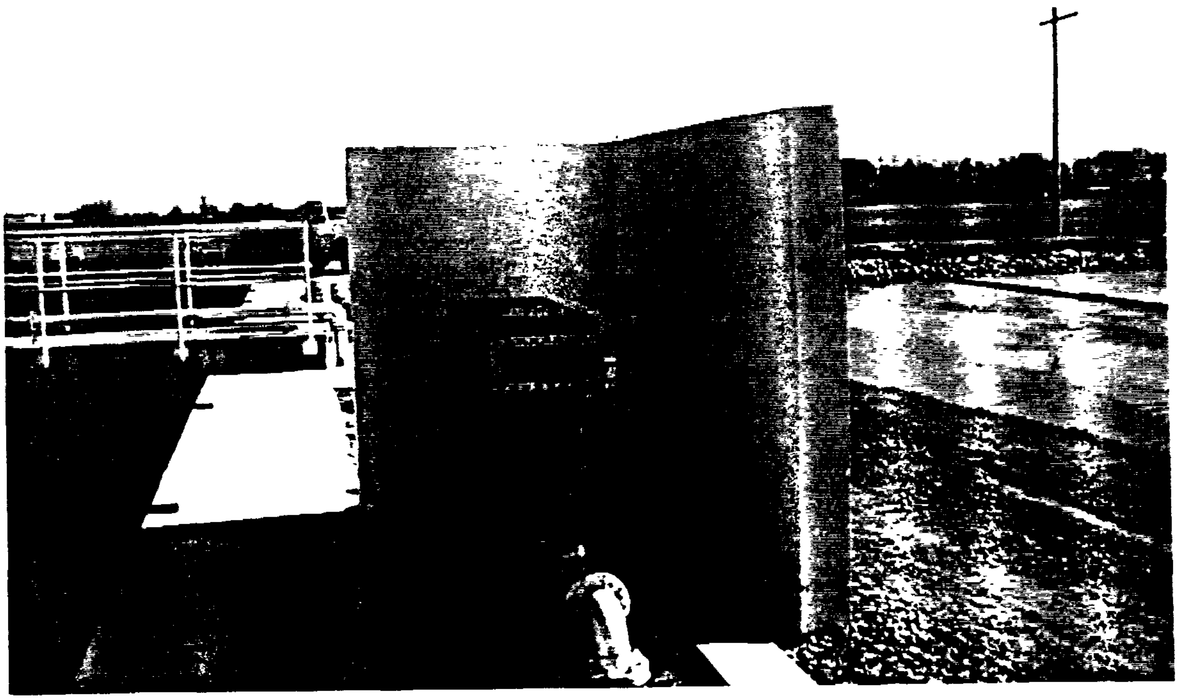


FIGURE 21. BLYTHEVILLE, ARKANSAS PHOTO G

# SECTION 7

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# APPENDIX A

# DESCRIPTION OF BIOLAC TREATMENT SYSTEMS

TABLE A-1. DESCRIPTION OF BIOLAC$^{R}$ TREATMENT SYSTEMS

| Facility Name<br>Location<br>Contact | Size<br>Design<br>Flow (mgd) | <br><br>BOD (#/day) | <br>Current<br>Flow (mgd) | <br><br>BOD (#/day) | Process Train | Biolac Description | Comments/Problems |
|---|---|---|---|---|---|---|---|
| Ardmore WWTP<br>Ardmore, Alabama<br>Bill Brakefield<br>Engineer<br>(615) 824-7980 | 0.35 | 730 | * | * | - Bar rack<br>- Biolac R<br>- Chlorination | - Aeration Basin Volume, 0.70 MG<br>- 7 chains; 8 floats/chain; 4 diffusers/float<br>- Integral clarifier<br>- Polishing basin Aerated zones<br>- 2 chains; 3 floats/chain; 2 diffusers/float<br>- Blowers: 3-15 hp (1 standby) | Plant not yet on line |
| Berry WWTP<br>Berry, Alabama<br>Mike Swindle<br>(Superintendent)<br>(205) 689-4786 | 0.15 | 275 | 0.04 | 30 | - Aquaguard traveling screen<br>- Biolac R<br>- Chlorination/dechlorination<br>- Post aeration (Cascade) | - Aeration basin Volume, 0.264 MG<br>- 5 Chains; 5 floats/chain; 4 diffusers/float<br>- Integral clarifier<br>- Polishing basin Aerated and nonaerated zones<br>- 1 chain; 4 floats/chain 2 diffusers/float<br>- Blowers: 3-7.5 hp (1 on fulltime) | Plant on line August 1989. Good system, expect even better effluent when MLSS gets to design MLSS(2500 mg/L). Rake drive cable frayed (replaced), float destroyed from rake overtravel no longer a problem now. Skim grease/oil once/week. |
| Camden North WWTP<br>Camden, Alabama<br>G.E. Jones - Engineer<br>Jones Engineering<br>(205) 872-7618 | 0.22 | 413 | * | * | - Bar screen<br>- Biolac R<br>- UV disinfection | - Aeration basin volume, 0.33 MG<br>- 6 chains; 6 floats/chain; 4 diffusers/float<br>- Integral Clarifier<br>- Polishing basin Aerated and nonaerated zones<br>- 2 chains; 4 floats/chain; 2 diffusers/float<br>- Blowers: 2-7.5 hp (no standby) | Plant not yet on line |
| Cedar Bluff WWTP<br>Cedar Bluff, Alabama<br>Keith Davis - engineer<br>Lad Environmental<br>(205) 845-5315 | 0.30 | 550 | * | * | - Aquaguard traveling screen<br>- Biolac R<br>- Chlorination/dechlorination | - Aeration basin volume 0.53MG<br>- 7 chains; 8 floats/chain; 4 diffusers/float<br>- Integral clarifier<br>- Polishing basins aerated and nonaerated zones<br>- 2 chains; 4 floats/chain; 2 diffusers/float<br>- Blowers: 3-15 hp (1 standby) | Plant not yet on line |
| Clayton WWTP<br>Clayton, Alabama<br>Bob Carter<br>Engineer<br>(205) 222-9431 | 0.40 | 512 | * | * | - Static screen<br>- Biolac R<br>- disinfection | - Aeration basin volume, 0.45 MG<br>- 6 chains; 8 floats/chain; 4 diffusers/float<br>- Integral clarifiers<br>- Polishing basin Aerated zones<br>- 1 chain; 5 floats/chain; 2 diffusers/float | Plant not yet on line |

TABLE A-1. DESCRIPTION OF BIOLAC$^R$ TREATMENT SYSTEMS
(Continued)

| Facility Name<br>Location<br>Contact | Size: Design Flow (mgd) | Design BOD (#/day) | Current Flow (mgd) | Current BOD (#/day) | Process Train | Biolac Description | Comments/Problems |
|---|---|---|---|---|---|---|---|
| Columbiana WWTP<br>Columbiana, Alabama<br>James Palmer<br>(Operator)<br>(205) 669-7845 | 0.75 | 1,251 | 0.5 | | - Bar screen<br>- grit chamber<br>- Biolac R | - Aeratin basin<br>- 6 chains; 8 floats/chain; 2 diffusers/float<br>- Integral clarifier<br>- Polishing basin aerated zones<br>- 3 chains; 4 floats/chain; 2 diffusers/float<br>- Blowers: 3-20 hp (1 standby) | Plant on line December 1989. Needed silencers for blowers, system running well, skim oil/ grease every other day main-tenance free otherwise. |
| Hanceville WWTP<br>Hanceville, Alabama<br>Bill Hicks<br>(Operator)<br>(205) 352-6177 | 0.57 | 832 | 0.25 | 365 | - Schriber screen<br>- Biolac R<br>- UV disinfection<br>- Post aeration (Cascade) | - Aeration basin<br>- 7 chains; 10 floats/chain 4 diffusers/float<br>- Integral clarifier<br>- Polishing volume aerated and nonaerated zones<br>- 2 chains; 4 floats/chain; 2 diffusers/float<br>- Blowers: 3-16 hp (1 on full time) | On line March 1989. Very pleased w/ system esp. compared to mech. aerators which oper-ator previously used. Rake motor burned out (water dam.- due to improper seal installa-tion). Rake overtraveled, operator bent trigger forward rake fine now. Rake floats hang up on other hardware at HWL. Skim oil/grease every 2 ks |
| New Brockton WWTP<br>New Brockton, Alabama<br>James Harrison<br>(Superintendent)<br>(205) 894-5550 | 0.176 | 300 | 0.05 | 98 | - Bar Rack<br>- Biolac R<br>- Nutrient removal 2 ponds with aquatic plants<br>- Post aeration (effluent flume) | - Aeratin basin volume, 0.2 MG<br>- 5 chains; 5 floats/chain; 2 diffusers/float<br>- Integral clarifier<br>- Blowers: 3 to 5 - 5 hp | Plant on line summer 1987. Very dissatisfied originally due to equipment problems. Clarifier rake motor was under sized (would kick out often in warm weather). Floating curtain cable and eyebolts rotted out. Diffuser clamps needed to be tightened. Auto valves on waste pump not working, must be switched manually. Meeting designed effluent BOD and NH3 but monitoring reports show lower limits that are not always met. |
| Oxford WWTP<br>Oxford, Alabama<br>Ronald Windham<br>Engineer<br>(205) 271-3200 | 1.00 | 1,877 | * | * | - Manual bar rack<br>- Aquaguard traveling screen<br>- Grit removal<br>- Biolac R<br>- Chlorination/dechlorination<br>- Post aeration (cascade) | - Aeration basin volume, 1.5 MG<br>- 11 chains; 13 floats/chain; 6 diffusers/float<br>- Integral clarifer<br>- Polishing basin aerated and non aerated zones<br>- 3 chains; 8 floats/chain; 2 diffusers/float<br>- Blowers: 2-60 hp (1 standby) | Plant not yet on line |

TABLE A-1. DESCRIPTION OF BIOLAC[R] TREATMENT SYSTEMS
(Continued)

| Facility Name<br>Location<br>Contact | Size: Design Flow (mgd) | Size: Design BOD (#/day) | Size: Current Flow (mgd) | Size: Current BOD (#/day) | Process Train | Biolac Description | Comments/Problems |
|---|---|---|---|---|---|---|---|
| Stevenson WWTP<br>Stevenson, Alabama<br>J.M. Garner<br>(Operator)<br>(205) 437-2490 | 0.75 | 2,502 | 0.15 | | - Aquaguard traveling screen<br>- Biolac R | - Aeration basin<br>- 12 chains; 10 floats/chain; 4 diffusers/float<br>- Integral Clarifier<br>- Polishing basin aerated and nonaerated zones<br>- 3 chains; 4 floats/chain; 2 diffusers/float<br>- Blowers: 3-40 hp (1 standby) | Experiencing problems unrelated to Biolac system. A industry has left the area resulting in greatly reduced flow & BOD loading. This makes supporting design MLSS levels impossible. |
| Bay WWTP<br>Bay, Arkansas<br>Crawford Holmes<br>(Superintendent)<br>(501) 781-3386<br>(City Hall #) | 0.15 | 313 | 0.1 | 175 | - Bar screen<br>- Biolac R<br>- Chlorination | - Aerated basin<br>- 6 chains; 5 floats/chain; 4 diffusers/float<br>- Polishing basin aerated and nonaerated<br>- 2 chains; 3 floats/chain; 2 diffusers/float<br>- Blowers: 2-7.5 hp / 5 cfm | Plant on line March 1989. Good system, low maint., flex diffuser every 2 weeks, clean air lift sludge pump w/ sewer cleaning equip. every 3-4 weeks, no clogging problems. |
| Blytheville North WWTP<br>Blytheville, Arkansas<br>Jimmy Gee<br>(Superintendent)<br>(501) 763-4961 | 0.80 | 1,134 | 0.39 | | - Aquaguard traveling screen<br>- Grinders<br>- Biolac R<br>- UV disinfection | - Aeratin basin volume, 1.09 MG<br>- 8 chains; 13 floats/screen; 4 diffusers/float<br>- Integral clarifer<br>- Polishing basin aerated and nonaerated zones<br>- 2 chains; 6 floats/chain; 2 diffusers/float<br>- Blowers: 3-25 hp (1 standby) | Plant on line April 1989. Happy w/system. Problems keeping blower filters clean during summer, planting and harvesting seasons. Reduced substantially by screening off intake access pts. Still clean once/week. Plant very well maintained. Some high BOD, TSS & NH3 numbers during initial months after startup. |
| Blytheville West WWTP<br>Blytheville, Arkansas<br>Jimmy Gee<br>(Superintendent)<br>(501) 763-4961 | 1.50 | 3,253 | 0.77 | | - Aquaguard traveling screen<br>- Grinders<br>- Biolac R<br>- UV disinfection | - Aerated Basin Volume, 3.12 MG<br>- 11 chains; 24 floats/chain; 4 diffusers/float<br>- Integral clarifiers<br>- Polishing basin aerated and nonaerated zones<br>- 2 chains; 13 floats/chain; 2 diffusers/float<br>- Blowers: 3-60 hp (1 standby) | Plant on line April 1989. Concrete sludge trough cracked soil settlement. Some high TSS & NH3 numbers during initial months after startup. |
| Blytheville South WWTP<br>Blytheville, Arkansas<br>Jimmy Gee<br>(Superintendent)<br>(501) 763-4961 | 1.40 | 3,562 | | | - Aquaguard traveling screen<br>- Grinders<br>- Biolac R<br>- UV disinfection | - Aeration basin volume, 3.12 MG<br>- 11 chains; 24 floats/chain; 4 diffusers/float<br>- Integral clarifier<br>- Polishing basin Aerated and nonaerated zones<br>- 2 chains; 13 floats/chain; 2 diffusers/float<br>- Blowers: 3-60 hp (1 standby) | Plant on line April 1989. Trouble maintaining MLSS. |

TABLE A-1. DESCRIPTION OF BIOLAC$^{R}$ TREATMENT SYSTEMS
(Continued)

| Facility Name<br>Location<br>Contact | Size: Design Flow (mgd) | Size: Design BOD (#/day) | Size: Current Flow (mgd) | Size: Current BOD (#/day) | Process Train | Biolac Description | Comments/Problems |
|---|---|---|---|---|---|---|---|
| Decatur WWTP<br>Decatur, Arkansas<br>Rick McClean<br>(Superintendent)<br>(501) 752-3769 | 1.35 | 5,630 | 1.1 | 5500 | - Bar screen<br>- Primary Clarifier<br>- Biolac R<br>- Sand filters<br>- Post aeration (surface aerators)<br>- Dechlorination | - Aeration basin<br>- 15 chains; 25 floats/chain; 6 diffusers/float<br>- Integral clarifier<br>- Polishing basin aerated and nonaerated zones<br>- 3 chains; 12 floats/chain; 4 diffusers/float<br>- Blowers: 4-50 hp (3 standby) | Meeting all eff. limits. Wave oxidation plant. Took some time to achieve denitrification. Replaced 3 of 4 rake drive motors. 75% of float assemblies were defective (PVC const. came unglued). 40% of diff will be replcd.(exposure to severe weather & handling may be cause). Add lime to maintain pH. |
| Maynard WWTP<br>Maynard, Arkansas<br>Paul Mitchell<br>(Operator)<br>(501) 647-2701 | 0.06 | 110 | * | * | - Bar screen<br>- Biolac R<br>- Chlorination | - Aerated basin volume,0.104 MG<br>- 3 chains; 3 floats/chain; 4 diffusers/float<br>- Polishing basin Aerated and nonaerated zones<br>- 1 chain; 2 floats/chain; 4 diffusers/float<br>- Blowers: 2-5 hp (no standby) | Plant not yet on line. |
| Piggot WWTP<br>Piggot, Arkansas<br>Bradley Scheffler<br>(Superintendent)<br>(501) 598-2946 | 0.60 | 1,000 | 0.3 | 450 | - Aquaguard traveling screen<br>- Biolac R<br>- UV disinfection | - Aeration basin volume, 0.952 MG<br>- 6 chains; 13 floats/chain; 4 diffusers/float plus 1 float at each corner at effluent end with 4 diffusers/float<br>- Integral clarifier<br>- Polishing basin aerated and nonaerated zones<br>- 2 chains; 8 floats/chain; 2 diffusers/float<br>- Blowers: 3-20 hp (1 standby and 1 runs 25% of time) | Plant on line April, 1989. Had trouble getting up to operating MLSS, some high BOD & TSS #'s as a result. Rake drive cable needed replacement. Low maintenance, flex diffusers occasionally & skim oil/grease daily. |
| Paint Brush Hills WWTP<br>Colorado Springs, CO<br>Kevin Smith<br>(Operator)<br>(719) 473-8600 | 0.90 | 1,350 | * | * | - Bar screen<br>- Biolac L | - Aeration basin<br>- 5 chains; 15 floats/chain; 4 diffusers/float<br>- No clarifier<br>- Polishing lagoon aerated and nonaerated zones<br>- 2 chains; 13 floats/chain; 4 diffusers/float<br>- Blowers: 2-30 hp | Plant on line March, 1989. Plant was built to serve a growing community but currently only serves a high school & 4 houses. Adequate evaluation can not be made yet. |
| Tri-Lakes WWTP<br>Monument, Colorado | 1.30 | 2,168 | * | * | - Bar screen<br>- Grit removal<br>- Biolac R<br>- Chlorination/dechlorination | - 2 Aeration basins at 2.1 MG each<br>- 11 chains/basin; 15 floats/chain; 4 diffusers/float<br>- External clarifier<br>- No polishing basin<br>- Blowers: 2-125 and 1-75 hp (1 standby) | Plant not yet on line. |

TABLE A-1. DESCRIPTION OF BIOLAC[R] TREATMENT SYSTEMS
(Continued)

| Facility Name<br>Location<br>Contact | Size: Design Flow (mgd) | Design BOD (#/day) | Current Flow (mgd) | Current BOD (#/day) | Process Train | Biolac Description | Comments/Problems |
|---|---|---|---|---|---|---|---|
| Quitman WWTP<br>Quitman, Georgia | 1.30 | 1,952 | * | * | - Biolac L<br>- Disinfection | - Aeration basin<br>- 11 chains; 31 floats, 17 floats, 14 floats, and 10 floats/chain in each of 4 cells; 4 diffusers/float<br>- No clarifier<br>- Polishing lagoon nonaerated zone<br>- Blowers: 3-30 hp (1 standby) | Plant not yet on line. |
| Ferdinand WWTP<br>Ferdinand, Indiana<br>Rusty Groeschen<br>(Operator)<br>(812) 367-2617 | 0.47 | 698 | * | * | - Grinders<br>- Grit removal<br>- Biolac R<br>- Chlorination/dechlorination<br>- Post aeration | - Aeration basin volume, 0.672 MG<br>- 7 chains; 9 floats/chain; 4 diffusers/float<br>- Integral clarifier<br>- Polishing basin aerated and nonaerated zones<br>- 2 chains; 7 floats/chain; 2 diffusers/float<br>- Blowers: 3-20 hp (1 standby) | Plant not yet on line. |
| Remington WWTP<br>Remington, Indiana<br>Marvin Sutter<br>(Operator)<br>(219) 261-2389 | 0.28 | 271 | * | * | - Bar screen<br>- Grinders<br>- Biolac R<br>- Chlorination/dechlorination | - Aeration basin volume, 0.45 MG<br>- 5 chains; 6 floats/chain; 4 diffusers/float<br>- Integral clarifier<br>- No polishing basin<br>- Blowers:3-40 hp (1 standby) | Plant not yet on line. |
| Rensselaer WWTP<br>Rensselaer, Indiana<br>Lawrence Swartz<br>(Operator)<br>(219) 866-5530 | 1.20 | 1,942 | * | * | - Aerated grit chamber<br>- Biolac R<br>- Chlorination/dechlorination<br>- Post aeration<br>(Wyss diffusers) | - 2 Aeration basins at 0.95 MG each<br>- 8 chains/basin; 10 floats/chain; 4 diffusers/float<br>- Integral clarifier<br>- No polishing basin<br>- Blowers: 3-50 hp (1 standby) | Plant not yet on line. Start up spring/summer 1990. |
| Western Wayne STP<br>Cambridge City, Indiana<br>Dan Hine<br>(Operator)<br>(317) 478-3788 | 0.80 | 1,341 | * | * | - Bar screen<br>- Biolac R<br>- Disinfection | - Aeration basin volume 1.3 MG<br>- 10 chains; 12 floats/chain; 4 diffusers/float<br>- No polishing basin<br>- Blowers: 3-20 hp | Plant not yet on line. |
| Ellsworth WWTP<br>Ellsworth, Kansas<br>John Kerschner<br>(Supt.- Water & Sewer)<br>(913) 472-3941 | 0.50 | 1,250 | 0.28 | 550 | - Bar screen<br>- Grit chamber<br>- Biolac L<br>- Stablization pond | - Aeration basin<br>- 10 chains; 10 floats/chain; 4 diffusers/float<br>- No clarifier<br>- No polishing pond (effluent not continuous, mostly used for irrigation)<br>- Blowers: 3-20 hp | On line April, 1988. Biolac is used to supplement stabilization ponds. Very happy w/ system. Changed check valves on blowers(water check valves were installed originally instead of air check valves). O & M -only routine blower maint. Some freezing in winter resulting in some restriction of chain/float movement. |

TABLE A-1. DESCRIPTION OF BIOLAC$^{R}$ TREATMENT SYSTEMS
(Continued)

| Facility Name<br>Location<br>Contact | Size: Design Flow (mgd) | Design BOD (#/day) | Current Flow (mgd) | Current BOD (#/day) | Process Train | Biolac Description | Comments/Problems |
|---|---|---|---|---|---|---|---|
| Wellsville WWTP<br>Wellsville, Kansas | 0.18 | 300 | * | * | - Biolac L | - 2 Aeration basins<br>- 2 chains/basin; 12 floats/chain; 2 diffusers/float<br>- No clarifier<br>- Polishing basin aerated and nonaerated zones<br>- 2 chains; 12 floats/chain; 2 diffusers/float<br>- Blowers: 2-20 hp (no standby) | Plant not yet on line. |
| Wichita WWTP<br>Wichita, Kansas<br>James Tush<br>(Superintendent)<br>(316) 522-9307 | 54.4 | 18,148 | * | * | - Primary clarifiers<br>- Trickling filters<br>- Biolac L (for nitrification)<br>- Chlorination<br>- Post aeration | - 6 Aeration basins, volume 2.26 MG each<br>- 25 chains/basin; 16 floats/chain; 4 diffusers/float<br>- External clarifier<br>- No polishing pond<br>- Blowers: 9-300 hp (3 standby) | Plant not yet on line.<br>Startup - March 1990 |
| Edmonton WWTP<br>Edmonton, Kentucky<br>Malcom England<br>(Operator)<br>(502) 432-4844 | 0.51 | 851 | 0.2 | 310 | - Bar screen and/or comminutor<br>- Biolac R<br>- aquaculture pond<br>- chlorination<br>- Post aeration | - Aeratin basin volume, 0.89 MG<br>- 10 chains; 10 floats/chain; 2 diffusers/float<br>- Integral clarifier<br>- Polishing basin aerated zone<br>- 2 chains; 1st chain - 5 floats/chain. 2nd chain 3 floats/chain; 2 diffusers/float<br>- Blowers: 3-20 hp (2 standby) | On line April, 1989. Significant hydraulic design problems. Rake limit switch problems & drive cable frayed. Cable was replaced w/new design. No problems w/air lift sludge pump but running continuously. Performance can not be evaluated due to hydraulics problems. |
| Greenville WWTP<br>Greenville, Kentucky<br>Roy McDonald<br>(Operator)<br>(502) 338-5260 | 0.75 | 2,160 | 0.57 | 1,110 | - Aqua-guard traveling screen<br>- Bar screen<br>- Biolac R<br>- Chlorination | - Aeration basin volume 1.37 MG<br>- 10 chains; 11 floats/chain; 4 diffusers/float<br>- Integral clarifier<br>- No polishing basin<br>- Blowers: 3-40 hp (2 standby) | Plant on line April 1988. Very good performance. Air lift sludge system doesn't perform as claimed. Floating sludge causes solids to settle out in chlorine out in chlorine contact chamber (happens more frequently in rainy weather ). Solids washout at high flows (rain). Rake cable needed replacement. |
| Morgantown WWTP<br>Morgantown, Kentucky<br>Randall Gaskey<br>(Operator)<br>(502) 526-5949 | 0.50 | 1,043 | 0.28 | 350 | - Aquaguard traveling screen<br>- Biolac R<br>- Chlorination | - Aeration basin<br>- 10 chains; 8 floats/chain; 2 diffusers/float<br>- Integral clarifier<br>- No polishing basin<br>- Blowers: 3-25 hp (1 standby, 1 - 30 min. on / 30 min. off) | On line March, 1989. Getting good removals. Some dead spots in basin (problem corrected by blower operation described at floats due to limit switch Destroyed two rake problems. Operator installed a PVC collar which has prevented rake overtravel. Floating sludge in clarifier when rake and/or air lift sludge pump are down. |

TABLE A-1. DESCRIPTION OF BIOLAC$^{R}$ TREATMENT SYSTEMS
(Continued)

| Facility Name / Location / Contact | Size: Design Flow (mgd) | Size: Design BOD (#/day) | Size: Current Flow (mgd) | Size: Current BOD (#/day) | Process Train | Biolac Description | Comments/Problems |
|---|---|---|---|---|---|---|---|
| LeSueur WWTP<br>LeSueur, Minnesota<br>Brad Bjerke<br>(Project Engineer)<br>(507) 625-4171 | 0.90 | 3,314 | * | * | - Mech. bar screen<br>- Grit removal<br>- Biolac R | - Aeration basin volume 3.2 MG<br>- 12 chains; 27 floats/chain; 1480 diffusers total<br>- No polishing basin<br>- Blowers: 4-60 hp (1 standby) | Plant not yet on line. |
| Wells WWTP<br>Wells, Minnesota<br>Brad Bjerke<br>(Project Engineer)<br>(507) 625-4171 | 0.55 | 1,147 | * | * | - Biolac R | - 2 Aeration basins volume 1.75 MG per basin<br>- 8 chains; 10 floats/chain; 4 diffusers/float<br>- No clarifier<br>- No polishing basin<br>- No information available on blowers | Plant not yet on line. |
| Baumgartner WWTP<br>St. Louis MSD<br>St. Louis, Missouri<br>PRC Engineering<br>(314) 832-0400 | 4.00 | 4,670 | * | * | - Aerated lagoon<br>- Biolac L<br>- Chlorination | - Aeration basin<br>- 10 chains; 30 floats/chain 4 diffusers/float<br>- No clarifier<br>- Polishing basin aerated zone<br>- 9 chains; 35 floats/chain; 4 diffusers/float<br>- No information available on blowers | Plant not yet on line. |
| Excelsior Springs WWTP<br>Excelsior Springs, MO<br>Rex Brinker<br>Dir. of Utilities<br>(816) 637-1415 | 2.40 | 3,980 | 1.3 | 2100 | - Pre-aeration using Biolac<br>- Discharge to overland flow area (April - Oct.) or further treatment in facultative lagoons. | - Pre-aeration basin<br>- 12 chains; 10 floats/chain; 4 diffusers/chain<br>- No clarifiers<br>- No polishing basin<br>- Blowers: 3-800 cfm (1 standby) | Biolac has been used for pre-aeration here for over 4 years. During original startup problems getting chains moving was experienced (due to poor air distribution). A 1 in 5 year storm resulted in chain & anchor problems w/4 of the 12 air lines. No problems w/new chain & anchor system. Low maintenance. |
| Livingston Manor WWTP<br>Livingston Manor, NY<br>Bob Walco<br>(Superintendent)<br>(914) 439-4910 | 0.80 | 1,668 | 0.51 | 1,170 | - pH adjustment<br>- Bar rack comminuter grit chamber<br>- Biolac R | - 2 Aeration basins at 1.05 MG each<br>- 7 chains; 12 floats/chain; 4 diffusers/float<br>- 2 External clarifier<br>- No polishing basin<br>- Blowers: 3-40 hp (1 standby) | Retrofit. Plant on line 1986. One of original biolac U.S. installations. More than share of problems. Rotted Cables, eye bolts and end caps on floats and diffuser clamps. Have had quite a bit of success using nylon rope or anchorline especially because rope stays out of MLSS. Despite cosmetic/equipment problems, plant gets excellent removal of BOD & TSS, generally 95% removal. TKN & NH3 generally 90% removal. |
| Rock Hill WWTP<br>Rock Hill, New York | 0.22 | 367 | * | * | No information available | No information available | Plant not yet on line. |

TABLE A-1. DESCRIPTION OF BIOLAC$^R$ TREATMENT SYSTEMS
(Continued)

| Facility Name<br>Location<br>Contact | Size: Design Flow (mgd) | Size: Design BOD (#/day) | Size: Current Flow (mgd) | Size: Current BOD (#/day) | Process Train | Biolac Description | Comments/Problems |
|---|---|---|---|---|---|---|---|
| Coalton WWTP<br>Coalton, Ohio<br>Rackoff Engineers<br>(614) 464-3575 | 0.046 | 61 | *<br>q | * | - Bar screen<br>- Biolac R<br>- Chlorination | - Aeration basin<br>- 2 chains; 3 floats/chain; 4 diffusers/float<br>- Integral clarifier<br>- Polishing basin Aerated zone<br>- 1 chain; 2 floats/chain; 2 diffusers/float<br>- Blowers: 3-2 hp (1 standby) | Plant not yet on line. |
| Franklin WWTP<br>Miami Conservancy Dist.<br>Nick Brookhart<br>(Wastewater Engineer)<br>1(800) 451-4932 | 4.00 | 18,000 | 4.5 | 29275 | - Bar screen<br>- Primary clarifier<br>- Biolac R<br>- Chlorination/dechlorination | - Aeration basin volume 9 MG<br>- 34 chains; 26 floats/chain; 6 diffusers/float<br>- 2 external clarifiers<br>- No polishing basin<br>- Blowers: 3-300 hp/6000 cfm blowers (1 standby) | Retrofit-<br>Plant on line October 1989. |
| Frazeysburg WWTP<br>Frazeysburg, Ohio<br>Mona Miller<br>(City Clerk)<br>(614) 828-2564 | 0.18 | 390 | * | * | No information available | No information available | Plant not yet on line. |
| Lowell WWTP<br>Lowell, Ohio<br>Paul Kulisek<br>(Operator)<br>(614) 896-3086 | 0.054 | 70 | 0.11 | 141 | - Bar racks<br>- Grinder pumps<br>- Grit chamber<br>- Biolac R<br>- UV disinfection | - Aeration basin<br>- 2 chains; 3 floats/chain; 4 diffusers/float<br>- Integral clarifier<br>- Polishing basin aerated and nonaerated zones<br>- 1 chain; 3 floats/chain; 4 diffusers/float<br>- Blowers: 3-3 hp (designed to have 2 running, 3 needed) | Plant on line Jan., 1989. Plant underdesigned hydraulically. Problems w/limit switches on rake system, operator fixed problem himself. Air lift sludge pumps clog w/ fine particles. Cracked elbow on one float assembly delivered. Solids settling in polishing basin. Generally reliable performance. |
| Durant WWTP<br>Durant, Oklahoma<br>C.O. Reese<br>(Superintendent)<br>(405) 920-0364 | 1.70 | 2,400 | 2.10 | 3,173 | - Bar rack<br>- Barminutor<br>- Biolac R<br>- Cascade post aeration | - Aeration basin volume 5.3 MG<br>- 1st lagoon - 8 chains; 20 floats/chain; 2 diffusers/float;<br>- 2nd lagoon - 4 different chains; 19 floats/chain, 17 floats/chain, 15 floats/chain, 13 floats/chain; all with 2 diffusers/float.<br>- Polishing basin area 11 acres. aerated zone<br>- 15 chains; 30 floats/chain; 2 diffusers/float<br>- Blowers: 8-75 hp - 5 for lagoon [illegible] | Partial retrofit & added polishing in April 1988 to help meet permit. Operator doesn't think they would be meeting permit now without Biolac. Slime accumulation on sleeves. Metal air line fatigue 3 or 4 holes developed. Need to reduce effluent toxicity. Clarifiers overloaded. |

TABLE A-1. DESCRIPTION OF BIOLAC$^{R}$ TREATMENT SYSTEMS
(Continued)

| Facility Name<br>Location<br>Contact | Size: Design Flow (mgd) | Size: Design BOD (#/day) | Size: Current Flow (mgd) | Size: Current BOD (#/day) | Process Train | Biolac Description | Comments/Problems |
|---|---|---|---|---|---|---|---|
| City of Canby WWTP<br>Canby, Oregon<br>Steve Hanson<br>(Superintendent)<br>(503) 266-4021<br>Ext. 248 | 1.15 | 2,160 | 0.76 | 1,270 | - Bar screen<br>- Grit removal<br>- Primary clarifiers<br>- Biolac R<br>- External clarifiers<br>- Chlorination | - Aeration basin<br>- 8 chains; 4 floats/chain; 4 diffusers/blower<br>- External clarifier<br>- No polishing basin<br>- Blowers: 1-50 hp, 1-30 hp, 2-20 hp | Plant on line in 1886. Control air in basin to produce anoxic zone to achieve nitrification denitrification. Older generation equipment - corrosion problems. |
| Chase City WWTP<br>Chase City, Virginia | 0.60 | 1,201 | * | * | - Grit chamber<br>- Biolac R<br>- Sand filter<br>- UV disinfection and reaeration | - 2 aeration basins at .765 MG each<br>- 7 chains; 7 floats; 4 diffusers/float<br>- External clarifier aerated and nonaerated zones<br>- 3 chains; 3 floats/chain; 4 diffusers/float<br>- Blowers: 4-25 hp (1 standby) | Plant not yet on line. |
| Fincastle WWTP<br>Fincastle, Virginia<br>Wayne Weikel<br>(Director)<br>(703) 473-3065 | 0.08 | 150 | 0.04 | 67 | - Bar screen<br>- Biolac L<br>- Chlorination<br>- Post aeration | - Aeration basin<br>- 2 chains; 7 floats/chain; 2 diffusers/float<br>- External clarifier<br>- Polishing basin aerated and nonaerated zones<br>- 2 chains; 8 floats/chain; 2 diffusers/float<br>- Blowers: 2-10 hp (1 standby) | Plant on line September 1986. Good performance. Corrosion of metal hardware. Basin froze to within a 3 foot diameter around floats for as long as 1 week with no decrease in treatment. |
| Lakeside WWTP<br>Winchester, Virginia<br>Hank Sliwinski<br>(Supt.- Several Plants)<br>(703) 722-2402<br>(Parkins Mill Plant #) | 0.275 | 459 | * | * | - Bar screen<br>- Biolac L<br>- Disinfection | - Aerated basin volume 2.23 MG<br>- 4 chains; 14 floats/chain; 2 diffusers/float<br>- No clarifier<br>- Polishing basin<br>- 3 chains; 8 floats/chain; 2 diffusers/float<br>- Blowers: 3-10 hp (1 standby) | Not able to contact operator. Equipment on line in 1988. |

# APPENDIX B

# PERFORMANCE DATA SUMMARY TABLES FOR SELECTED BIOLAC PLANTS

TABLE B-1. PERFORMANCE DATA SUMMARY
CITY OF MORGANTOWN, KENTUCKY - BIOLAC R PLANT

| Month | Flow (MGD) | Influent BOD (mg/L) | Effluent BOD (mg/L) | % BOD Removal | Loading lbs BOD/d | Influent TSS (mg/L) | Effluent TSS (mg/L) | % TSS Removal | NH3-N (mg/L) |
|---|---|---|---|---|---|---|---|---|---|
| January 1989 | .322 | 95. | 59.1 | 37.8 | 255. | 150. | 29. | 80.6 | 7.7 |
| February 1989 | .388 | 136. | 57.5 | 57.7 | 440. | 120. | 16.5 | 86.3 | 7.6 |
| March 1989 | .425 | 61.5 | 31.4 | 48.9 | 218. | 100. | 6.4 | 93.6 | 5.4 |
| April 1989 | .345 | 138. | 19.3 | 86. | 397. | 184. | 7.2 | 96.1 | <0.01 |
| May 1989 | .247 | 194. | 10.5 | 94.6 | 399. | 222. | 20. | 91. | <0.01 |
| June 1989 | .278 | 106. | 21.3 | 84.7 | 246. | 168. | 14. | 91.7 | <0.1 |
| July 1989 | .285 | 151.5 | 11.9 | 92.1 | 360. | 86. | 24. | 97.2 | 0.1 |
| August 1989 | .270 | 608. | 6.9 | 98.9 | 1369. | 77. | <0.4 | 99.5 | <0.1 |
| September 1989 | .316 | 258. | 6.4 | 97.5 | 680. | 392. | 4.4 | 98.9 | 0.3 |
| Mean: | 0.320 | 194.2 | 24.9 | 77.6 | 484.9 | 166.6 | 13.5 | 170.5 | 2.4 |
| Mean: April to September 1989 | 0.290 | 242.7 | 12.7 | 92.3 | 575.2 | 188.2 | 11.7 | 95.7 | 0.1 |
| Design | 0.5 | - | - | - | 1045 | - | - | - | - |
| % of Design | 58% | - | - | - | 55% | - | - | - | - |

Startup January 1989 to March 1989
Sampling Program: 1 sample per month

TABLE B-2. PERFORMANCE DATA SUMMARY
CITY OF GREENVILLE, KENTUCKY - BIOLAC-R PLANT

| Month | Flow (MGD) | Influent BOD (mg/L) | Effluent BOD (mg/L) | % BOD Removal | Loading lbs BOD/d | Influent TSS (mg/L) | Effluent TSS (mg/L) | % TSS Removal | NH3-N (mg/L) | MLSS (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| May 1988 | .580 | 198. | 23. | 88.4 | 97. | 166. | 25. | 85. | .30 | |
| June 1988 | .260 | 405. | 20. | 95.1 | 878. | 625. | 81. | 87.0 | .60 | 1856. |
| July 1988 | .360 | 225. | 10. | 95.6 | 675. | 180. | 22. | 87.8 | .40 | |
| August 1988 | .270 | 170. | 2. | 98.8 | 382. | 142. | 6. | 95.8 | .75 | |
| September 1988 | .280 | 320. | 4. | 98.75 | 747. | 174. | 2. | 98.9 | .70 | 1736. |
| October 1988 | .270 | 278. | 4. | 98.6 | 626. | 202. | 4. | 98.0 | .54 | 1278. |
| November 1988 | .480 | 140. | 4. | 97.1 | 560. | 162. | 3. | 98.2 | .46 | 1392. |
| December 1988 | .490 | 150. | 3. | 98.0 | 613. | 300. | 7. | 97.7 | .45 | 2019. |
| January 1989 | .680 | 125. | 2. | 98.4 | 709. | 137. | 7. | 94.9 | .20 | 2178. |
| February 1989 | .530 | 123. | 6. | 95.1 | 543. | 157. | 12. | 92.4 | .20 | 3532. |
| March 1989 | .740 | 129. | 5. | 96.1 | 796. | 122. | 8. | 93.4 | .30 | 3700. |
| April 1989 | .580 | 105. | 6. | 94.3 | 508. | 370. | 7. | 98.1 | .25 | 3400. |
| May 1989 | .290 | 85. | 2.6 | 96.4 | 206 | 182. | 6.2 | 96.6 | 2.9 | 3704. |
| June 1989 | .350 | 85. | 2.6 | 96.4 | 248. | 80. | 5.6 | 93.0 | .20 | 2648. |
| July 1989 | .330 | 123. | 2.6 | 97.9 | 338. | 250. | 1.2 | 99.5 | .35 | |
| August 1989 | .336 | 184. | 2.0 | 98. | 515. | 156. | 2.0 | 98.7 | .15 | |
| Mean: | 0.4 | 177.8 | 6.2 | 96.5 | 527.6 | 212.8 | 12.4 | 94.7 | 0.5 | 2494.8 |
| Design | 0.73 | | | | 1293 | | | | | |
| % Design | 55% | | | | 41% | | | | | |

Sampling program: 1 day per month

TABLE B-3. PERFORMANCE DATA SUMMARY
CITY OF NEW BROCKTON, ALABAMA - BIOLAC-R PLANT

| Month | Flow (MGD) | Influent BOD (mg/L) | Effluent BOD (mg/L) | % BOD Removal | Loading lbs BOD/d | Influent TSS (mg/L) | Effluent TSS (mg/L) | % TSS Removal | NH3-N (mg/L) |
|---|---|---|---|---|---|---|---|---|---|
| February 1988 | | 182. | 19. | 89.6 | | 105. | 11. | 89.6 | .7 |
| March 1988 | | 280. | 9. | 96.8 | | 300. | 22. | 92.7 | .9 |
| April 1988 | | 184. | 6. | 96.7 | | 218. | 11. | 94.9 | 1.3 |
| April 1988 | | 173. | 4. | 97.7 | | 218. | 11. | 94.9 | |
| May 1988 | | 70. | 18. | 97.4 | | 47. | 10. | 78.8 | 4.5 |
| June 1988 | | 283. | 19. | 93.3 | | 234. | 17. | 92.7 | .8 |
| July 1988 | | 250. | 7. | 97.3 | | 201. | 15. | 92.5 | .8 |
| July 1988 | | 290. | 6. | 98.0 | | 258. | 12. | 95.4 | 1.6 |
| July 1988 | | 250. | 3. | 98.8 | | 300. | 6. | 980. | 2.2 |
| July 1988 | | 190. | 5. | 97.4 | | 118. | 3. | 97.5 | 2.2 |
| August 1988 | | 450. | 8. | 98.23 | | 505. | 8. | 98.4 | 1.6 |
| August 1988 | | 234. | 6. | 97.44 | | 248. | 6. | 97.6 | 2.2 |
| September 1988 | | 600. | 8. | 98.7 | | 658. | 13. | 98.02 | 2.2 |
| September 1988 | | 270. | 2. | 99. | | 380. | 6. | 98.4 | 2.4 |
| September 1988 | | 108. | 7. | 93.5 | | 185. | 16. | 91.35 | 2.4 |
| September 1988 | | 225. | 21. | 90.7 | | 329. | 20. | 93.9 | |
| September 1988 | | 79. | 15. | 81.0 | | 163. | 17. | 89.6 | |
| October 1988 | | 113. | 20. | 82.3 | | 200. | 18. | 91.0 | |
| December 1988 | | 218. | 2. | 99.1 | | 222. | 1. | 99.6 | 1.4 |
| February 1989 | | 175. | 6. | 96.6 | | 145. | 14. | 90.4 | 2.8 |
| Mean: | | 231.2 | 9.6 | 95.0 | | 251.7 | 11.9 | 93.8 | 1.9 |
| June 1989 | 0.05 | 167 | 3 | 98.2 | 69.6 | 153 | 4 | 97.4 | 2.4 |
| July 1989 | 0.06 | 368 | 3 | 99.2 | 184.1 | 547 | 2 | 99.6 | 4.0 |
| August 1989 | 0.05 | 194 | 2 | 98.9 | 80.9 | 176 | 2 | 98.9 | 0.2 |
| Mean: June to August 1989 | 0.053 | 243 | 2.7 | 98.8 | 111.5 | 292.0 | 2.7 | 98.6 | 2.2 |
| Design | 0.175 | | | | | | | | |
| % Design | 30% | | | | | | | | |

Sampling program monthly

TABLE B-4. PERFORMANCE DATA SUMMARY
CITY OF EDMONTON, KENTUCKY - BIOLAC-R PLANT

| Month | Flow (MGD) | Influent BOD (mg/L) | Effluent BOD (mg/L) | % BOD Removal | Loading lbs BOD/d | Influent TSS (mg/L) | Effluent TSS (mg/L) | % TSS Removal | NH3-N (mg/L) |
|---|---|---|---|---|---|---|---|---|---|
| May 1989 | ND | 100. | 31. | 69. | ND | 106. | 26. | 75.5 | <1.00 |
| June 1989 | ND | 80. | 33. | 58.75 | ND | 26. | 22. | 15.4 | <1.00 |
| July 1989 | ND | 110. | 18. | 83.6 | ND | 64. | 4. | 93.75 | <1.00 |
| August 1989 | ND | 291. | 3. | 99.0 | ND | 513. | 11. | 97.9 | 7.50 |
| September 1989 | ND | 396. | 12. | 95.9 | ND | 453. | 29. | 93.6 | <1.00 |
| October 1989 | ND | 114. | 14. | 87.7 | ND | 102. | 29. | 71.6 | 5.30 |
| November 1989 | ND | 102. | 11. | 89.2 | ND | 197. | 19. | 90.36 | <1.00 |
| Mean: | | 170.4 | 17.4 | 83.3 | | 208.7 | 20.0 | 76.9 | 2.5 |
| Mean: September to November 1989 | 0.2(1) | 202.6 | 11.6 | 9.1 | 185(1) | 265.8 | 18.4 | 89.5 | 3.2 |
| Design | 0.51 | | | | 850 | | | | |
| %Design | 39% | | | | 22% | | | | |

Startup April to June 1989

Sampling program 1 day per month

(1)From operator

TABLE B-5. PERFORMANCE DATA SUMMARY
CITY OF FINCASTLE, VIRGINIA - BIOLAC-L PLANT

| Month | Flow (MGD) | Influent BOD (mg/L) | Effluent BOD (mg/L) | % BOD Removal | Loading lbs BOD/d | Influent TSS (mg/L) | Effluent TSS (mg/L) | % TSS Removal |
|---|---|---|---|---|---|---|---|---|
| September 1988 | .044 | 230. | 15.21 | 93.4 | 84.4 | 217.6 | 8. | 96.3 |
| October 1988 | .048 | 200. | 14.25 | 92.9 | 80.1 | 222.1 | 13.1 | 94.1 |
| November 1988 | .050 | 239. | 12.93 | 94.6 | 99.7 | 250.4 | 11. | 95.6 |
| December 1988 | .042 | 215. | 14.1 | 93.4 | 75.3 | 246. | 14.5 | 94.1 |
| January 1989 | .049 | 227.5 | 19.05 | 91.6 | 93. | 242.5 | 27.63 | 88.6 |
| February 1989 | .048 | 222. | 21.96 | 90.1 | 89. | 255. | 49.87 | 80.45 |
| March 1989 | .052 | 229.6 | 29.40 | 87.2 | 99.6 | 252.8 | 45.2 | 82.1 |
| April 1989 | .049 | 217. | 29.34 | 86.5 | 89.2 | 205.8 | 21.3 | 89.7 |
| May 1989 | .069 | 181.6 | 26.96 | 83.5 | 104.5 | 152. | 29.4 | 80.7 |
| June 1989 | .036 | 189. | 14.9 | 92.12 | 56.7 | 155.5 | 15.5 | 90.03 |
| July 1989 | .057 | 235. | 10.31 | 95.6 | 111.7 | 131. | 7.25 | 94.5 |
| August 1989 | .031 | 229. | 14.63 | 93.63 | 59.4 | 155.0 | 14.8 | 90.5 |
| Mean: | 0.048 | 217.9 | 18.6 | 91.2 | 86.9 | 207 | 21.5 | 89.7 |
| Design | 0.075 | | | | | | | |
| % Design | 64% | | | | | | | |

Sampling program one day per month

TABLE B-6. PERFORMANCE DATA SUMMARY
CITY OF LOWELL, OHIO - BIOLAC-R PLANT

| Month | Flow (MGD) | Influent BOD (mg/L) | Effluent BOD (mg/L) | % BOD Removal | Loading lbs BOD/d | Influent TSS (mg/L) | Effluent TSS (mg/L) | % TSS Removal | NH3-N (mg/L) | MLSS (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| July 1989 | 0.120 | 168 | 29.0 | 82.6 | 167.7 | 214.5 | 57.0 | 73.4 | 17 | 763 |
| August 1989 | 0.122 | 130 | 7.5 | 94.2 | 132.3 | 93.3 | 8.0 | 91.4 | 3 | 3517 |
| September 1989 | 0.092 | 260 | 3.5 | 98.6 | 199.5 | 208.5 | 12.5 | 94.0 | 0 | 5412 |
| Mean: | 0.111 | 185.9 | 13.3 | 91.8 | 166.5 | 172.1 | 25,8 | 86.3 | 6.7 | 3230 |
| Design | 0.18 | | | | | | | | | |
| % Design | 62% | | | | | | | | | |

Sampling program weekly

TABLE B-7. PERFORMANCE DATA SUMMARY
CITY OF HANCEVILLE, KENTUCKY - BIOLAC-R PLANT

| Month | Flow (MGD) | Influent BOD (mg/L) | Effluent BOD (mg/L) | % BOD Removal | Loading lbs BOD/d | Influent TSS (mg/L) | Effluent TSS (mg/L) | % TSS Removal | NH3-N (mg/L) |
|---|---|---|---|---|---|---|---|---|---|
| March 1989 | 0.500 | 59.2 | 12.4 | 79.0 | 247 | 76 | 6.5 | 91.4 | 21. |
| April 1989 | 0.605 | 54.0 | 9.8 | 81.9 | 272 | 64 | 11.0 | 82.8 | 2.1 |
| May 1989 | 0.497 | 39.9 | 12.8 | 67.9 | 165 | 44 | 7.0 | 84.0 | 15.7 |
| June 1989 | 0.666 | 137.0 | 15.8 | 88.5 | 761 | 119 | 9.0 | 92.4 | 1.0 |
| July 1989 | 0.728 | 90.8 | 10.5 | 88.4 | 551 | 51 | 2.7 | 94.8 | 1.0 |
| August 1989 | 0.274 | 113.0 | 7.5 | 93.4 | 258 | 79 | 7.3 | 90.7 | 1.0 |
| September 1989 | 0.300 | 194.0 | 5.1 | 98.0 | 485 | 142 | 17.0 | 90.0 | 0.1 |
| Mean: | 0.5 | 98.3 | 10.6 | 85.3 | 391. | 482.0 | 8.6 | 89.4 | 3.3 |
| Mean: June to September 1989 | 0.5 | 133.7 | 9.7 | 92.0 | 514. | 97.8 | 9.0 | 92. | 0.8 |
| Design | 0.57 | | | | 832 | | | | |
| % Design | 88% | | | | 62% | | | | |

TABLE B-8. LIVINGSTON MANOR, NEW YORK

| Date | Flow | Influent BOD | Effluent BOD | % Removal BOD | Loading lbs BOD/Day | Influent TSS | Effluent TSS | % TSS Removal | Influent TKN | Effluent TKN | % TNK Removal | Influent NH3-N | Effluent $NH_3$-N | % $NH_3$-N Removal |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| June 1986 | 0.530 | 210. | 9.3 | 95.6 | 928. | 187. | 18.5 | 90.1 | - | - | - | - | - | - |
| June 1986 | 0.616 | 268. | 5.6 | 97.9 | 1,377. | 246. | 9.5 | 96.0 | - | - | - | - | - | - |
| June 1986 | 0.540 | 376. | 16.0 | 95.7 | 1,693. | 650. | 21. | 96.7 | - | - | - | - | - | - |
| July 1986 | 0.611 | 241. | 16.5 | 93.1 | 1,228. | 236. | 17. | 92.8 | - | - | - | - | - | - |
| July 1986 | 0.569 | 211. | 14.3 | 93.2 | 1,001. | 106. | 4.5 | 95.8 | - | - | - | - | - | - |
| July 1986 | 0.548 | 168. | 8.8 | 94.8 | 768. | 302. | 24. | 92.1 | - | - | - | - | - | - |
| July 1986 | 0.621 | 199. | 21.0 | 89.4 | 1,031. | 84. | 8. | 90.5 | - | - | - | - | - | - |
| June 1987 | 0.677 | 141. | 3.1 | 97.8 | 796. | 184. | 5.8 | 96.8 | 38.9 | 1.12 | 97.1 | 12.6 | 0.1 | 99.2 |
| June 1987 | 0.661 | 184. | 3.0 | 98.3 | 1,014. | 160. | 6.0 | 96.3 | 52.7 | 5.3 | 89.9 | 17.6 | 2.5 | 85.8 |
| June 1987 | 0.692 | 243. | 2.7 | 98.9 | 1,402. | 604. | 10.8 | 98.2 | 44.0 | 1.7 | 96.1 | 14.3 | 0.1 | 99.3 |
| July 1987 | 0.638 | 208. | 0.3 | 99.8 | 1,007. | 240. | 35. | 85.4 | 43.1 | 1.7 | 96.1 | 13.2 | 0.1 | 99.2 |
| July 1987 | 0.801 | 254. | 1.0 | 99.6 | 1,697. | 140. | 4. | 97.1 | 52.1 | 3.8 | 92.7 | 14.8 | 0.1 | 99.3 |
| July 1987 | 0.725 | 180. | 1.2 | 99.3 | 1,088. | 140. | 17. | 87.9 | 45.4 | 0.7 | 98.5 | 13.2 | 0.1 | 99.4 |
| June 1988 | 0.526 | 261. | 1. | 99.6 | 1,145. | 96. | 2. | 97.9 | 53.2 | 2.5 | 95.3 | 20.1 | 1.1 | 94.5 |
| June 1988 | 0.488 | 375. | 1. | 99.7 | 1,526. | 164. | 1. | 99.3 | 42.6 | 2.5 | 94.1 | 16.2 | 0.8 | 95.1 |
| June 1988 | 0.451 | 320. | 2. | 99.3 | 1,204. | 204. | 2. | 99.0 | 41.2 | 0.4 | 99.0 | 37.7 | 0.3 | 99.2 |
| July 1988 | 0.489 | 275. | 2. | 99.3 | 1,122. | 184. | 3. | 98.4 | 45.9 | 0.6 | 98.7 | 33.6 | 0.3 | 99.1 |
| July 1988 | 0.452 | 284. | 3. | 98.9 | 1,071. | 104. | 2. | 98.1 | 43.4 | 0.3 | 99.3 | 13.4 | 0.1 | 99.3 |
| July 1988 | 0.748 | 227. | 2. | 99.1 | 1,416. | 206. | 5. | 97.6 | 50.4 | 0.8 | 98.4 | 29.7 | 0.6 | 98. |
| January 1989 | 0.480 | 305. | 2. | 98.3 | 1,221. | 148. | 1. | 99.3 | 59.4 | 4.5 | 92.4 | 4.5 | 3.7 | 17.8 |
| January 1989 | 0.248 | 492. | 4. | 99.2 | 1,018. | 300. | 10. | 96.7 | 66.1 | 7.3 | 89.0 | 17.6 | 5.3 | 69.9 |
| February 1989 | 0.222 | 330. | 2. | 99.4 | 611. | 798. | 5. | 99.4 | 63.3 | 0.56 | 99.1 | 12.9 | 0.1 | 99.2 |
| February 1989 | 0.606 | 175. | 6. | 96.6 | 884. | 58. | 4. | 93.1 | 21.8 | 1.7 | 92.2 | 11.7 | 0.28 | 97.6 |
| March 1989 | 0.515 | 227. | 1. | 99.6 | 975. | 194. | 9. | 95.4 | 61.6 | 1.4 | 97.7 | 12.3 | 0.3 | 97.6 |
| March 1989 | 0.491 | 254. | 3. | 98.8 | 1,040. | 128. | 8. | 93.8 | 46.8 | 2.0 | 95.7 | 11.2 | 0.28 | 97.5 |
| April 1989 | 0.578 | 311. | 2. | 99.4 | 1,499. | 224. | 1. | 99.6 | 38.6 | 1.4 | 96.4 | 10.6 | 0.84 | 92.1 |
| April 1989 | 0.334 | 148. | 4. | 97.3 | 412. | 192. | 9. | 95.3 | 29.12 | 0.84 | 97.1 | 14.8 | 0.28 | 98.1 |
| May 1989 | 0.921 | 166. | 4. | 97.6 | 1,275. | 78. | 3. | 96.2 | 21.84 | 10.64 | 51.3 | 14.56 | 1.68 | 88.5 |
| May 1989 | 0.365 | 222. | 4. | 98.2 | 676. | 100. | 7. | 93.0 | 36.4 | 5.04 | 86.2 | 22.12 | 3.92 | 82.3 |
| June 1989 | 0.404 | 359. | 4. | 98.9 | 1,210. | 166. | 5. | 97.0 | 47.6 | 1.12 | 97.6 | 13.1 | 1.12 | 91.5 |
| June 1989 | 0.624 | 250. | 5. | 98.0 | 1,301. | 120. | 14. | 88.3 | 42.84 | 9.52 | 77.7 | 13.44 | 8.96 | 33.3 |
| July 1989 | 0.593 | 254. | 6. | 97.6 | 1,256. | 152. | 10. | 93.4 | 31.08 | 5.88 | 81.1 | 13.8 | 4.48 | 67.5 |
| July 1989 | 0.507 | 384. | 11. | 97.1 | 1,624. | 364. | 10. | 97.3 | 57.68 | 16.8 | 70.9 | 11.48 | 14.48 | -26.1 |
| August 1989 | 0.277 | 228. | 2. | 99.1 | 527. | 172. | 3. | 98.3 | 40.04 | 0.84 | 97.9 | 16.43 | 0.28 | 98.3 |
| August 1989 | 0.488 | 385. | 4. | 99.0 | 1,567. | 178. | 8. | 95.5 | 52.08 | 1.96 | 96.2 | 17.5 | 0.89 | 94.9 |
| Average | 0.544<br>±0.150 | 260.<br>±79.6 | 51.<br>±5.0 | 97.9<br>±2.3 | 1,132<br>±320. | 217.<br>±161. | 8.7<br>±7.4 | 95.4<br>±3.6 | 45.3<br>±11.3 | 3.3<br>±3.8 | 91.9<br>±10.6 | 16.2<br>±7.0 | 1.9<br>±3.2 | 84.5<br>±29.4 |

TABLE B-9. PERFORMANCE DATA SUMMARY
CITY OF BLYTHEVILLE, ARKANSAS WEST
BIOLAC-R PLANT

| Month | Flow (MGD) | BOD (mg/L) | Effluent TSS (mg/L) | Effluent NH3-N (mg/L) |
|---|---|---|---|---|
| April 1989 | 0.920 | 12.3 | 43.5 | 47.8 |
| May 1989 | 0.832 | 10.2 | 12.8 | 31.8 |
| June 1989 | 0.740 | 13.4 | 14.2 | 50.0 |
| July 1989 | 0.814 | 8.1 | 5.5 | 6.8 |
| August 1989 | 0.556 | 4.6 | 36.0 | 1.4 |
| September 1989 | 0.649 | 9.9 | 10.4 | 0.2 |
| October 1989 | 0.848 | 7.9 | 7.8 | 0.4 |
| Mean: | 0.766 | 9.5 | 18.6 | 19.8 |
| Mean: June to October 1989 | 0.717 | 7.6 | 14.9 | 2.2 |
| Design: | 1.50 | - | - | - |
| % of Design: | 48 | | | |

Startup April 1989 to June 1989

TABLE B-10. PERFORMANCE DATA SUMMARY
CITY OF BLYTHEVILLE, ARKANSAS NORTH
BIOLAC-R PLANT

| Month | Flow (MGD) | BOD (mg/L) | Effluent TSS (mg/L) | Effluent NH3-N (mg/L) |
|---|---|---|---|---|
| April 1989 | 0.462 | 4.1 | 4.0 | 39.2 |
| May 1989 | 0.338 | 7.1 | 5.3 | 4.3 |
| June 1989 | 0.345 | 12.8 | 53.0 | 51.0 |
| July 1989 | 0.403 | 21.5 | 22.0 | 85.2 |
| August 1989 | 0.474 | 11.9 | 13.0 | 1.2 |
| September 1989 | 0.263 | 5.9 | 12.5 | 0.7 |
| October 1989 | 0.446 | 23.6 | 14.6 | 0.5 |
| Mean: | 0.39 | 13.8 | 26.3 | 26.0 |
| Mean: August to October 1989 | 0.39 | 13.8 | 13.3 | 1.0 |
| Design | 0.8 | | | |
| % of Design | 49 | | | |

TABLE B-11. PERFORMANCE DATA SUMMARY
CITY OF BLYTHEVILLE, ARKANSAS - SOUTH PLANT
BIOLAC-R PLANT

| Month | Flow (MGD) | BOD (mg/L) | Effluent TSS (mg/L) | Effluent NH3-N (mg/L) |
|---|---|---|---|---|
| April 1989 | 0.676 | 6.9 | 13.0 | 38.7 |
| May 1989 | 0.620 | 12.4 | 18.7 | 7.9 |
| June 1989 | 0.673 | 16.5 | 9.5 | 70.4 |
| July 1989 | 0.645 | 25.2 | 19.5 | 95.3 |
| August 1989 | 0.519 | 33.8 | 38.2 | 3.3 |
| September 1989 | 0.543 | 11.0 | 9.6 | 0.2 |
| October 1989 | 0.538 | 0.2 | 18.5 | 0.4 |
| Mean: | 0.602 | 15.1 | 18.1 | 30.9 |
| Design: | 1.40 | | | |
| % Design: | 43% | | | |

TABLE B-12. PERFORMANCE DATA SUMMARY
CITY OF BAY, ARKANSAS - SOUTH PLANT
BIOLAC R PLANT

| Month | Flow (MGD) | BOD (mg/L) | Effluent TSS (mg/L) | Effluent NH3-N (mg/L) |
|---|---|---|---|---|
| May 1988 | 0.120 | 20.4 | 34.0 | |
| December 1988 | 0.275 | 36.3 | 93.0 | 2.0 |
| January 1989 | 0.136 | 39.1 | 87.1 | 5.0 |
| February 1989 | 0.211 | 33.7 | 75.0 | 4.5 |
| March 1989* | 0.067 | 30.0 | 41.4 | 18.9 |
| April 1989 | 0.049 | 21.7 | 24.8 | 26.0 |
| May 1989 | 0.055 | 14.9 | 28.3 | 19.3 |
| June 1989 | 0.118 | 24.9 | 12.4 | 22.4 |
| July 1989 | 0.287 | 10.1 | 11.2 | 21.5 |
| August 1989 | 0.557 | 3.7 | 2.0 | 1.1 |
| September 1989 | 0.100 | 2.7 | 1.2 | 0.2 |
| Mean: June to September 1989 | 0.266 | 10.4 | 6.7 | 11.3 |
| Design: | 0.15 | | | |
| % Design | 177% | | | |

Sampling program two grab samples per month
*Biolac system on line; startup March 1989 to May 1989

TABLE B-13. PERFORMANCE DATA SUMMARY
CITY OF PIGGOTT, ARIZONA
BIOLAC R PLANT

| Month | Flow (MGD) | BOD (mg/L) | Effluent TSS (mg/L) |
|---|---|---|---|
| June 1989 | 0.561 | 19 | 34 |
| July 1989 | 0.194 | 17 | 24 |
| August 1989 | 0.382 | 28 | 44 |
| September 1989 | 0.249 | 19 | 37 |
| Mean: | 0.35 | 20.8 | 34.8 |
| Design: | 0.60 | | |
| % Design: | 58% | | |

TABLE B-14. PERFORMANCE DATA SUMMARY
CITY OF DURANT, OKLAHOMA
PARTIAL RETROFIL WITH BIOLAC AERATION
SYSTEM AND POLISHING POND

| Month | Flow (MGD) | Influent BOD (mg/L) | Effluent BOD (mg/L) | % BOD Removal | BOD Load | Influent TSS (mg/L) | Effluent TSS (mg/L) | % Removal |
|---|---|---|---|---|---|---|---|---|
| July 1988 | 1.78 | 212 | 16 | 92.4 | 3147 | 205 | 20 | 90.24 |
| August 1988 | 1.79 | 179. | 6. | 96.6 | 2672. | 238. | 20. | 91.6 |
| September 1988 | 1.84 | 209. | 11. | 94.7 | 3207. | 304. | 48. | 84.2 |
| October 1988 | 1.67 | 204. | 13. | 93.6 | 2841. | 253. | 57. | 77.5 |
| November 1988 | 1.72 | 286. | 7. | 97.5 | 4102. | 289. | 32. | 88.9 |
| December 1988 | 1.67 | 270. | 2. | 99.3 | 3760. | 321. | 18. | 94.4 |
| January 1989 | 1.72 | 278. | 6. | 97.8 | 3987. | 327. | 24. | 92.6 |
| February 1989 | 2.15 | 170. | 11. | 93.5 | 3048. | 179. | 27. | 84.9 |
| March 1989 | 2.6 | 244. | 8. | 96.7 | 5290. | 215. | 22. | 89.7 |
| April 1989 | 1.87 | 171. | 18. | 89.5 | 2666. | 243. | 37. | 84.8 |
| May 1989 | 2.45 | 138. | 10. | 92.8 | 2819. | 248. | 41. | 83.5 |
| June 1989 | 2.88 | 160. | 5. | 96.9 | 3843. | 165. | 30. | 81.8 |
| July 1989 | 2.61 | 87. | 5. | 94.3 | 1893. | 197. | 22. | 88.8 |
| August 1989 | 2.25 | 123. | 6. | 95.1 | 2308. | 204. | 20. | 90.2 |
| September 1989 | 2.26 | 93. | 9. | 90.32 | 1752. | 166. | 27. | 83.7 |
| October 1989 | 1.99 | 183. | 8. | 95.63 | 3037. | 256. | 30. | 88.3 |
| Mean: | 2.1 | 187.9 | 8.8 | 94.8 | 3148. | 238. | 29.7 | 87.2 |
| Design | 1.7 | | | | | | | |
| % Design | 124% | | | | | | | |