

# Wastewater Treatment and Sludge Management

Energy Reference Guide

NEW YORK  
STATE  
ENERGY  
RESEARCH  
AND  
DEVELOPMENT  
AUTHORITY

**The New York State Energy Research and Development Authority (NYSERDA)** is a public benefit corporation created in 1975 by the New York State Legislature. F. William Valentino is President and Chief Operating Officer.

NYSERDA's primary mission is to carry out a broad program of energy research, development and demonstration projects designed to develop and apply efficient technologies to help ensure that New York has secure and economical future supplies of energy, while protecting environmental values and promoting economic growth.

NYSERDA derives its basic research revenues from an assessment levied on the intrastate sales of New York State's investor-owned electric and gas utilities. Additional research dollars come from limited corporate funds and a voluntary annual contribution by the New York Power Authority.

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- Managing a 365-acre portion of a Superfund clean-up site in Malta, 20 miles north of Albany. Part of the site was once owned by the federal government. Portions of it have been used by the federal government and its contractors since the 1940s for activities that have included rocket engine and fuel testing, weapons testing, and space research.

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**WASTEWATER TREATMENT  
AND  
SLUDGE MANAGEMENT**

Energy Reference Guide

Prepared for

**THE NEW YORK STATE  
ENERGY RESEARCH AND DEVELOPMENT AUTHORITY**

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**ENVIRONMENTAL FACILITIES CORPORATION**

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## **ABSTRACT**

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This report summarizes the efforts of a multi-year evaluation undertaken by the New York State Energy Research and Development Authority in cooperation with the New York State Environmental Facilities Corporation and the New York State Department of Environmental Conservation. The focus was to evaluate 24 wastewater treatment plants (WWTPs) throughout New York State with respect to energy efficiency.

This report presents the project overview, an introduction to energy conservation at WWTPs, treatment processes and potential energy conservation measures and summaries of the case studies conducted for the municipalities.

Key words:           Municipal Wastewater Treatment  
                          Energy Efficiency  
                          Demand-Side Energy Management  
                          Environment

The New York State Energy Research and Development Authority (NYSERDA) in cooperation with the New York State Environmental Facilities Corporation (EFC) and the New York State Department of Environmental Conservation (NYSDEC) began a project in 1992 that was designed to help New York State municipalities identify and implement energy-efficient treatment technologies at their wastewater treatment plants (WWTPs). These technologies could reduce the amount of energy used for wastewater treatment and sludge management, recover or produce energy at the WWTPs and/or achieve greater energy efficiency through systems integration.

This project consists of a study of WWTPs around New York State and then a series of workshops conducted to inform plant operators, managers, and engineers of technologies to consider for improving energy efficiency.

The study used a diverse WWTP pool, in terms of geographic location, plant type and size. A detailed screening process was conducted that included:

- Wastewater Treatment Plant Selection - An initial list of 75 WWTP projects was prepared from the information presented in the EFC's State Revolving Loan Fund listing and the NYSDEC's publication, "Descriptive Data of Sewage Treatment Systems".
- Contact Letter - NYSERDA issued an initial contact letter explaining overall project goals.
- Phone Interview - Phone interviews were conducted to determine the overall project feasibility and the municipality's interest level.
- Onsite Screening - Site visits were conducted at 26 facilities to discuss 32 separate energy conservation projects.

## **PREFACE**

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Once a site was chosen for evaluation, Malcolm Pirnie Inc., the project consultant, worked with the municipality to gather the necessary process information. A report was prepared that summarized current plant operations and energy use patterns; proposed modifications to the plant; and identified associated impact on energy use, alternative energy conservation measures, and alternative treatment strategies.

This Energy Reference Guide has been prepared as part of NYSERDA's technology transfer mission to share the results of the project. The guide summarizes various WWTP processes and their associated energy requirements, energy conservation measures that may be appropriate and the case studies conducted for the municipalities.

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Most of the wastewater treatment facilities constructed in the United States were either designed or constructed in the early to mid-1970s under the Construction Grants Program. At this time energy was considered to be a relatively inexhaustible, dependable, and inexpensive resource. Hence, these treatment facilities were designed for performance reliability, not energy efficiency. Since the oil embargo of the mid-1970s, energy costs have risen and have become a significant concern to many municipalities.

Energy costs at wastewater treatment plants (WWTPs) typically account for as much as 25% of a municipality's total operating budget. Therefore, it is critical to strive for the most energy efficient operation economically possible. To achieve this energy efficiency, WWTP staff must continually review the plant's current operations, optimize operations when possible, or install alternative treatment processes.

These reviews can occur via audits that can be conducted in phases or as an overall energy management program, depending upon resources. Each audit must contain the following components:

- Develop baseline information on energy consumption and cost
- Conduct an onsite facility survey
- Identify alternative energy conservation measures
- Perform an economic analysis of each alternative
- Develop an implementation plan for feasible alternatives.

## SETTING THE BASELINE

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Developing the energy use baseline can be a simple but tedious task in some cases depending upon the availability of information. For an audit to be complete, the following information should be analyzed:

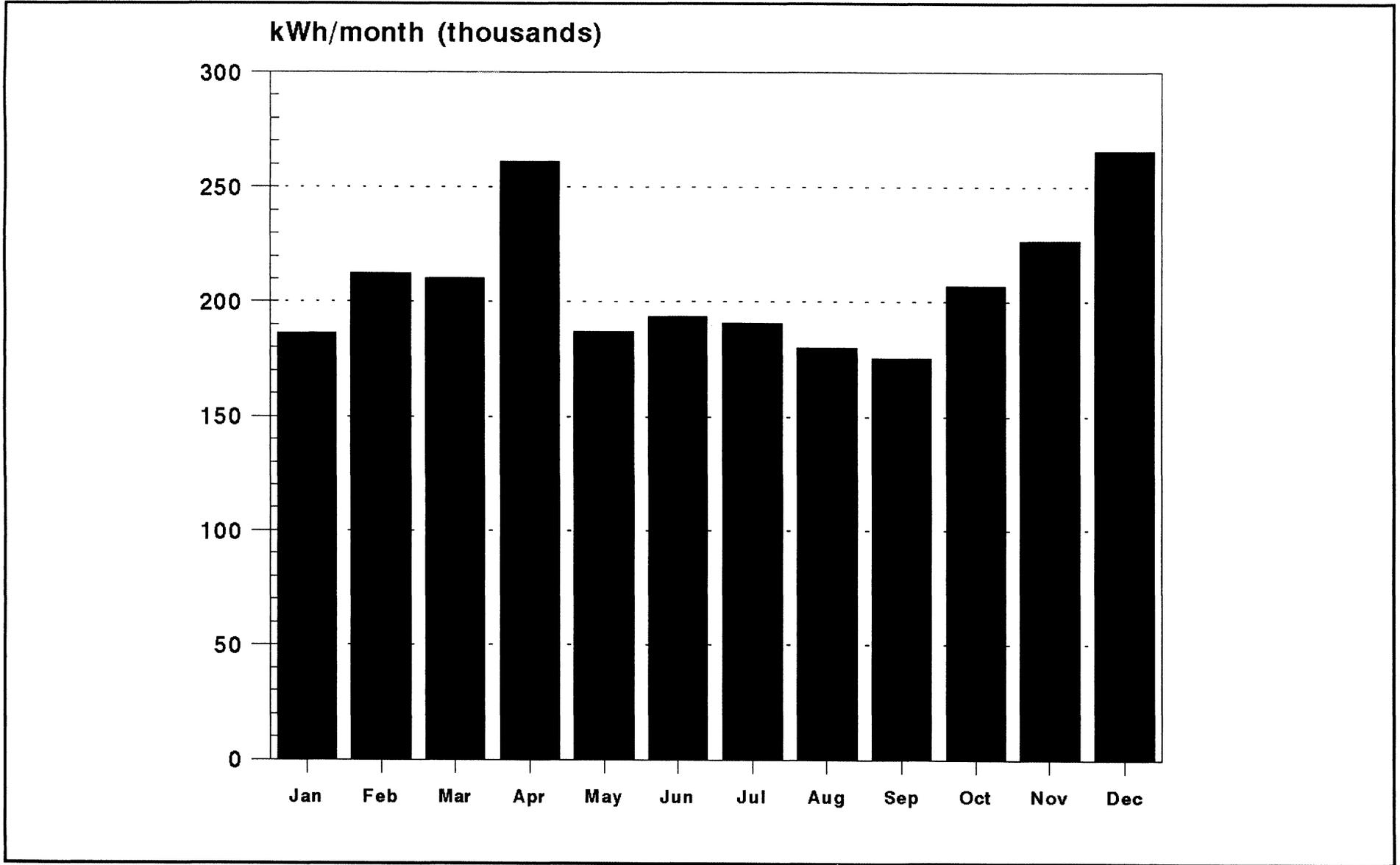
- Plant Equipment - This includes motor horsepower, efficiency, and run-time hours for each piece of equipment. The information can be obtained from operation and maintenance manuals, facility plans and specifications and operational logs. It can be summarized in table format. A sample format is presented in Table 1-1.
- Electric Bills - Creating a plot of monthly electricity consumption (kilowatt-hours) and electrical demand (kilowatts) for the previous 12 to 24 months will show trends in usage. Low periods may indicate times of the year when equipment may not be operating at peak capacity or efficiency. Figures 1-1 and 1-2 present the electrical consumption and demand for a typical 9.0 million gallon per day (mgd) activated sludge WWTP.
- Utility Rate Schedules - Utility companies typically have a variety of rate classifications available. When a WWTP is constructed it is placed in a rate classification based upon the best guess of estimated electrical use and demand. Very often operations change over the years and a different rate classification may be better suited for the treatment plant's new needs. Rate schedules are available free of charge from utility companies and, in most cases, the utility will conduct a rate analysis if requested by the customer. If the treatment plant operates a large portion of its equipment (say its sludge handling process) during the night, an on-peak/off-peak rate classification (if available) may be beneficial and should be evaluated.

**TABLE 1-1**  
**WASTEWATER TREATMENT FACILITIES ENERGY EVALUATION**  
**SAMPLE FORMAT – EXISTING MOTORS**

Motor			Qty.	Size (hp)	Average Load Factor	Est. Hours Per Week	KWH Per Wk	KWH Per Yr	Percentage of Total	KWH/Yr Per Location	
Service	Location	Name									
P	Pump Station No. 1	Raw Sewage Pump #1	1	5	100%	13	47	2,443	1.08%	5,429	
P		Raw Sewage Pump #2	1	5	100%	15	57	2,986	1.32%		
P	Pump Station No. 2	Raw Sewage Pump #1	1	9.4	100%	8	59	3,062	1.35%	6,379	
P		Raw Sewage Pump #2	1	9.4	100%	9	64	3,317	1.46%		
O	Influent Box	Comminutor	1	0.75	100%	168	94	4,886	2.15%	4,886	
	Aeration	SUMMER (July – August)									
B		Blower 1	1	30	100%	168	3,758	33,825	14.91%	179,773	
B		Blower 2	1	30	100%	0	0	0	0.00%		
B		Blower 3	1	20	100%	84	1,253	11,275	4.97%		
		WINTER (September – June)									
B		Blower 1	1	30	100%	84	1,879	80,804	35.63%		
B		Blower 2	1	30	100%	0	0	0	0.00%		
B		Blower 3	1	20	100%	84	1,253	53,869	23.75%		
P		Disinfection	Chlorine Metering Pump	1	0.2	100%	168	25	1,303		0.57%
P	Sludge Handling	Return Sludge Pump 1	1	2	100%	168	251	13,029	5.74%		28,152
P		Return Sludge Pump 2	1	2	100%	0	0	0	0.00%		
P		Waste Sludge Pump 1	1	1	100%	40	30	1,551	0.68%		
P		Waste Sludge Pump 2	1	1	100%	0	0	0	0.00%		
O		Belt Press Motor	1	2	100%	40	60	3,102	1.37%		
P		Belt Press Feed Pump	1	3	100%	40	89	4,653	2.05%		
P		Polymer Feed Pump	1	0.75	100%	40	22	1,163	0.51%		
O		Screw Conveyor	1	3	100%	40	89	4,653	2.05%		
O	Building Heat	Electric Heaters (*)	6	0.25	100%	40	45	895	0.39%	895	
TOTALS							9,031	226,816		226,816	

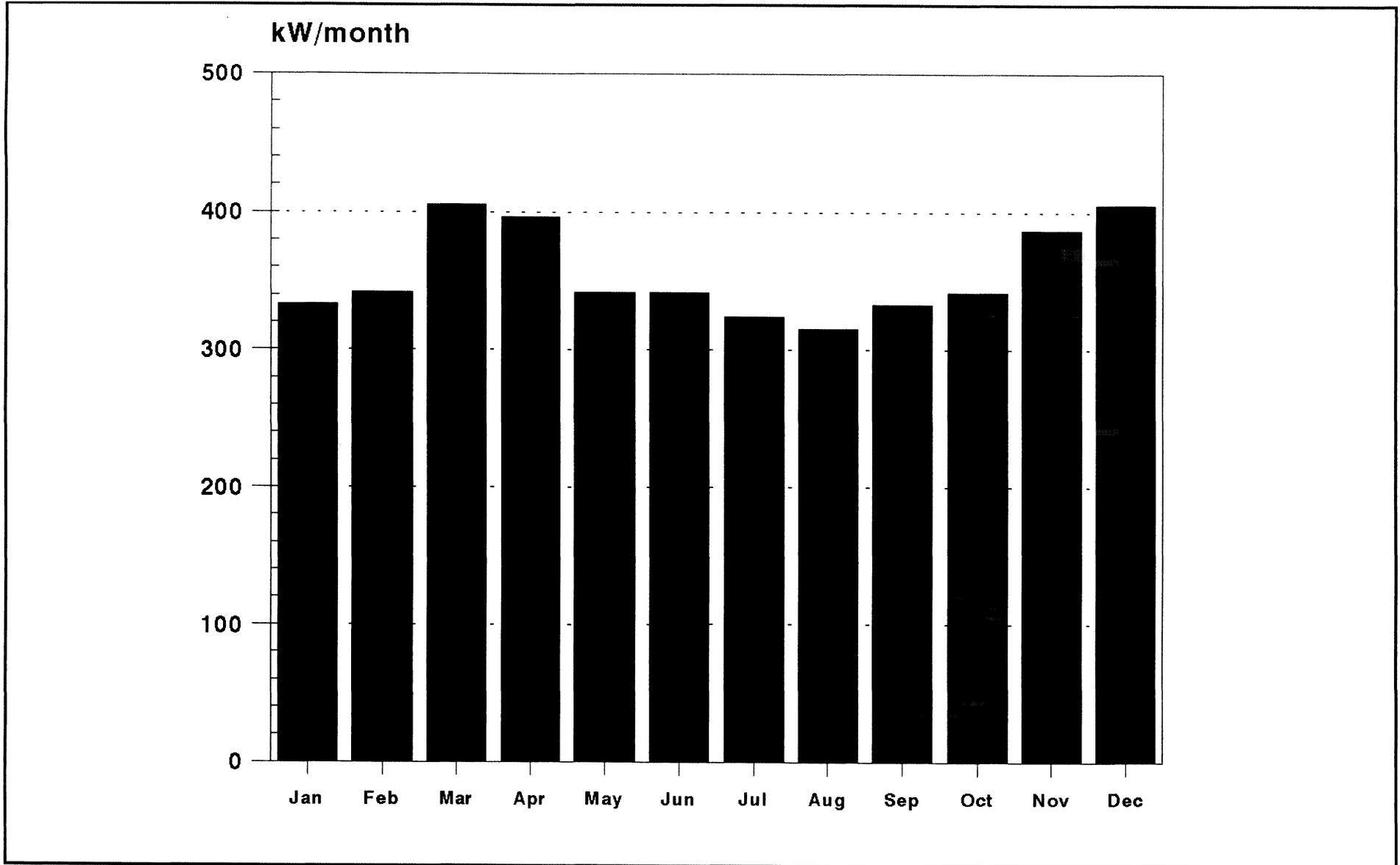
Motor Service: P = Pump C = Compressor O = Other B = Blowers  
F = Fan M = Material Handling

NOTE: (\*) Electrical requirements of the heaters based on 20 weeks per year.



9.0 MGD ACTIVATED SLUDGE FACILITY  
ELECTRICAL CONSUMPTION

FIGURE 1-1



9.0 MGD ACTIVATED SLUDGE FACILITY  
ELECTRICAL DEMAND

FIGURE 1-2

## LOAD FACTORS

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When completing a summary of existing motors and estimated energy use, similar to Table 1-1, load factors play a large part in determining the cost of operating equipment. Load factors apply to equipment which is capable of being operated at different speeds or output levels. The load factor is the average percentage of the total rated load at which a motor operates. An example of calculating a load factor for a motor that operates 1500 hours per year at 50% of its rating and 2500 hours per year at 90% is:

$$(1500 * 50 + 2500 * 90)/4000 = 75\%$$

It is important ensure that load factors are as accurate as possible because they will affect the estimated electrical usage of a treatment process. An incorrect estimate of electrical usage may result in an erroneous economic analysis.

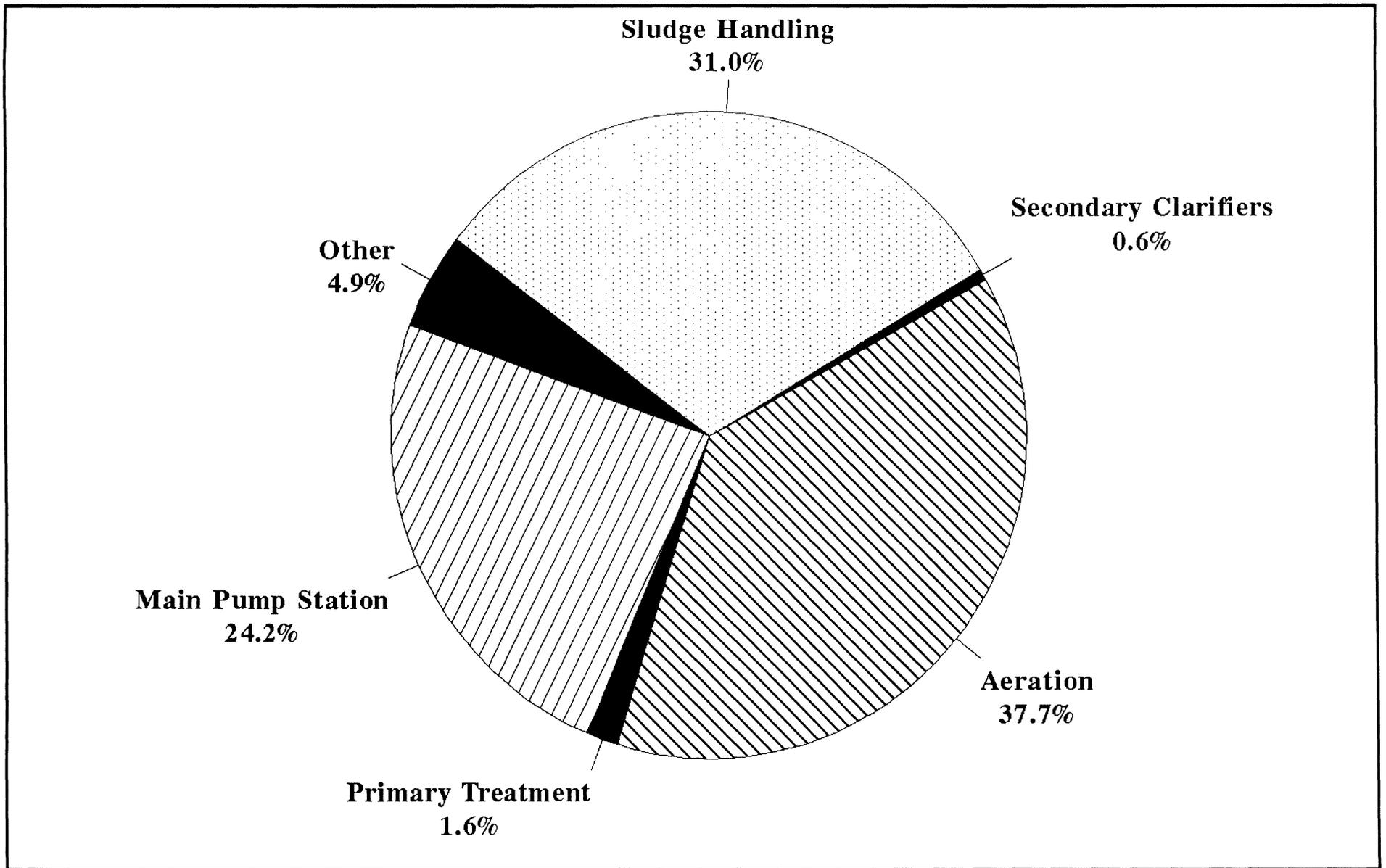
## TYPICAL ENERGY CONSUMPTION FOR WWTP PROCESSES

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Once operational hours and load factors are determined, the annual kilowatt-hours (kWh) can be determined. Profiles can be put together to show how much energy the different treatment processes use. These can be presented in a variety of formats (e.g., pie charts, bar charts). Examples of different formats are presented in Figures 1-3 and 1-4. These examples are for the same 9.0 mgd activated sludge facility shown in Figures 1-1 and 1-2.

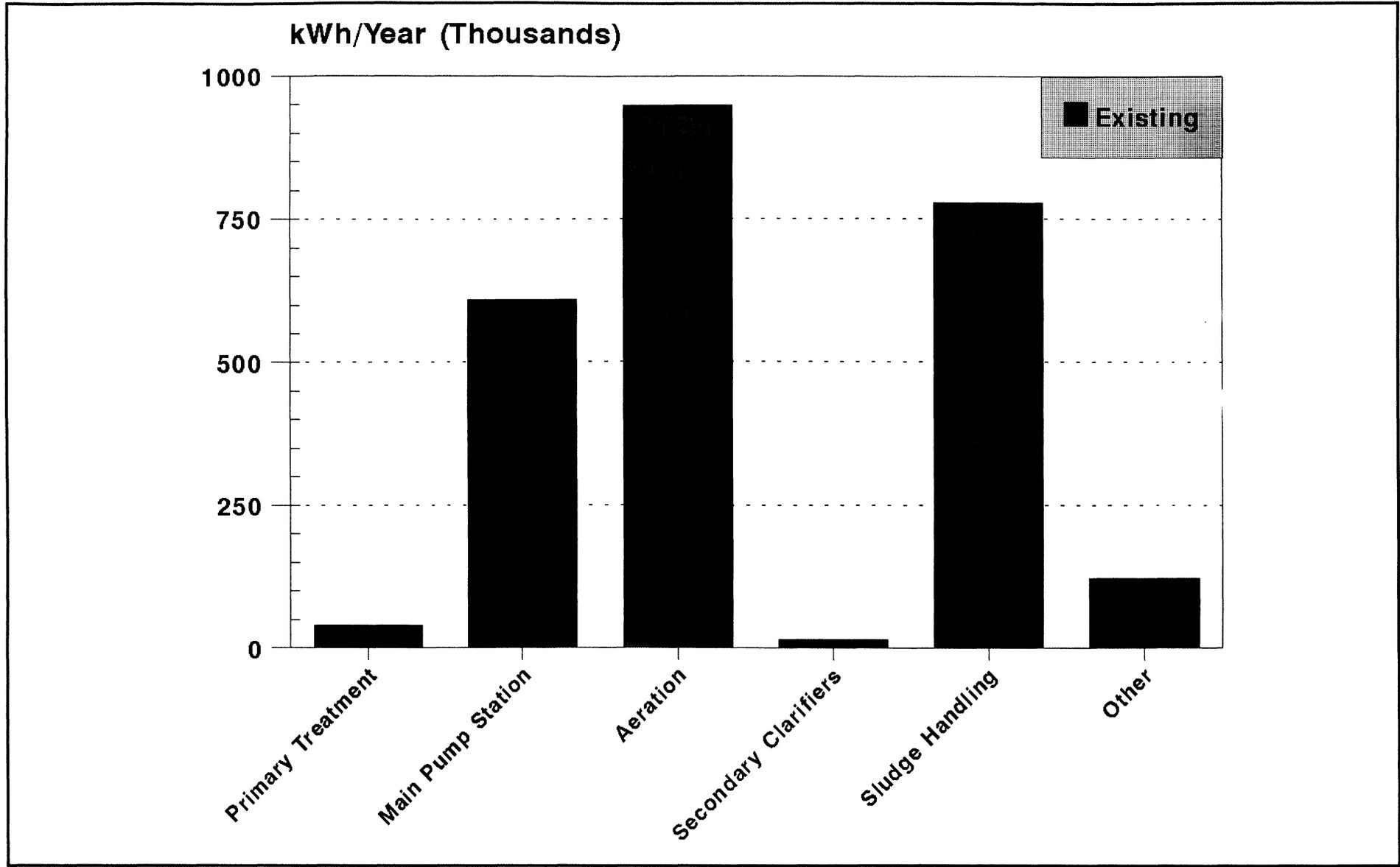
Once it has been determined what the most energy intensive processes are, then the energy management program should be focused on those areas. The largest energy savings usually come in the following process areas:

- Pumping - Typically only the larger (20-hp and greater) pumps will yield energy savings that will justify capital costs.
- Grit Removal
- Activated Sludge Aeration Tanks
- Sludge Dewatering.



9.0 MGD ACTIVATED SLUDGE FACILITY  
 TYPICAL ENERGY USE FOR EXISTING  
 PROCESSES

FIGURE 1-3



9.0 MGD ACTIVATED SLUDGE FACILITY  
 TYPICAL ENERGY USE FOR EACH  
 PROCESS AREA

FIGURE 1-4

## UNDERSTANDING AN ELECTRIC BILL

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**Basic Billing Concepts** There are two major charges that are found on an electric bill. The energy component of the bill is the quantity (kWh) of electricity supplied while the demand component is the measure of the power (kW) supplied. Different rate schedules are offered for different customers. It is important that the most suitable rate schedule for the wastewater facility is used in order to save money. Most utility companies will change a customer's rate schedule at no charge.

**Energy** Energy is measured in kilowatt hours (kWh). The longer a pump runs, the more kWh it uses. Therefore, it is important to monitor how long each motor in the plant is operated so its energy use may be calculated. It is easy to calculate a motor's energy use: multiply its horsepower by the standard conversion factor (1 hp = 746 watts) and by runtime, and then divide by the motor's efficiency.

**Demand** Demand is measured in kilowatts (kW). Meters typically record the greatest power demand in 15-minute or 30-minute intervals. The demand charge is based on the highest demand interval each month. It is possible to reduce the demand cost by shifting the time when intermittently operated motors, drives, etc., are run.

Some electric utilities have a "ratchet clause" in the rate schedule. This clause charges the customer for a percentage of either: the maximum demand during the past eleven months; or the maximum demand during the previous month. The ratchet charges can be lowered by reducing the maximum demand. This can be done by planning when to operate large equipment in the months of your greatest demand.

**Optional Rate Schedules** Some power companies charge more for electricity used during peak hours because this electricity is more expensive to produce. A power company uses its most economical plants for routine electricity production but must use other plants to supplement these main plants in times of high demand. Rates are designed to encourage customers to reduce their electricity requirements during peak hours. The difference between on-peak and off-peak rates may be as much as \$0.06 per kWh, or higher.

Building new generating and distribution facilities is very expensive so the electric utility offers reduced rates to large customers who promise to lower their demand during peak operating hours. Both the customer and electric utility benefit from such a plan.

**Reading Your Facility's Bill** Electric bills often use many abbreviations and codes that are difficult for the consumer to understand. Spend time learning what each code means and then see how charges are combined to calculate the bill. If you are still having difficulty reading your bill, consult your electric utility account representative for help.

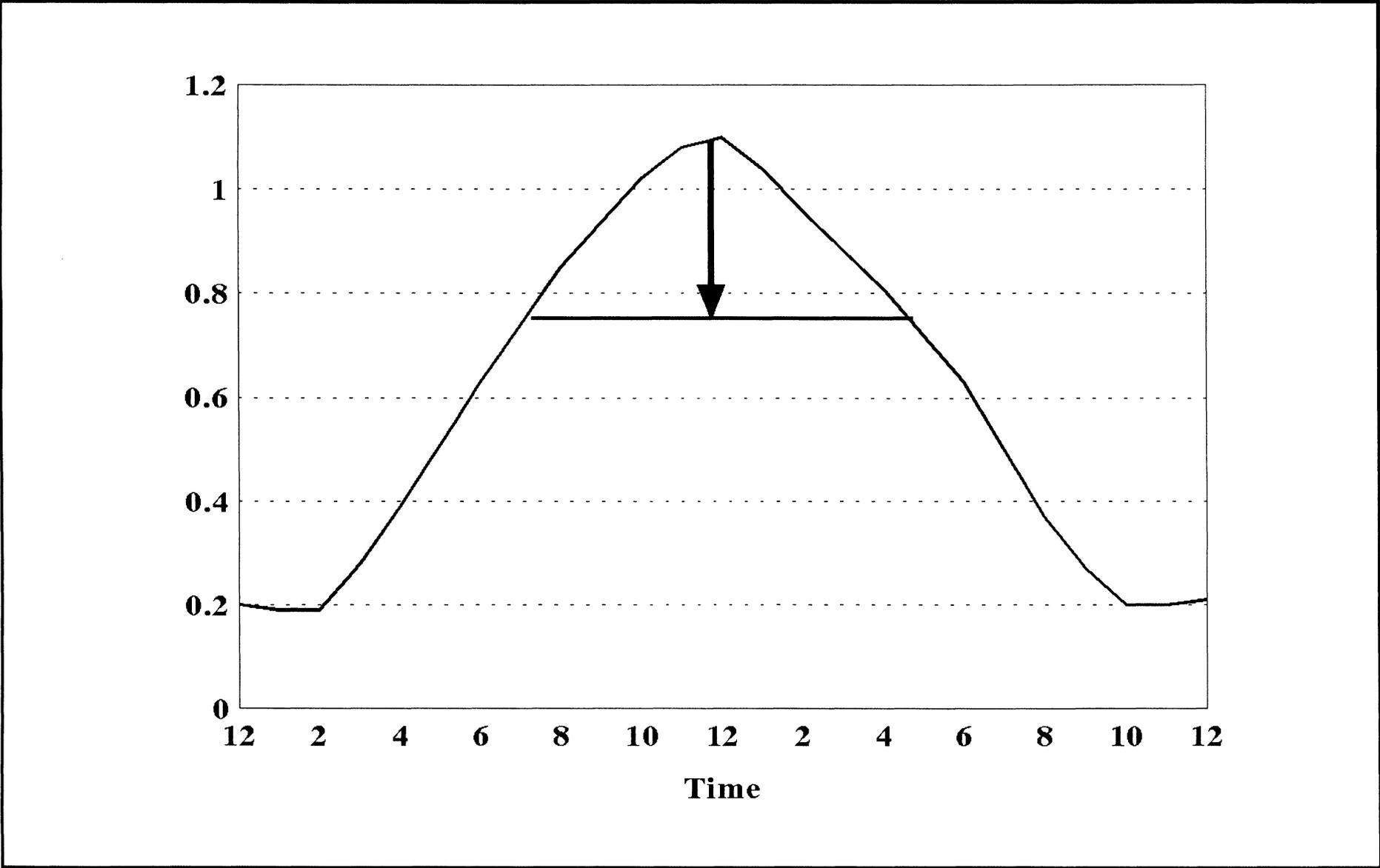
## **DEMAND-SIDE ENERGY MANAGEMENT AT WWTPs**

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Demand-side management is an energy conservation program which can offer significant opportunity for the wastewater industry to reduce operating costs, and at the same time, assist the electric utilities in controlling their costs. It is the planning and implementation of electric utility programs designed to influence customer use of electricity to produce desired changes in the utility's load shape.

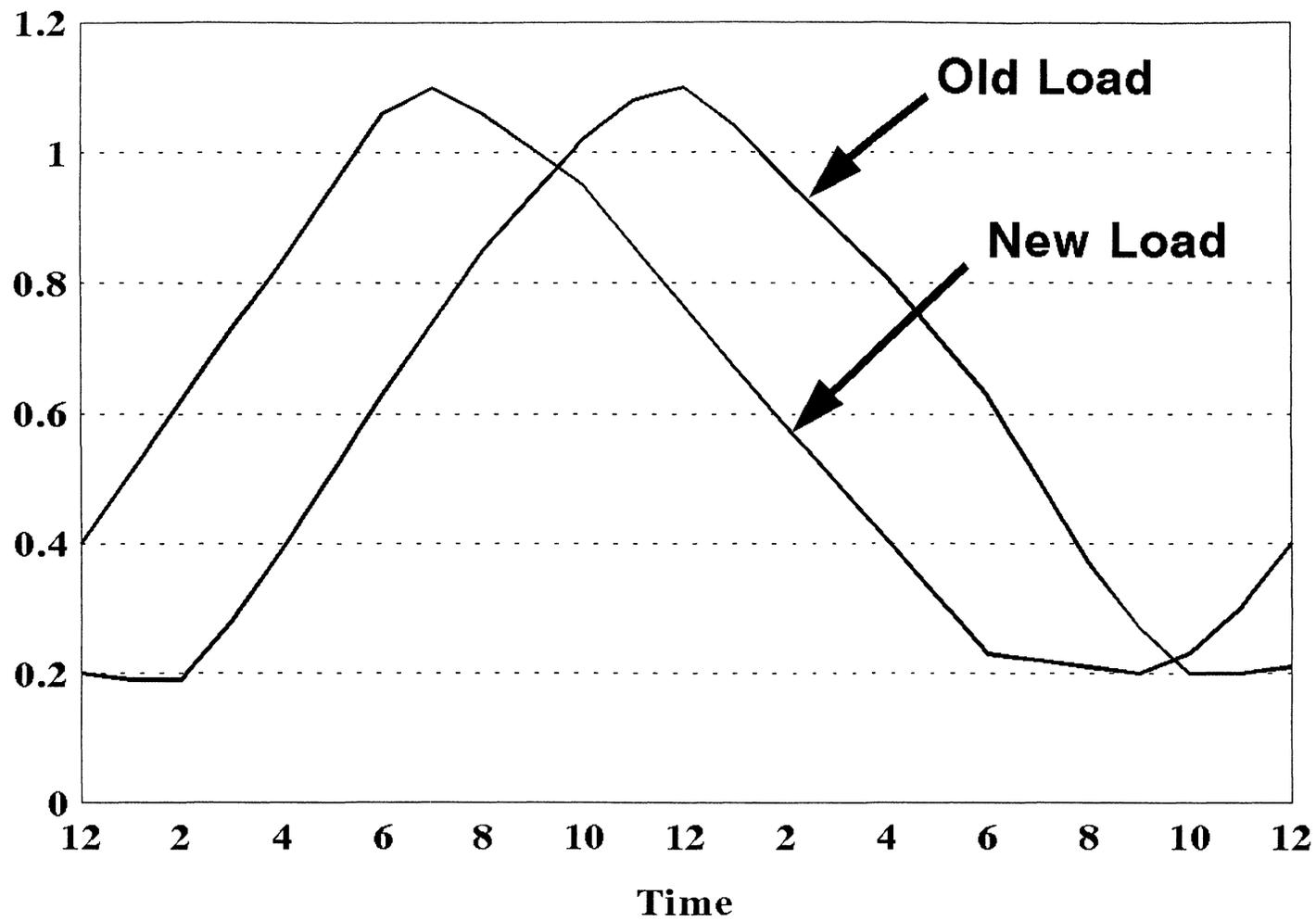
The DSM incentive program being offered vary. However they all strive to achieve one or more of the following objectives:

- **Peak Clipping (Shaving).** This program encourages customers to reduce their demand during the "maximum power demand periods", as shown in Figure 1-5. Some peak clipping strategies include: Time-of-Use rates, interruptible rate, stand-by generation, curtailable loads and real-time power monitoring. Spot pricing of electricity at the margin is also used to encourage peak clipping.
- **Load Shifting.** This program encourages the shifting of load to non peak demand periods, as shown in Figure 1-6. The on-peak/off-peak rate structure is a typical example of a DSM program offering to encourage load shifting. Some load shift strategies include: delayed processing by storing influent, accelerated processing, and heating/cooling storage.
- **Valley Filling.** This program provides incentives for increased off-peak use of electricity, as shown on Figure 1-7, to match the "spinning reserve" of generating utilities. Facilities which are able to increase usage in this time period often receive favorable rates. Some valley filling strategies include: thermal energy storage, interceptor storage, and off-peak processing of sludge.
- **Conservation.** Conservation seeks the overall reduction in power use, as shown in Figure 1-8. Some conservation strategies include: load controllers, real-time monitoring, matching equipment to flow, variable frequency drives, high-efficiency motors, and equipment redesigns for energy conservation.



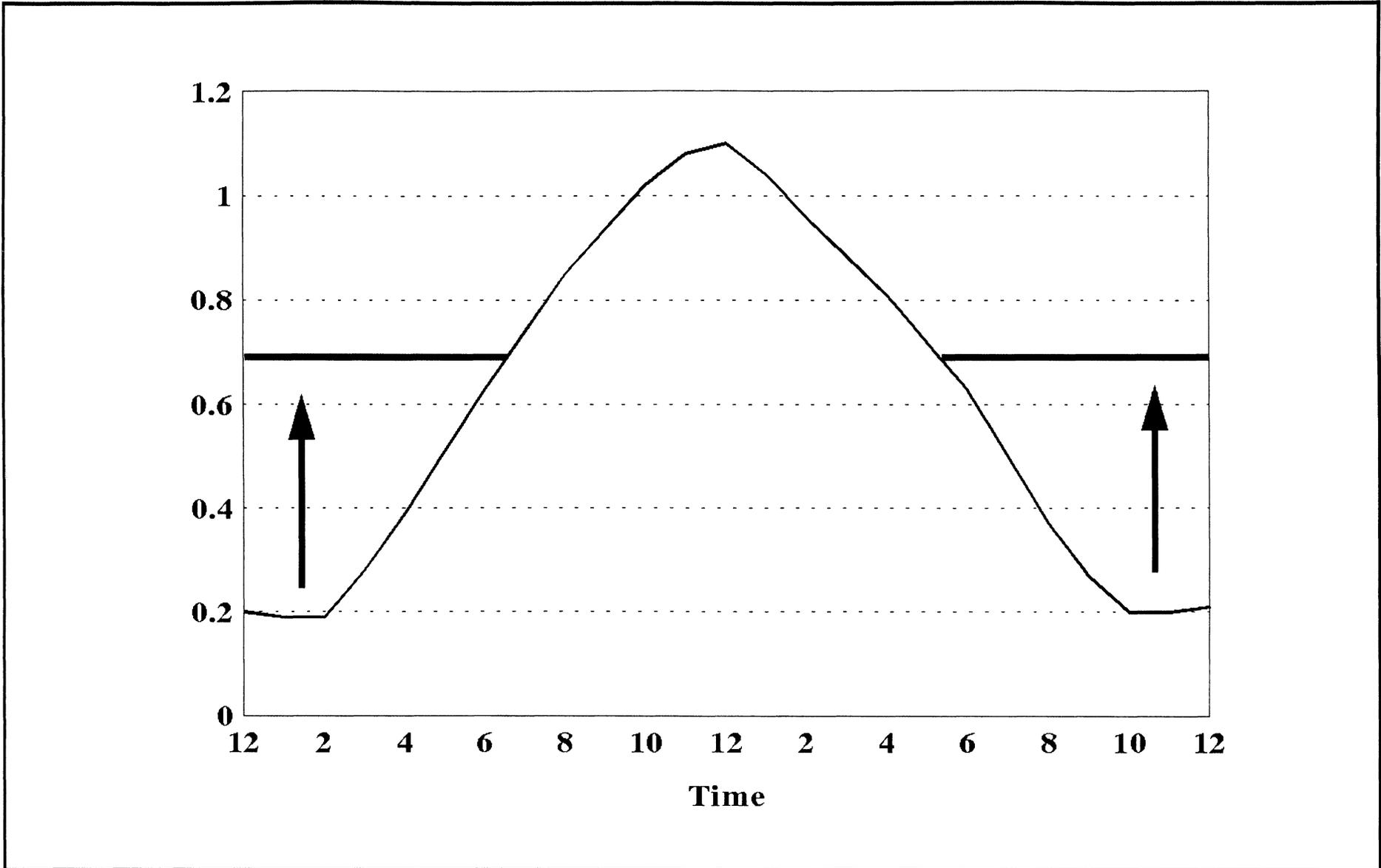
**PEAK CLIPPING**

FIGURE 1-5



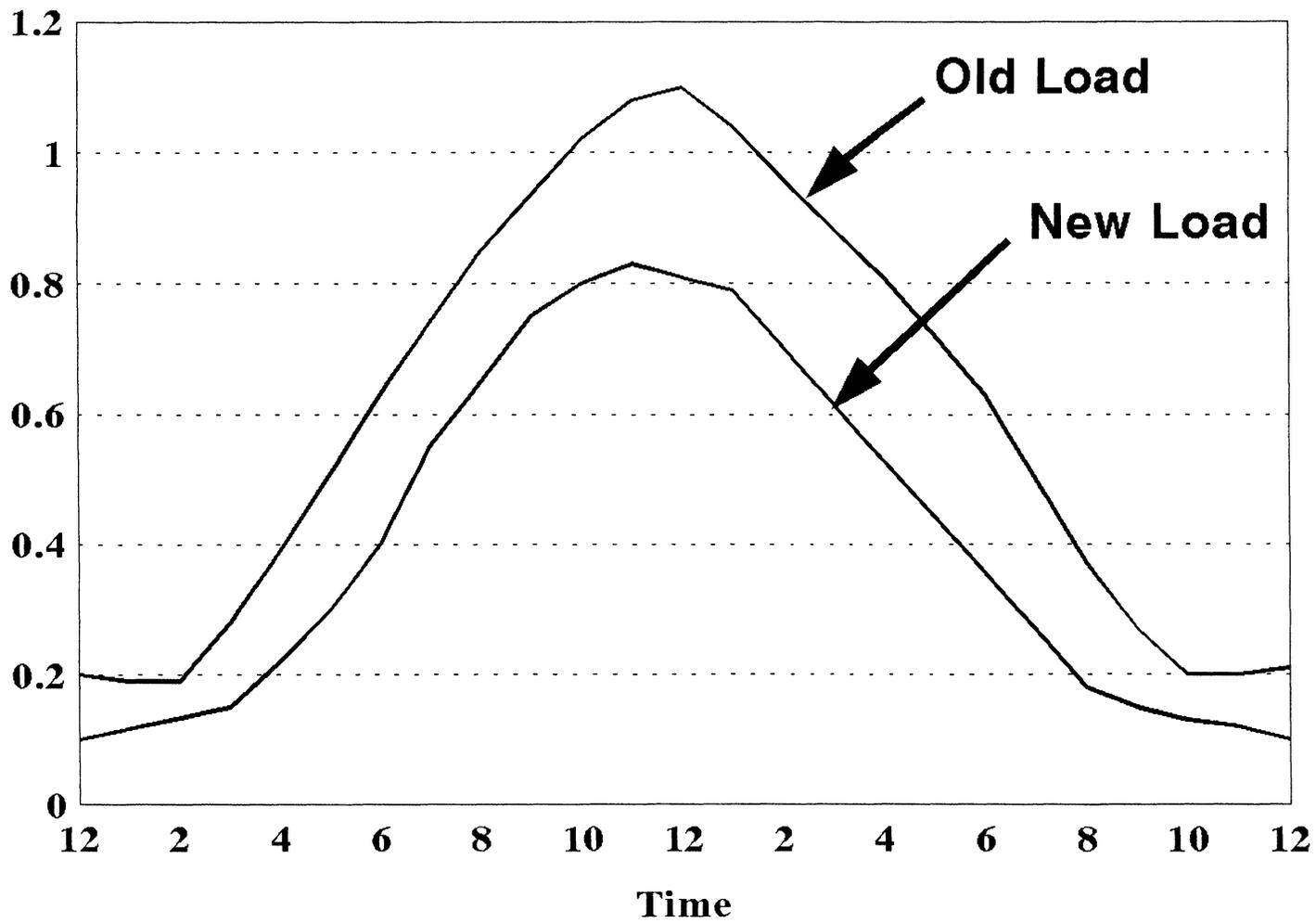
**LOAD SHIFTING**

FIGURE 1-6



**VALLEY FILLING**

FIGURE 1-7



CONSERVATION

FIGURE 1-8

There are over 570 wastewater treatment plants in New York State, and no two locations are the same. Each location has different influent flows and loadings, effluent requirements, and plant personnel. It is therefore extremely difficult to present all treatment processes and potential energy conservation measures for every treatment scheme.

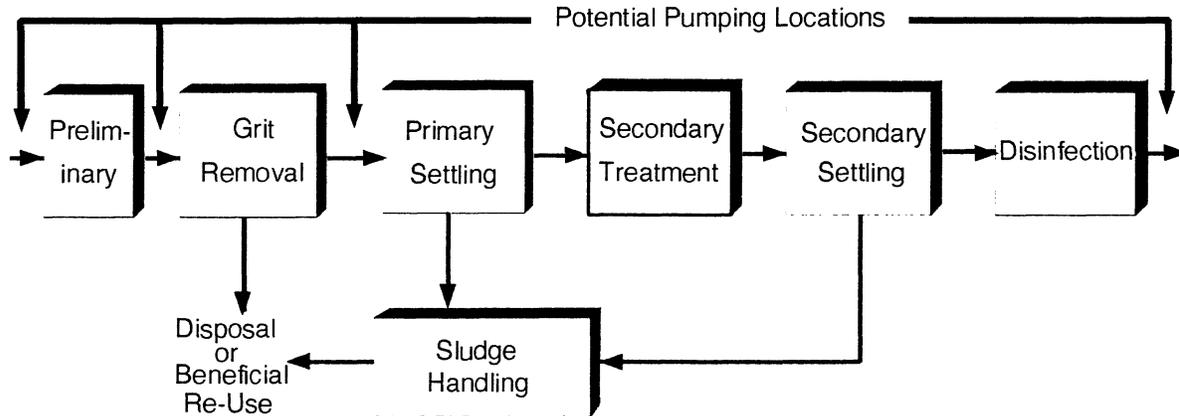
Consequently, this section is grouped into major process categories. These categories describe:

- Raw Wastewater Pumping
- Preliminary Treatment
- Grit Removal
- Primary Treatment
- Secondary Treatment - Biological
- Tertiary Treatment
- Disinfection
- Post Aeration
- Sludge Management
- Miscellaneous

The most common treatment alternatives in each category are presented as well as potential energy conservation measures. The footers at the bottom of each page identify whether the topic is a treatment process or an energy conservation measure. [Note: Even though grit removal is a subset of preliminary treatment, it has been given a separate category heading because of the diversity of equipment alternatives available and their respective impacts on energy utilization.]

# **PUMPING**

## Treatment Schematic



**Use and Applications** Wastewater pumping is a vital part of plant operations. Pumps are installed anywhere within a treatment plant scheme where the flow can not pass through hydraulically by gravity.

**Energy Consumption** Pumping can consume a large part of the total electricity used at a wastewater treatment plant. The flow and head requirements dictate the amount of energy required to move the wastewater. Pumps can vary in efficiency because of design characteristics established by the manufacturer or its position in the pumping sequence. The energy efficiency of pump motors varies with the load on the motor. Also, the kind of maintenance a pump receives has a major effect on its energy consumption.

Some examples of energy consumption include:

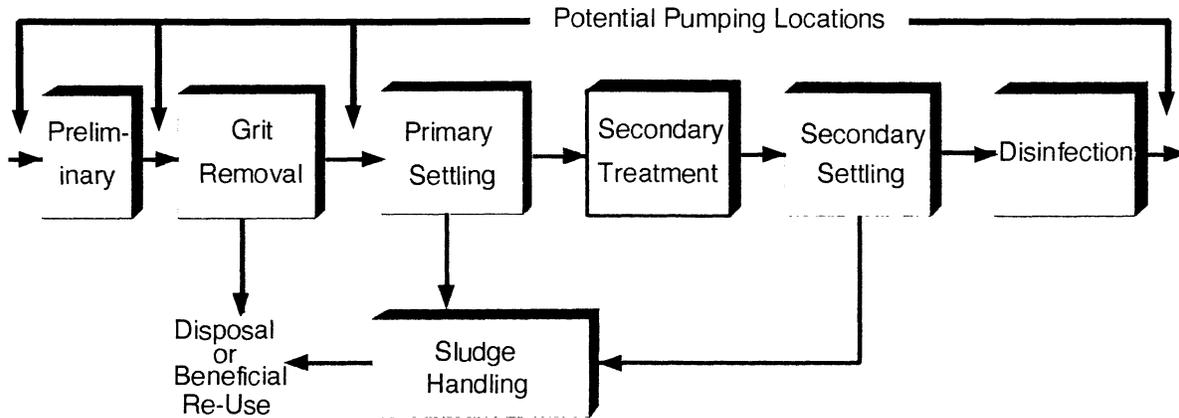
A 4.0 mgd facility, which operates at an average flow of 2.66 mgd, has two 75-hp raw wastewater pumps. They operate one continuously at a 51% load factor using an estimated 249,177 kWh/yr, which results in a cost of \$21.36 per million gallon (MG) treated.

A 9.0 mgd facility, operating at an average flow of 10.7 mgd, has four 60-hp raw wastewater pumps. They operate one pump continuously at full load and one intermittently at a 65% load factor. This uses an estimated 602,585 kWh/yr, which yields a cost of \$10.12 per MG treated.

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## VARIABLE SPEED DRIVES - PUMPS

### Treatment Plant Location



### Use and Applications

Manual and automatic variable speed systems vary from constant speed systems only in that the fixed operating speed may be easily adjusted. Automatic variable speed controls are often more reliable and maintenance free than presumably simpler on-off controls. Variable speed drives can be installed on almost any pump but are most cost effective in applications where the desired output varies greatly.

### Description

At variable speeds, the pump actually operates on an infinite number of speed curves between the maximum and minimum limits. In many instances the use of automatic variable speed controls will reduce structural costs substantially. Because each pump can operate at an infinite number of flow rates, the total number of pumping units may be reduced. Continuous operation also allows the design engineer to improve the usual limitations on starts per hour associated with constant speed pumping, thereby reducing wet well size.

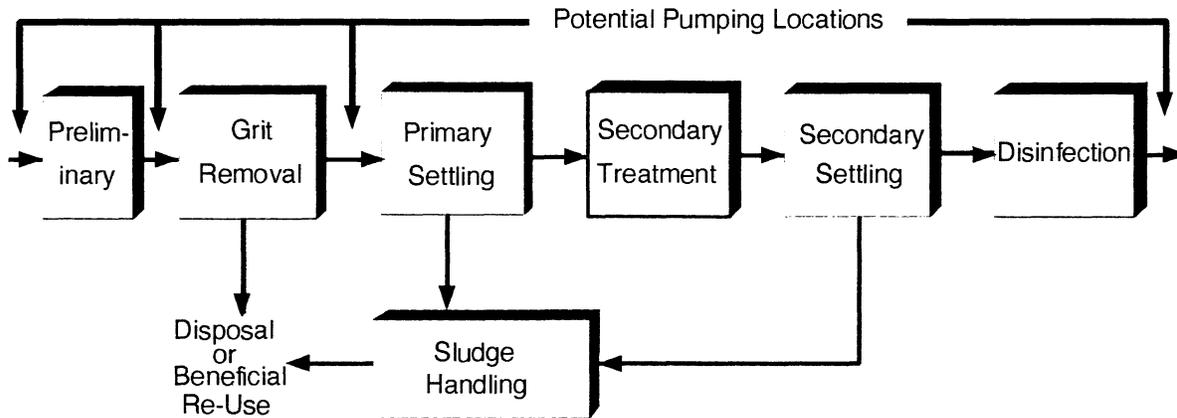
### Potential Energy Savings

Potential energy savings will vary depending on size and operation of the pumping system. Typical results from the facility studies yielded:

Type of Pumping System	Percent Savings
Backwash	15%
Trickling Filter Dosing	20%
Tertiary	40%
Raw Sewage	52%

## HIGH EFFICIENCY MOTORS

### Treatment Plant Location



### Use and Applications

A high efficiency motor can be installed in any pumping system within a treatment facility. The purpose is to improve the overall energy efficiency of the pumping system. A more efficient system will require less electrical energy for operation.

### Description

Motors come in various sizes and have standard and high efficiency ratings. The following shows a comparison of different size motors and their associated efficiency ratings:

Nameplate Horsepower	Standard Efficiency	NEMA Minimum High Efficiency
1	76.8%	82.5%
10	86.4%	88.5%
50	91.5%	93.0%
100	91.9%	94.1%

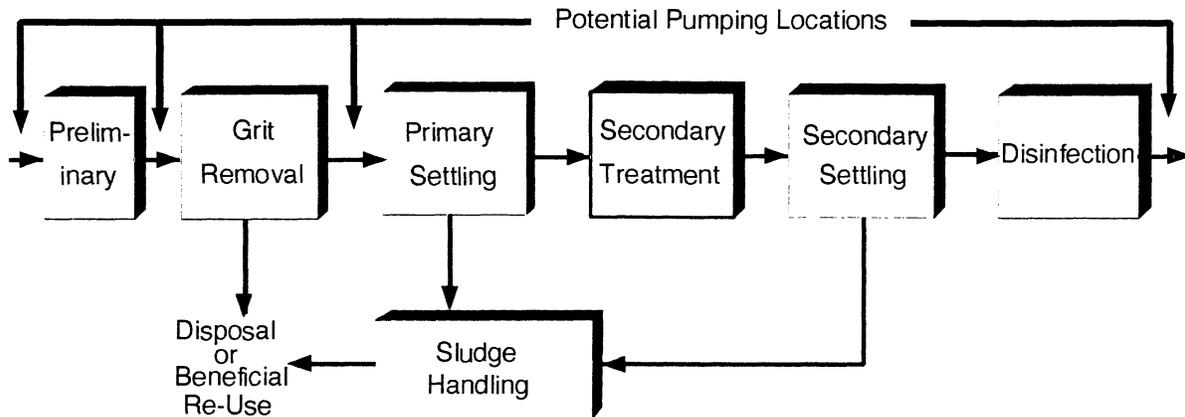
Taken from Niagara Mohawk - Industrial Data Collection Procedures Manual

### Potential Energy Savings

Potential energy savings will vary depending on size and operation of the pumping system. An example:

10-hp motor, standard efficiency (86.4%), operated 24 hr/day, will use 207 kWh/day

10-hp motor, high efficiency (88.5%), operated 24 hr/day, will use 202 kWh/day. This yields a savings of 2.3%

**Treatment Plant Location****Use and Applications**

A smaller pump (with high efficiency motor) can be installed in almost any pumping system within a treatment facility. Most often it is applicable for larger pumping systems (raw wastewater, tertiary pumps) where the original system may have been over designed. The purpose is to improve the overall system efficiency by installing a pump that best matches the lower flow requirements. A better matched system will require less electrical energy for operation.

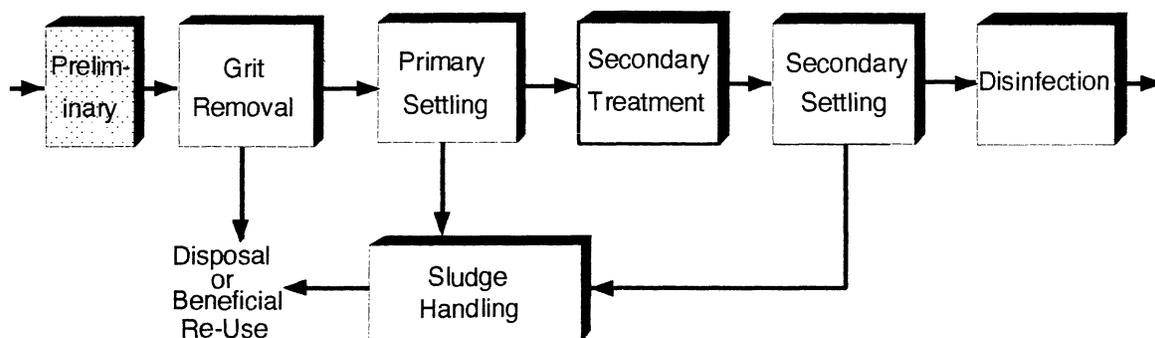
**Description**

Quite often pumping systems are designed to meet peak conditions but minimum (off-peak) conditions are typically not a concern. This causes large pumps to either operate at a lower speed (not at highest efficiency point) or shut on and off to meet low flow requirements and energy is wasted. Installing a smaller pump for low-flow periods can often save substantial energy.

**Potential Energy Savings**

Potential energy savings will vary depending on the size and operation of the existing pumping system.

## **PRELIMINARY TREATMENT**

**Treatment Schematic**

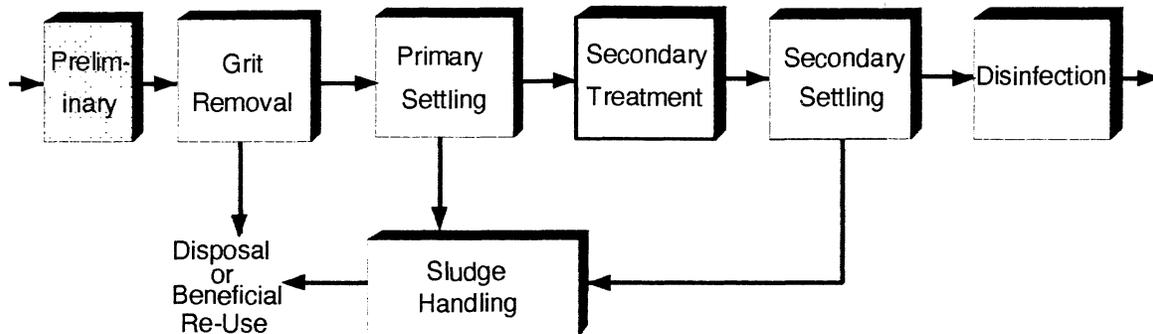
**Use and Applications** Bar racks (bar screens) are used to protect pumps, valves, pipelines, and other downstream equipment from damage or clogging by rags and large objects. Bar racks are used ahead of raw wastewater pumps, meters, grit chambers, and primary sedimentation tanks. They are also used in bypass channels around mechanically cleaned screens or comminutors.

**Process Description** Bar racks are a type of coarse screening. Bar racks consist of parallel bars, either vertical or inclined, that are placed in waterways to remove debris. The screened material is then raked from the rack.

There are two major types of bar racks: mechanical and hand-cleaned. In most cases, mechanical bar racks are used because they: minimize the manual labor needed to clean the racks; remove and dispose of the debris on a pre-programmed cycle; and reduce flooding and overflows due to clogging.

**Energy Consumption** Mechanical bar racks require minimal horsepower for operation. For example, a 9.0 mgd mechanical bar screen, at a facility averaging 10.7 mgd, would require a 0.75-hp motor. A 0.75-hp bar screen operating 50 hours/week would consume 1,454 kWh/year, resulting in a cost of \$0.02 per MG treated.

Bar racks prolong the life of wastewater machinery by removing debris large enough to damage equipment. An indication of their effectiveness can be obtained by examining the maintenance costs and down time of the equipment and processes that the coarse screen is intended to protect.

**Treatment Schematic**

**Use and Applications** Comminutors are typically located after the influent bar screens prior to the grit removal process. They cut up the coarse suspended solids in the flow to improve the downstream operations and processes and to eliminate problems caused by the varied sizes of solids present in wastewater. Comminutors may help reduce the amount of floatable matter that accumulates in the anaerobic sludge digesters. The use of such a device also tends to reduce odors, flies, and unsightliness often found around screenings.

**Process Description** There are different types of comminutors available. In one type, coarse material is cut by cutting teeth and shear bars on a revolving drum as the solids are carried past a stationary comb. Other types of comminutors consist of a stationary semi-circular screen grid mounted in a rectangular channel with rotary cutting disks.

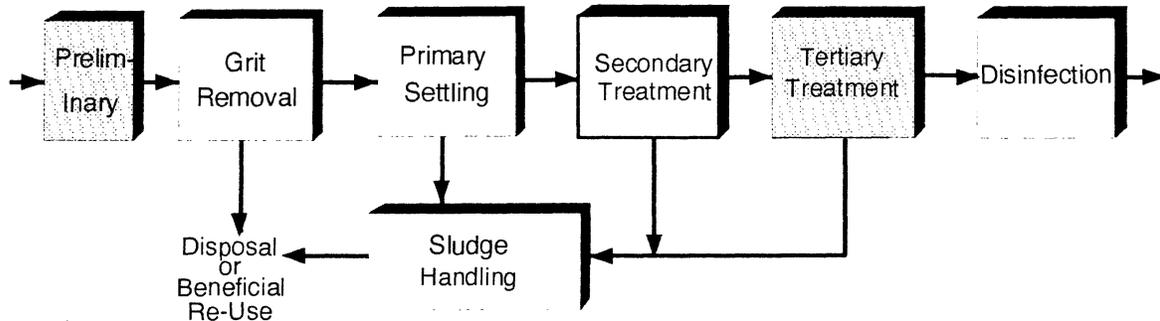
Comminutors should be constructed with a bypass arrangement so that a manual bar screen can be used in case the influent flowrate exceeds the capacity of the comminutor or if there is a power or mechanical failure.

**Energy Consumption** Comminutors use relatively low horsepower yet prolong the life of the downstream equipment by reducing wear on the equipment surfaces where there is a small clearance between moving and stationary parts. Some examples of energy consumption include:

A 4.0 mgd facility, averaging 2.66 mgd, needs one 1.5-hp comminutor that operates continuously, this uses 9,772 kWh/year for a cost of \$0.78 per MG treated.

A 21 mgd facility, with an average flow of 8.2 mgd, has two 2-hp comminutors that operate continuously using 26,130 kWh/year and yield a cost of \$0.44 per MG treated.

### Treatment Schematic



**Use and Applications** Fine screens are used to remove suspended solids, algae, aquatic plants, or floatables for the purpose of upgrading secondary treated wastewater effluent to tertiary standards or to protect downstream processes. They are sometimes used in place of primary sedimentation tanks. Fine screens may clog frequently.

**Process Description** Fine screens, usually made of steel mesh or perforated steel plates, have openings of 4.75 mm or smaller. There are two major types of fine screens:

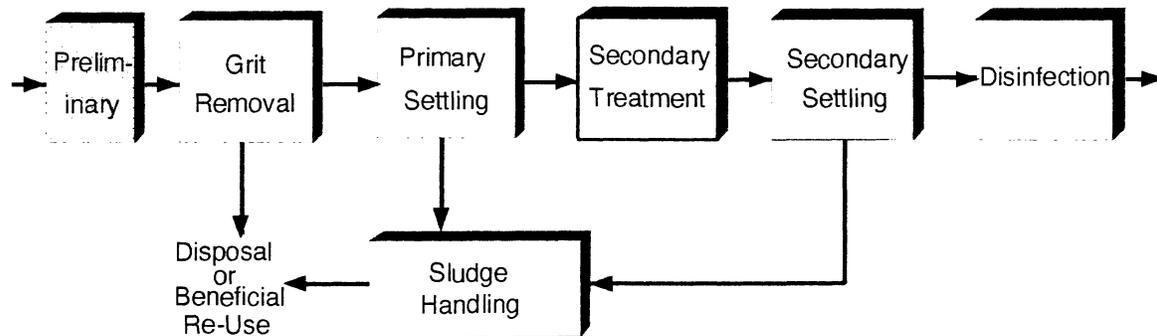
Fixed screens - Fixed screens with openings less than 2.3 mm have been used for pretreatment and/or primary treatment. The application of fixed screens to municipal wastewater treatment can result in biochemical oxygen demand (BOD) and suspended solids (SS) removal in the range of 20 to 35 percent.

Moving screens - Moving screens consist of a strainer with a rotating cylinder having a screen attached to the circumferential area of the drum. Different screens can be employed, with openings commonly varying from 0.02 to 3 mm.

**Energy Consumption** Fine screening systems require minimal (if any) energy for operation yet improve overall treatment capability. Fine screens remove 5 to 25% of suspended solids and help to protect downstream processes. Some examples of energy consumption include:

A 1.0 mgd facility, with an average flow of 0.39 mgd, uses a hydrosieve screen that has two 1.5-hp conveyors that operate 45 hours/week using an estimated 6,398 kWh/year for a cost of \$2.68 per MG treated.

A 2.85 mgd facility uses four vibrating screens, each with a 2-hp motor, for an industrial waste stream that averages 0.6 mgd. Typically one operates full time while two operate 120 hours/week and the fourth operates 48 hours/week. This system uses 35,365 kWh/year, yielding a cost of \$15.32 per MG treated.

**Treatment Schematic**

**Use and Applications** Pre-aeration promotes a more uniform distribution of suspended and floating solids. Aerating wastewater prior to primary sedimentation can also improve its treatability, provide grease separation, odor control, grit removal and flocculation, and increase BOD removals. It is now common to combine grit removal with pre-aeration as one unit process. Diffused air and mechanical aerators are two methods of introducing air into wastewater.

In deciding when to use pre-aeration, particular attention must be paid to the wastewater quality to determine whether pre-aeration is the most practical and beneficial preliminary treatment plan.

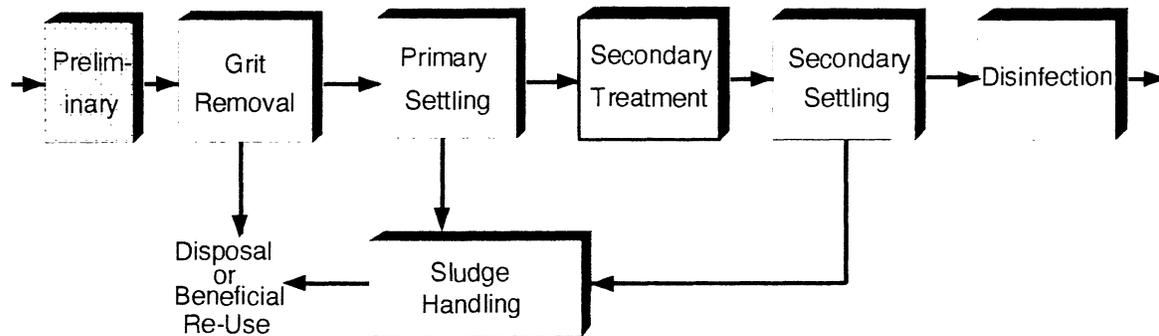
**Process Description** In the diffused air system, compressed air is introduced near the tank bottom. This causes the tank's contents to be circulated by the air-lift effect. The operator must keep the diffusers clean to ensure an even and adequate air supply to the aeration tank. In this system, few or no operating problems are encountered.

There are several types of mechanical aeration devices. Mechanical devices employ motor-driven impellers alone or in combination with air-injection devices. The floating and fixed bridge aerators are quite common. Some use a blade to agitate the tank's surface and disperse air bubbles into the aeration liquor. Others circulate the mixed liquor by an updraft or downdraft pump or turbine.

**Energy Consumption** When using the diffused air system, the efficiency of oxygen transfer depends upon the design of the diffuser, the size of the bubbles produced, and the depth of submergence.

Diffused air systems will require less energy than mechanical systems yet may not be applicable for all waste streams.

### Treatment Plant Location



### Use and Applications

Flow equalization can be an effective measure in reducing peak flowrates. Flow equalization is used to overcome the operational problems caused by flowrate variations, to improve the performance of the downstream processes, and to reduce the size and cost of downstream treatment facilities. Benefits derived by upstream flow equalization include: reduced hydraulic loading on already overtaxed treatment facilities; reduced potential of overflows and possible resulting health hazards or pollution problems; and reduced peak loading of the treatment plant.

### Description

Flow equalization is the dampening of flowrate variations so that a constant or nearly constant flowrate is achieved. This technique can be applied in a number of different situations, depending on the characteristics of the collection system. A desirable secondary objective of flow equalization is to dampen the concentration and mass flow of wastewater in the equalization basin.

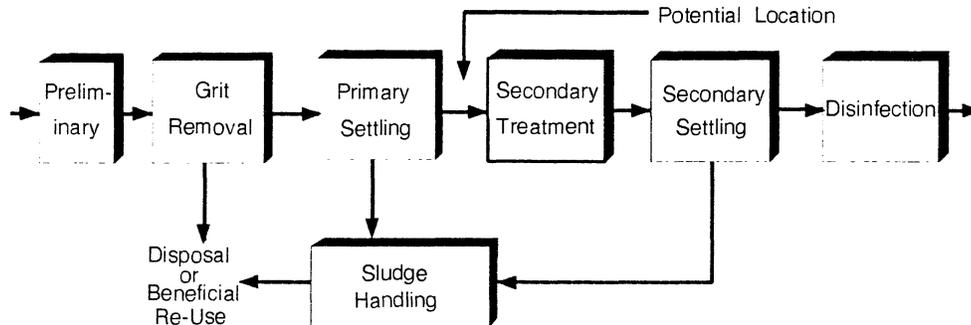
### Potential Energy Savings

Energy savings will vary depending upon the application. Energy savings can potentially be realized in all pumping systems and the activated sludge system as a result of smoothing out the diurnal peaks that typically coincide with the highest electrical demand charges, and by allowing for off-peak treatment capabilities. Savings in the range of 5-10% of overall influent pumping costs can be realized where off-peak power billing is practiced and storage is readily available.

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## ANAEROBIC PRETREATMENT

### Treatment Plant Location



### Use and Applications

Industrial wastes high in COD can be stabilized very efficiently by anaerobic pretreatment.

### Description

Anaerobic pretreatment is an energy efficient technology for treating high strength wastes in the absence of oxygen. Following the anaerobic step the partially treated effluent typically flows into the aerobic secondary treatment process at a WWTP. The anaerobic process performs best with the influent chemical oxygen demand (COD) concentrations in the range of 1,500-5,000 mg/l.

There are three major types of anaerobic treatment processes:

Upflow anaerobic sludge-blanket (UASB) - The wastewater is introduced at the bottom of the reactor and flows upward through a sludge blanket composed of biologically formed granules or particles.

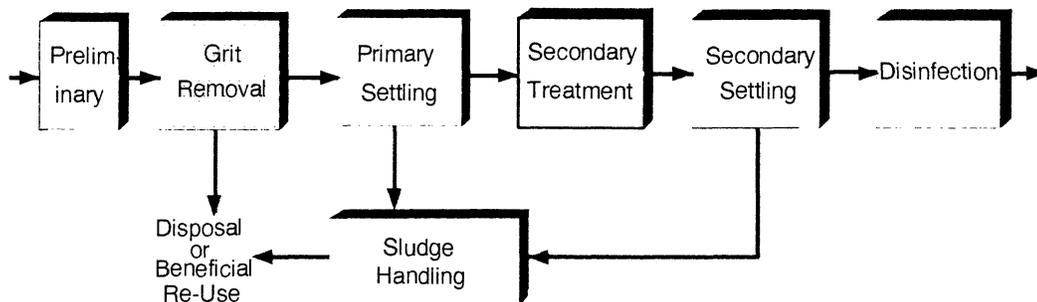
Anaerobic filter - A column filled with various types of solid media used for the treatment of the carbonaceous organic matter in wastewater. The waste flows upward through the column, contacting the media on which anaerobic bacteria grow and are retained.

Expanded-bed - The wastewater is pumped upward through a bed of a medium on which a biological growth has been developed. Effluent is recycled to dilute the incoming waste and to provide an adequate flow to maintain the bed in an expanded condition.

### Potential Energy Savings

Incorporation of anaerobic pretreatment can reduce loadings to downstream biological processes. This may result in energy savings if the downstream aeration system, for example, can use less oxygen to treat the wastewater. Because of the low synthesis rate of anaerobic microorganisms, the total sludge volume that must be disposed of is reduced, resulting in residual disposal cost savings. Savings are site specific, but may be in the range of 5 - 20%.

## **GRIT REMOVAL**

**Treatment Schematic**

**Use and Applications** The main purpose of any grit removal system is to protect downstream mechanical equipment from abrasion and abnormal wear, minimize clogging pipes and channels, and prevent accumulation of inert material downstream. These systems usually remove material with a specific gravity of 2.65 or more, such as sand and gravel.

**Process Description** The four most popular grit removal technologies are:

Velocity-controlled horizontal-flow channels - Velocity-controlled channels, the oldest type of grit chamber, are straight channels designed to maintain a velocity close to 1.0 ft/sec to provide sufficient time for grit particles to settle to the bottom of the channel.

Aerated grit chambers - Aerated grit chambers are long channels that trap grit particles in an air-induced rotation of the wastewater.

Vortex grit chambers - Vortex grit chambers use centrifugal force to separate grit from wastewater. Influent wastewater enters the unit tangentially, creating a vortex.

Detritus tanks - Detritus tanks are also a controlled horizontal flow system. Square sedimentation tanks are generally used, and grit and organics are initially settled.

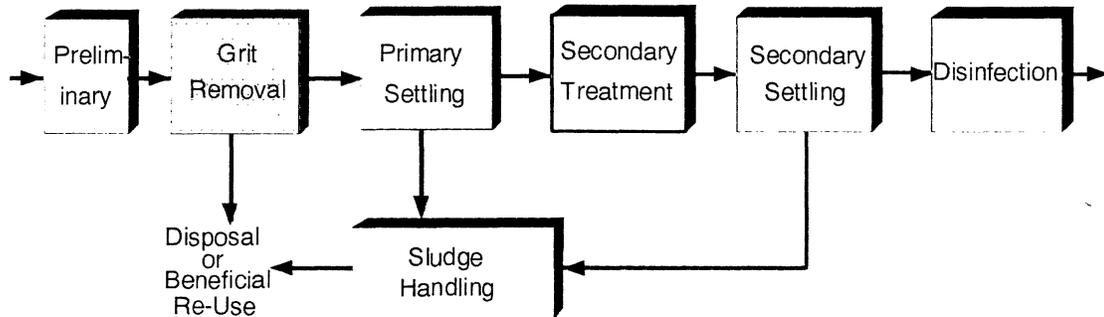
**Energy Consumption** All grit removal options require a dewatering system; this equipment is usually run by low-horsepower motors. Chain and flight collectors, grit pumps, air blowers, drive motors, and rotating arm mechanisms may also be needed but usually require relatively low-horsepower motors.

For example, a 1.0 mgd vortex system that operates at an average of 0.88 mgd has a 0.75-hp paddle motor, 5-hp grit pump, a 0.5-hp grit separator and a 0.5-hp grit classifier. This system uses 56,768 kWh/year, yielding a cost of \$2.29 per MG treated. A 21 mgd aerated grit system, averaging 8.2 mgd, has three 15-hp blowers, three 10-hp grit pumps, a 5-hp belt conveyor and two 1-hp grit classifiers. This system uses 273,955 kWh/year, resulting in a cost of \$3.98 per MG treated. A 48 mgd detritus system, operating at an average of 36 mgd, has four 15-hp grit pumps, two 2-hp collector mechanisms, two 10-hp compressors and four 1-hp cyclones and uses 501,612 kWh/year. This results in a cost of \$2.42 per MG treated.

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## VORTEX GRIT REMOVAL

### Treatment Plant Location



### Use and Applications

In the vortex grit removal system, centrifugal force is used to separate grit from organics. The units are manufactured in a variety of sizes and can be used in various combinations to meet virtually any influent flow requirement.

### Description

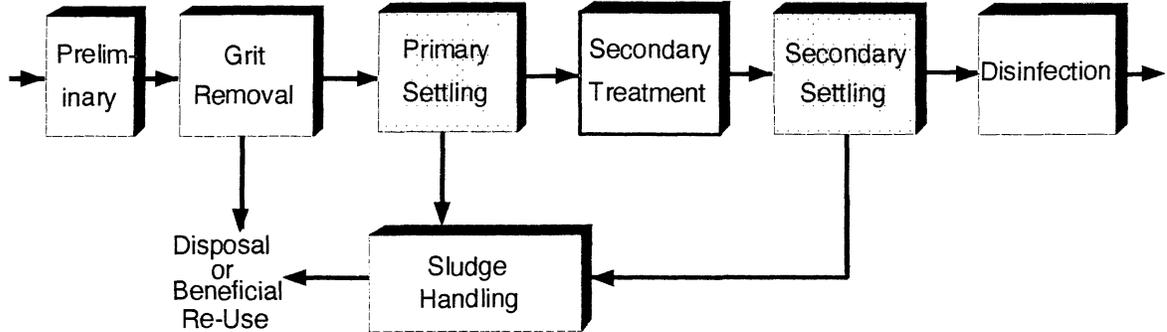
Wastewater is discharged into the degritter so that it is properly introduced into the flow pattern provided by the circulating mechanism. The circulator imports a flow of liquid in the upper part of the basin and produces a vortex and rotating pattern of flow. The vortex causes the grit to be brought to the center of the basin where the grit falls into a rake or screw mechanism for removal. Units are sized based upon maximum influent flow.

### Potential Energy Savings

A vortex unit requires minimal horsepower for operation. Potential energy savings will vary depending on operation and configuration of existing system. When compared to an aerated grit system, potential energy usage savings can range from 80 to 95%.

## **PRIMARY TREATMENT**

### Treatment Schematic



**Use and Applications** The purpose of sedimentation tanks is to remove readily settleable solids and floating material to reduce the wastewater suspended solids concentration. Sedimentation tanks may provide the principal degree of wastewater treatment, or they may be used as a preliminary step in the further processing of the wastewater. Sedimentation tanks can remove: settleable solids capable of forming sludge deposits in the receiving waters; free oil and grease and other floatable material; and a portion of the organic load.

**Process Description** Settling tanks allow for the gravity settling of solids. Surface skimming is used to remove scum and floating material. There are two types of sedimentation tanks:

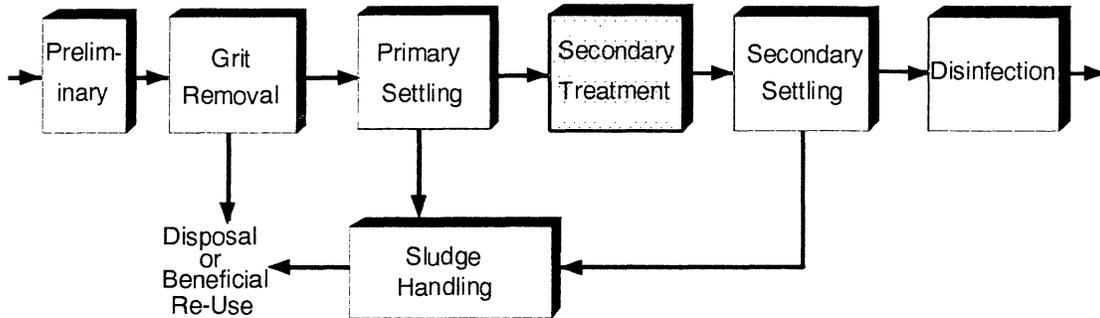
Rectangular tanks - Rectangular sedimentation tanks may use either chain-and-flight sludge collectors or traveling-bridge type collectors. In rectangular tanks, flow distribution in the tank is crucial. Scum is usually collected at the effluent end of rectangular tanks.

Circular tanks - In circular sedimentation tanks, the flow pattern is radial. To achieve a radial-flow pattern, the wastewater can be introduced in the center (center-feed) or around the fringe (peripheral-feed) of the tank. Both are acceptable, but the center-feed type is more frequently used.

Sedimentation tanks are ordinarily designed on the basis of a surface loading rate expressed as gallons per square foot of surface area per day. Sludge is usually withdrawn from either type of tank by sludge pumps for discharge to the sludge-disposal units. Two or more tanks should be provided so that the process may remain in operation while one tank is out of service for maintenance or repair.

**Energy Consumption** Sedimentation tanks are operated via minimal-horsepower drive units. For example a 1 mgd system, operating at an average flow of 0.88 mgd, uses 9,772 kWh/year for a cost of \$0.39 per MG treated, while a 30 mgd system, averaging 25 mgd, uses 32,572 kWh/year for a cost of \$0.30 per MG treated. Often, energy conservation can be achieved by removing excess units in service.

## **SECONDARY TREATMENT - BIOLOGICAL**

**Treatment Schematic**

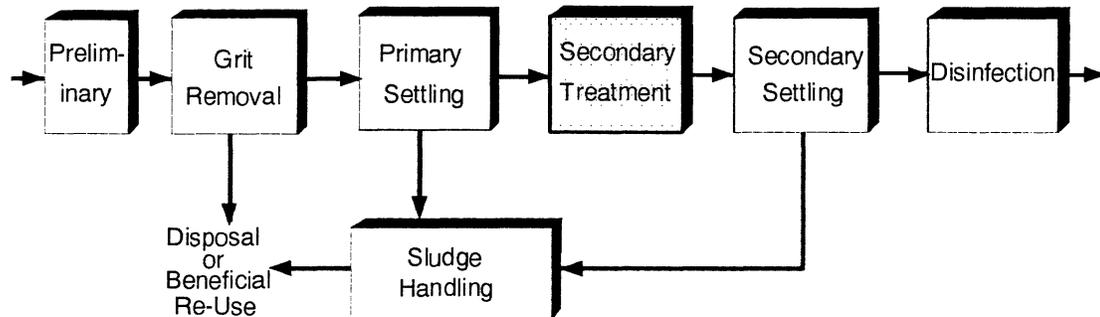
**Use and Applications** Activated sludge is an aerobic biological treatment process that uses the metabolic reactions of microorganisms to clean up wastewater and produce an acceptable effluent quality. Activated sludge is considered to be a secondary treatment process and generally follows a primary clarifier. The process can be used to remove carbonaceous BOD as well as ammonia.

**Process Description** In the basic activated sludge process, primary effluent enters an aerated tank where previously developed biological floc particles are brought into contact with the organic matter of the wastewater. Oxygen is introduced into the system to maintain the biological population. This can be accomplished by injection of high-purity oxygen into covered tanks or via a variety of mechanical or diffuser-type aeration systems. These systems include: surface or submerged mechanical aerators and coarse or fine bubble diffusers.

As the contents of the aeration tanks are discharged, a gravity clarifier is usually used to separate the suspended solids from the treated wastewater. Some of the settled biological solids are recycled back to the aeration tank to maintain a concentrated population of microorganisms for wastewater treatment.

**Energy Consumption** The energy efficiency depends on: the numbers and types of active microorganisms present in the aeration tank; environmental factors such as dissolved oxygen concentration, nutrients, pH, temperature and presence of toxic materials; and how readily organic material can be oxidized or used for cell synthesis.

Air (energy) requirements are a function of equipment utilized. The oxygen transfer efficiency increases as the size of the air bubbles decreases. For example, a 9 mgd facility with surface aerators operating at an average flow of 10.7 mgd uses 947,850 kWh/year for a cost of \$15.92 per MG treated. A 1.0 mgd coarse bubble system, with an average flow of 0.88 mgd, would use 750,013 kWh/year resulting in a cost of \$22.98 per MG treated, while a 48 mgd fine bubble facility averaging 36 mgd would use 5,323,045 kWh/year yielding a cost of \$25.71 per MG treated.

**Treatment Schematic**

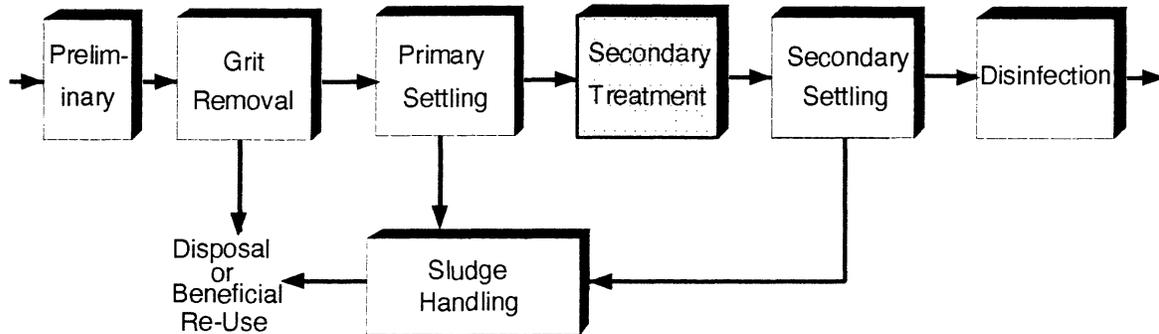
**Use and Applications** An aerated lagoon is a holding basin in which air is mechanically introduced to speed up aerobic decomposition. The essential function of this treatment process is waste conversion. Aerated lagoons are widely used in industrial wastewater treatment because their size is conducive to treating high strength wastes with a long hydraulic detention time and because they are less expensive than the activated sludge process. However, the land requirement is much greater for the aerated lagoon.

The aerated lagoon is very similar to the stabilization pond except that air is added mechanically (it does not depend on algae and sunlight to furnish dissolved oxygen for bacterial respiration). The detention time is shorter and the wastewater depth is greater.

**Process Description** The aerated-lagoon process is essentially the same as the extended-aeration activated-sludge process, except that an earthen basin is used for the reactor and a downstream settling tank or facultative stabilization pond that serves as the final clarifier. The oxygen required by the process is supplied by surface or diffused aerators. As with other suspended-growth systems, the turbulence created is used to maintain the contents of the basin in suspension. To meet secondary treatment standards of the U.S. Environmental Protection Agency, many aerated lagoons are now used in conjunction with settling facilities and incorporate the recycle of biological solids.

**Energy Consumption** Energy consumption is comparable to the extended aeration process and will vary depending upon aeration equipment installed in the lagoon. Surface or floating pump-type aerators are energy intensive; conversion to a floating diffused air system can reduce energy requirements.

For example, a 0.5 mgd facility that has an oxidation pond with coarse bubble diffusers and operates at an average flow of 0.24 mgd, uses 228,000 kWh/year to operate the pumps and blowers, resulting in a cost of \$166 per MG treated.

**Treatment Schematic**

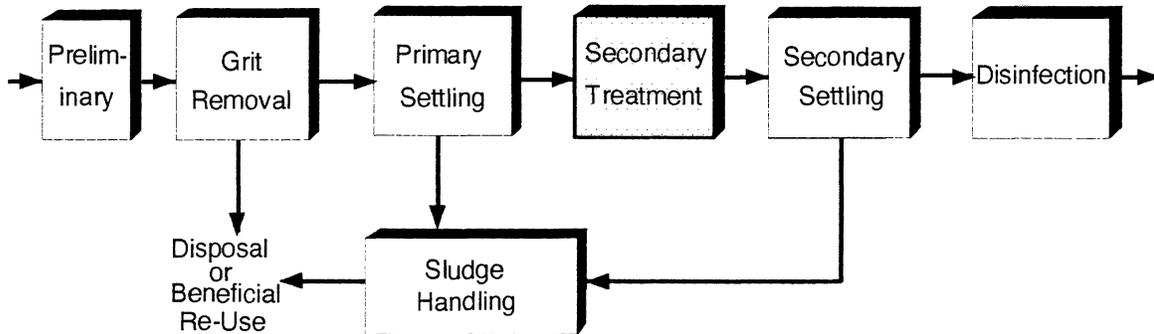
**Use and Applications** The oxidation ditch is a biological secondary treatment technique similar to extended aeration. It was developed to minimize waste-activated sludge production through endogenous decay of the sludge mass. Primary clarification is usually not provided in these plants.

**Process Description** The oxidation ditch is a ring-shaped channel equipped with mechanical aeration devices. Oxidation ditches use mechanical brush aerators, surface aerators, and jet aerator devices to aerate and pump the wastewater. Screened wastewater enters the ditch, is aerated, and circulates at about 0.8 to 1.2 ft/s. Secondary sedimentation tanks are used in most applications for solids separation.

**Energy Consumption** The economics of oxidation ditches appear most favorable when the solids retention time (SRT) is long, particularly where nitrification or nitrification/denitrification is required. In these applications, energy use is comparable to extended aeration and/or lagoon systems.

Some examples of energy consumption include, a 0.4 mgd facility with a jet aeration system that has an average flow of 0.17 mgd uses a total of 219,594 kWh/year for a cost of \$228 per MG treated, while a 2.85 mgd system with brush aerators, operating at an average flow of 1.25 mgd, uses a total of 1,889,186 kWh/year for a cost of \$337 per MG treated.

**Treatment Plant Location**



**Use and Applications**

Fine bubble diffused air systems can be used in a variety of locations within treatment plants. Their main function is to supply air/oxygen to the treatment system. The majority of applications occur in activated sludge tanks, although for larger treatment facilities post aeration and aerobic digestion applications are feasible. Fine bubble diffusers can replace surface and jet aeration systems as well as coarse bubble diffused air systems.

**Description**

Fine bubble diffusers are manufactured in a variety of shapes and materials. The most common are:

- Ceramic discs
- Ceramic domes
- Plastic tubes
- Membrane panels.

Oxygen transfer efficiency (OTE) of the equipment will vary by manufacturer. The OTE is also affected by the airflow per diffuser and the submergence depth. The greater the airflow per diffuser, the lower the OTE, while the OTE will increase with a greater submergence depth. Typical OTEs at a 15-foot submergence depth for various diffusers are:

Diffuser Type	OTE (%)
Ceramic Discs (grid)	30 - 34
Ceramic Domes (grid)	25 - 37
Plastic Tubes (grid)	28 - 32
Membrane Panels (grid)	38 - 40

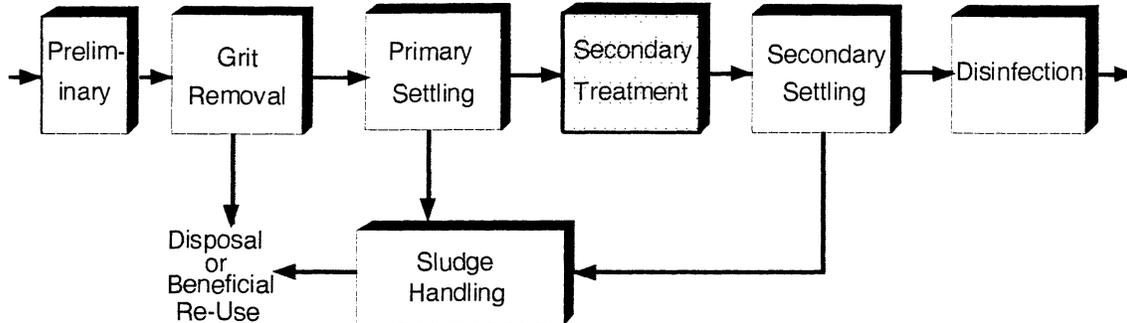
**Potential Energy Savings**

Actual energy savings will depend upon configuration and operation of existing system. Typical savings from a surface aerator to fine bubble system is in the range of 40 to 55%, while a coarse bubble to fine bubble conversion could save 30 to 45%.

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## DISSOLVED OXYGEN CONTROL

### Treatment Plant Location



### Use and Applications

Failure to maintain an adequate residual dissolved oxygen (DO) concentration can inhibit biological activity and contribute to problems such as sludge bulking and inhibition or loss of nitrification. Conversely, allowing too high a DO results in wasted energy. DO control may either be manual or automatic. However, automatic DO control is typically more energy-efficient than manual control. Potential benefits from automatic DO control are minimization of aeration energy costs, improved process performance, and a resulting reduction in effluent variability.

### Description

Manual DO control does improve the process of wastewater treatment. However, changing conditions make it very difficult for an operator to manually manipulate airflow rates and air distribution to maintain desired DO concentrations throughout a sustained operating period. Therefore, airflow typically is manually fixed at a rate high enough to satisfy the oxygen demand anticipated during peak loading periods. This practice can result in excess aeration during periods of reduced loading.

Automatic DO control can provide substantial savings in aeration energy use over manual DO control. Automatic DO control is justified for plants having considerable fluctuations in input loading, adequate aeration tank capacity, and adequate aerator turndown without loss of efficiency. It is not recommended for all plants. An industrial or municipal wastewater plant in which all blowers must be operated at full capacity on a continuous basis or where loading does not vary has no need for automatic blower control.

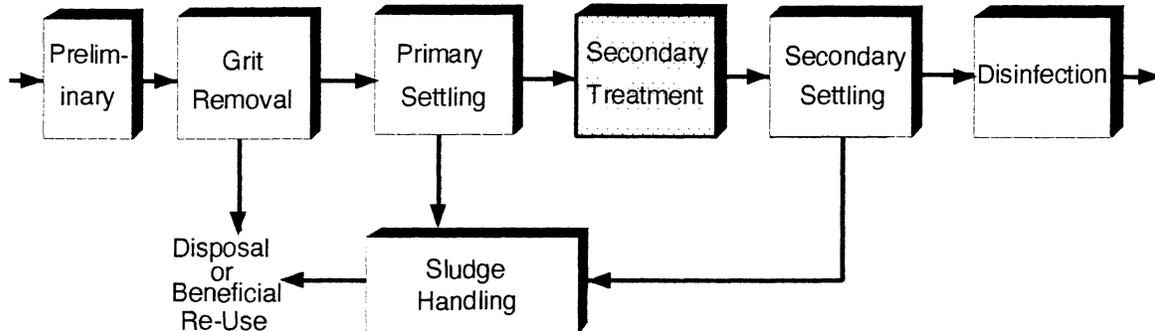
### Potential Energy Savings

Generally, the potential aeration energy savings achievable by automatic aeration or DO control is 25-40%, but can be as high as 50%. Potential savings are plant-specific and depend on plant loading characteristics, plant configuration and process hardware design, and the existing level of manual control.

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## BLOWER GUIDE VANE CONTROL

### Treatment Plant Location



### Use and Applications

Blower guide vane control is a common method of adjusting the capacity and pressure of a constant speed centrifugal blower. Blower guide vane control is usually installed on blowers where output requirements vary (e.g., in the activated sludge process), but can be installed in a grit removal system and pre- or post-aeration systems.

### Description

Inlet guide vanes for compressors are located ahead of the impeller. At the full-load design point the vanes are in a straight, fully open position allowing the air to enter directly into the impeller. When reduced pressure or flow is required, the inlet guide vanes are turned so the air is directed into the blower in the same direction that the impeller is turning.

### Potential Energy Savings

When the cost of electric power is high, the use of movable inlet guide vanes is recommended for power savings since the money saved on power costs will be considerable over the life of the blower.

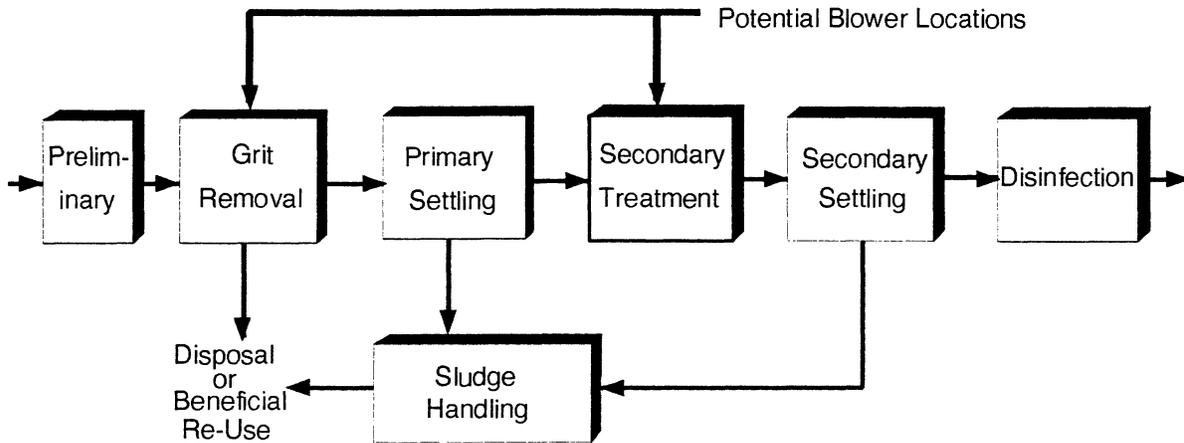
Power savings resulting from inlet guide vanes occur across the performance range of the blower, not just at the design point. The horsepower savings resulting from inlet guide vanes become more pronounced as the suction air drops below the design temperature, which is usually around 100 °F.

Blower guide vane control may be as cost effective as variable speed control, depending on the type of blower, size, and degree of "turndown" required.

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## VARIABLE SPEED DRIVES - BLOWERS

### Treatment Plant Location



### Use and Applications

Manual and automatic variable speed systems vary from constant speed systems only in that the fixed operating speed may be adjusted easily. Automatic variable speed controls are often more reliable and maintenance free than presumably simpler on-off controls. Variable speed drives can be installed on almost any blower but are most cost effective in application where the desired output varies greatly.

### Description

At variable speeds, the blower actually operates on an infinite number of speed curves between the maximum and minimum limits. In many instances the use of automatic variable speed controls will reduce energy costs substantially. Because a blower can operate at an infinite number of air flow rates, the output can correspond to the actual oxygen demand of the system.

### Potential Energy Savings

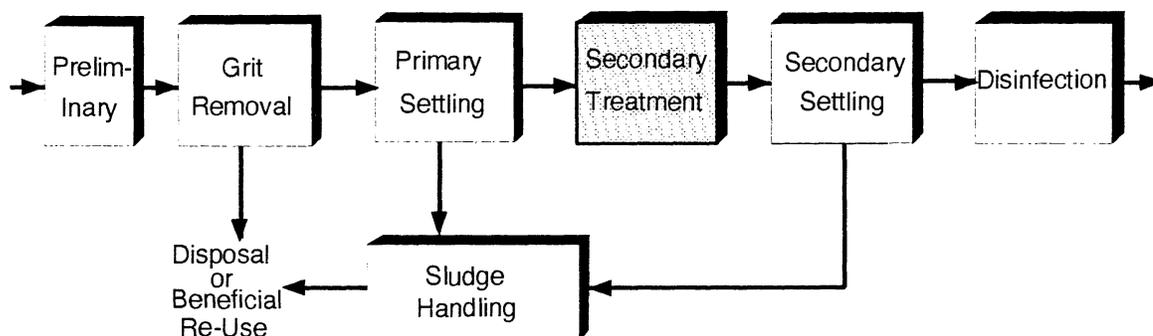
Potential energy savings will vary depending on size and operation of the blower system and variations in influent aeration tanks loadings. For example a 0.4 mgd facility, with four 15-hp positive displacement constant speed blowers, typically operates one blower continuously and a second unit very intermittently, using a total of 99,327 kWh/year. The installation of one variable speed drives would reduce output during off-peak loadings and could potentially save 19,500 kWh/year, a savings of 19.6%

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## ROTATING BIOLOGICAL CONTACTORS

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### Treatment Schematic



**Use and Applications** Rotating biological contactors (RBCs) used for secondary treatment can be operated seasonally to enhance nitrification or continuously to reduce BOD loadings.

RBCs are typically used in the following applications: for smaller (<0.3 mgd) treatment systems as a package secondary treatment scheme; where effluent quality equivalent to trickling filters or bio-filters is required; or for seasonal nitrification/two-stage treatment. A single standard-density RBC shaft can treat approximately 0.3 mgd of medium strength (250 mg/l BOD) wastewater. For larger facilities, modular RBCs are installed.

**Process Description** A series of closely spaced circular polystyrene or polyvinyl chloride disks is partially submerged in wastewater. Biological growth (biomass) attaches to the surface of the disks. The biomass is kept in aerobic conditions by the rotation of the disks. The rotation alternately contacts the biomass with the organic material in the wastewater and the atmosphere for adsorption of oxygen.

**Energy Consumption** Energy requirements (i.e., kWh/lb of BOD removed) can be lower than for sequencing batch reactors (SBRs) or activated sludge aeration systems. Some examples of energy consumption include:

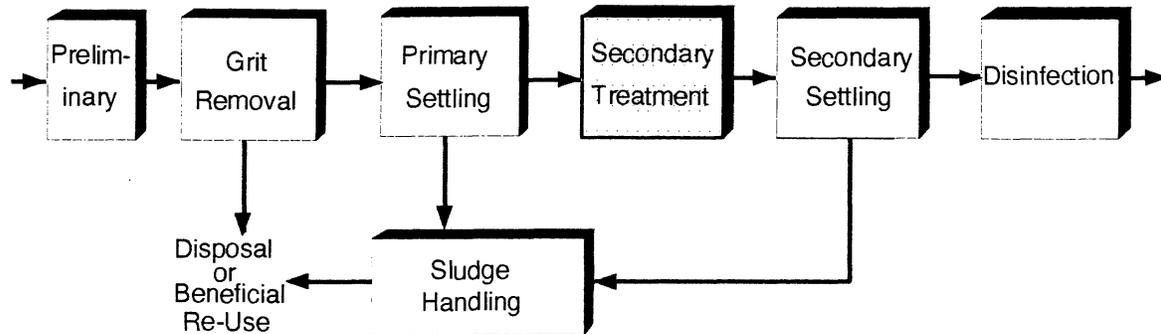
A 1.0 mgd second stage RBC system, operating at an average flow of 0.39 mgd, with two trains of five RBCs, each RBC with a 7.5 -hp motor, uses 325,722 kWh/year for operation. This results in an average cost of \$137 per MG treated.

A 0.4 mgd RBC facility, with an average flow of 0.35 mgd, has 1 RBC unit with a 7.5-hp motor. This system uses 48,858 kWh/year with an average cost of \$25.01 per MG treated.

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## TRICKLING FILTERS (BIO-TOWERS)

### Treatment Schematic



**Use and Applications** The trickling filter (bio-tower) is an attached-growth process that is used to remove organic matter found in wastewater. The trickling filter can also be used to achieve nitrification. In predicting the performance of trickling filters, the organic and hydraulic loadings and the degree of treatment required must be considered.

**Process Description** In a trickling filter, biological growth covers a packed media through which wastewater is percolated. Most often, the filter media consists of either rock or a variety of plastic packing material. Usually the wastewater is distributed as a uniform spray over the packed media bed by a rotating flow-distributor arm. Filters are constructed with an underdrain system for collecting the treated wastewater and any biological solids that have become detached from the media. The underdrain system is important both as a collection unit and as a porous structure through which air can circulate up through the media. The collected liquid is passed to a settling tank where the solids are separated from the treated wastewater.

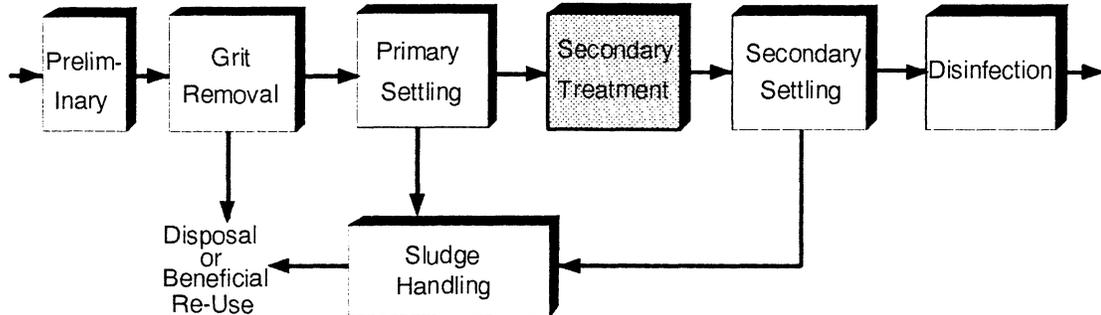
**Energy Consumption** Energy requirements for trickling filters are minimal when compared to activated sludge or rotating biological contactors. However, recirculation pumping can add significantly to the energy use. Where higher effluent standards are required, activated sludge processes have largely displaced trickling filters since trickling filter systems will typically only achieve 80 to 85% BOD removal.

A trickling filter system can use no energy if recirculation pumps are not used while a 21 mgd facility, operating at an average flow of 8.2 mgd, with recirculation pumps would use 195,433 kWh/year, this results in an average cost of \$4.41 per MG treated.

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## SEQUENCING BATCH REACTOR

### Treatment Schematic



**Use and Applications** A sequencing batch reactor (SBR) is a fill-and-draw activated-sludge treatment system. The unit processes involved in the SBR and conventional activated-sludge systems are identical. Aeration and sedimentation/clarification are carried out in both systems. However, in the SBR operation, these two processes are carried out sequentially in the same tank. All wastewaters commonly treated by conventional activated sludge plants can be treated with SBRs. A SBR process is simple to operate yet is generally only economical when used for smaller flows, (i.e. <2.0 mgd) since above this range, construction costs typically approach or exceed conventional activated sludge systems.

**Process Description** All SBR systems have five steps: fill, react, settle, draw, and idle. Overall cycle times can vary from 3 to 24 hours. Multiple units are required.

Air is introduced into the system during a portion of the fill cycle and the react cycle. Wasting typically occurs during the settle or idle cycle.

By modifying the reaction time, nitrification or nitrogen removal and phosphorus removal can be accomplished.

**Energy Consumption** Improvements in aeration devices and control systems have allowed the development of fill-and-draw systems to achieve their present level of effectiveness. A SBR is now able to compete successfully with conventional activated sludge systems. In some applications a SBR system will be more energy efficient to operate but may be more capital intensive to install. Many SBRs now have fine bubble diffuser systems and mixers that improve oxygen contact with the microorganisms.

SBRs are able to achieve virtually any desired level of efficiency by varying the length of the react step. This ability to optimize treatment with regard to permit requirements can result in overall energy savings.

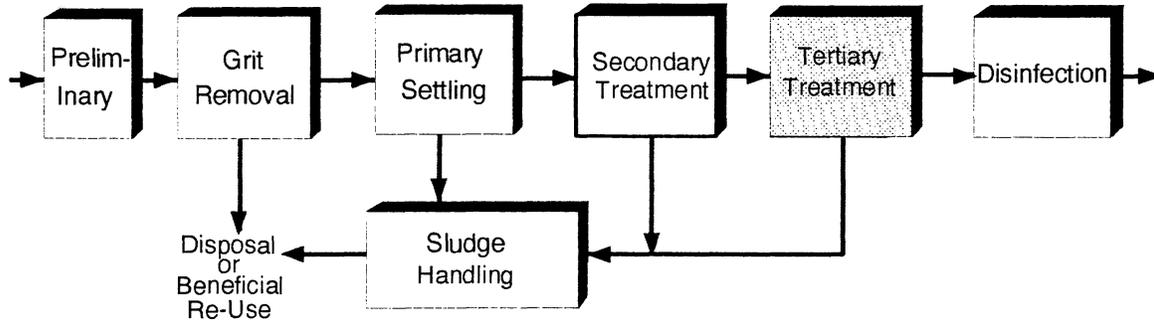
Per an equipment manufacturer, a 1.0 mgd SBR system uses one 30-hp mixer and one 40-hp blower. Under normal conditions, the system would use 353,700 kWh/year. At an average energy cost of \$0.08/kWh the system has a cost of \$77.52 per MG treated.

## **TERTIARY TREATMENT**

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## NITROGEN REMOVAL PROCESSES

### Treatment Schematic



**Use and Applications** Discharges containing nitrogen may accelerate the eutrophication of lakes and reservoirs and may stimulate the growth of algae and rooted aquatic plants in shallow streams. Nitrogen is removed by assimilation and by conversion to nitrogen gas through nitrification and denitrification.

**Process Description** Nitrification removes the short-term nitrogenous oxygen demand from the wastewater. Nitrification is the biological oxidation of ammonia to nitrate with nitrite formation as an intermediate. The extent of nitrification that occurs during treatment is dependent on the extent to which nitrification organisms are present. Nitrification generally will take place in a low-rate filter that is operating within its design loading or in a properly designed activated sludge system. For larger plants, multi-stage biological treatment may be necessary.

Where necessary to remove nitrogen, a third (denitrification) stage may be added. Denitrification is the biological conversion of the nitrate-nitrogen to nitrogen gas. The nitrogen gas evolves to the atmosphere from the surface of the wastewater.

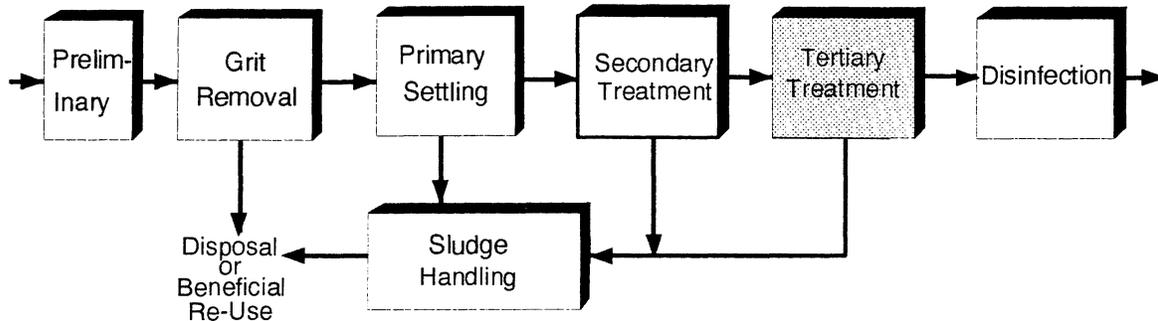
**Energy Consumption** The associated energy consumption for nitrification within an aeration tank corresponds directly to the amount of oxygen required for nitrification. For every pound of ammonia removed from the system 4.6 pounds of oxygen are required in addition to the oxygen required for the carbonaceous demand. For example, a 4 mgd activated sludge facility, operating at an average flow of 2.52 mgd, with separate tanks for seasonal nitrification, operating these tanks for six weeks per year uses an additional 120,264 kWh/year, resulting in an average cost of \$35.21 per MG treated.

For a fixed film system, a RBC can be added following a trickling filter or a first-stage RBC. This is an energy efficient method of nitrification for fixed film systems. For example, a 4 mgd trickling filter facility, with an average flow of 2.6 mgd, adding RBCs for year round nitrification would use an additional 342,008 kWh/year, this results in an average cost of \$24.34 per MG treated.

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## PHOSPHORUS REMOVAL PROCESS

### Treatment Schematic



**Use and Applications** Many states are now requiring phosphorus removal for effluent discharged to specific water courses. Removing nutrients from wastewater is an important operation because these compounds play a critical role in lake eutrophication. Phosphorus originates in wastewater from: the carriage water; fecal and waste materials; industrial and commercial uses; and synthetic detergents and household cleaning products. Phosphorus can incorporate into biological solids or chemical precipitates.

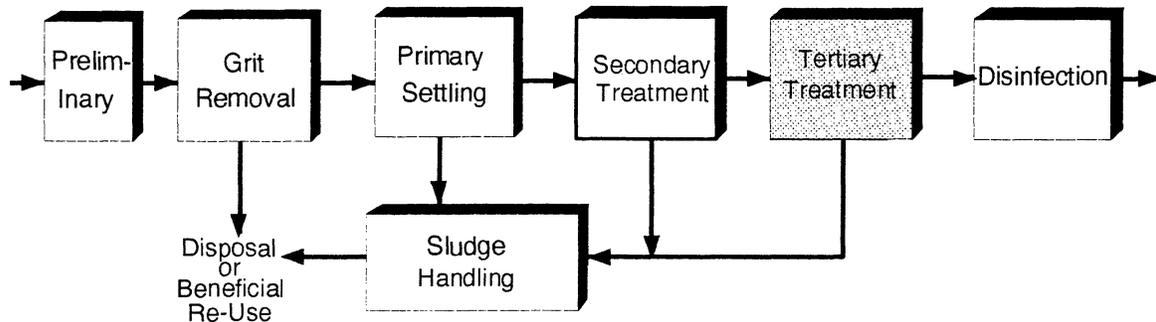
**Process Description** Phosphorus may be removed in trickling filter plants by adding minerals to the primary or secondary settling tank. Direct mineral addition to the trickling filter generally results in poor removal of phosphorus.

While some phosphorus is removed naturally by biological micro-organisms, biological phosphorus removal is accomplished by sequencing and producing the appropriate environmental condition in the reactor(s). Biological phosphorus removal requires both anaerobic (anoxic) and aerobic reactors or zones within a reactor. The sludge containing the excess phosphorus is either wasted or removed and treated in a side stream.

Chemical precipitation is another technique that is used in removing phosphorus from wastewater. Metal salts and lime have been used in this technique. Chemical precipitation of phosphate usually becomes necessary when the phosphorus discharge criteria are lower than those that can be achieved by primary sedimentation and secondary biological wastewater treatment.

**Energy Consumption** Energy consumption will vary by process. Chemical precipitation will use less energy than biological treatment but may be more costly because of increased chemical use, increased sludge production, and disposal costs.

### Treatment Schematic



**Use and Applications** Granular media filtration can improve suspended solids removal from primary or secondary effluent or can be used as an independent secondary treatment process in a physical-chemical treatment plant. Chemical addition before granular media filtration may improve the filter performance. Granular media filtration may be a pretreatment for ultraviolet (UV) disinfection since turbidity can interfere with UV disinfection. Granular media filtration is classified based on mode of operation, direction of fluid flow, filter media type, and flow control.

Wastewater treatment facilities with strict suspended solids effluent limitations may benefit from granular media filtration for tertiary treatment. Granular media filtration can also be used to treat wastewaters with high levels of particulate BOD in the secondary effluent and for phosphorus removal.

Granular media filtration, particularly activated carbon filtration, can be applied to municipal wastewaters with large industrial components, or strictly industrial wastes. Municipal wastewaters containing high-strength industrial waste may be difficult to treat biologically.

**Process Description** Reactor beds contain single or multiple layers of filter media such as sand, anthracite, or activated carbon. Wastewater is applied to the filter in an upward or downward flow pattern. Filtration removes particles by physical and/or chemical mechanisms. When used for secondary treatment, activated carbon filtration also removes dissolved organic compounds. The length of a filter run is usually determined by the headloss across the filter bed or breakthrough of target pollutants. At the end of the filter run, the filter is backwashed with water, air, or a combination of the two.

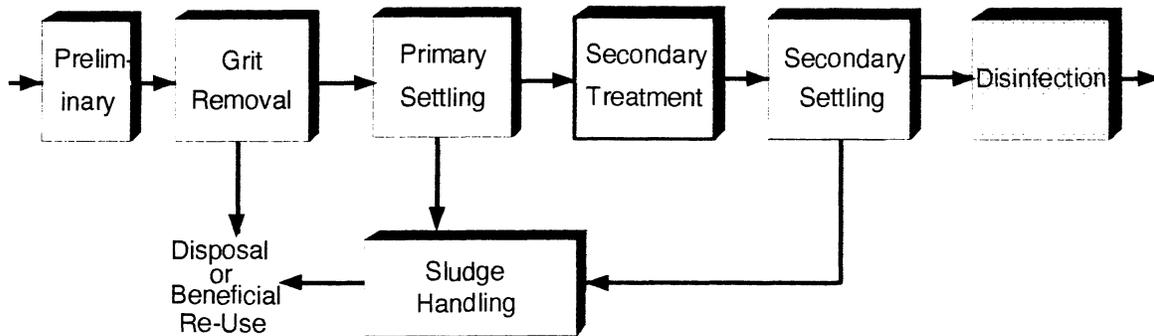
**Energy Consumption** Energy requirements (i.e., kWh/gal treated or kWh/lb of target compound removed) vary depending on operational configuration, pumping requirements (influent feed pumps, backwash pumps), and chemical addition.

# **DISINFECTION**

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## CHLORINATION/DECHLORINATION

### Treatment Schematic



**Use and Applications** Depending upon the classification of the receiving stream, some WWTPs are required to disinfect their effluent prior to discharge. Wastewater disinfection is used in an attempt to destroy pathogenic agents in a waste stream and protect the best use(s) of the receiving stream.

Until recently the addition of chlorine was the most typical disinfection technique used. Many other chemicals are now being used, including: sodium hypochlorite (liquid), bromine (gas), bromine dioxide (gas), and various other chlorine compounds.

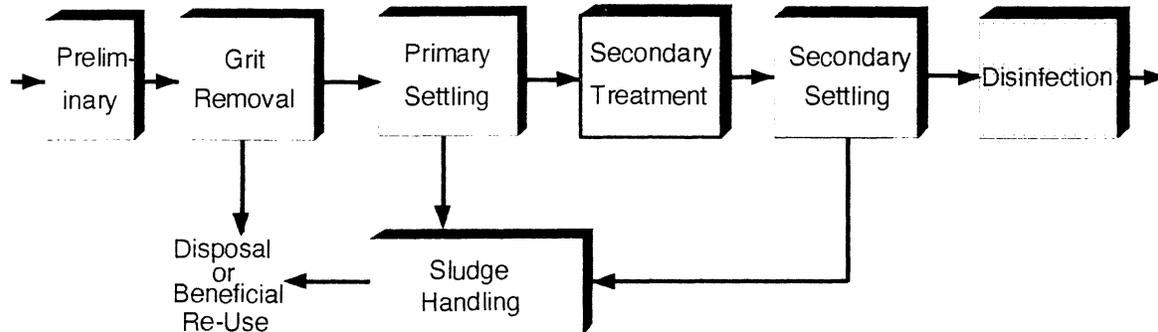
In some locations, dechlorination is now required to meet more stringent water quality criteria for total residual chlorine.

**Process Description** Disinfection with chlorine is accomplished by adding the chemical directly to the effluent. Because of the volumetric differences, the chlorine is typically diluted prior to mixing with the effluent stream.

De-chlorination is accomplished by using a reducing chemical such as sulfur dioxide (gas), sodium bisulfate (liquid), or sodium metabisulfite (liquid).

**Energy Consumption** The energy requirements of chlorination/dechlorination are limited to the horsepower requirements of the metering equipment and mixing at the point of chemical application. The chemical costs are actually the main factor in determining whether or not chlorination/dechlorination is a cost effective measure. The wide spread use of chlorine as a disinfecting agent is largely reflective of its low cost in comparison to other alternatives.

For example a 48 mgd facility, with an average flow of 36 mgd, uses two 0.5-hp metering pumps for the chlorine gas/sulfur dioxide system. The disinfection system uses 2,255 kWh for the four month disinfection period, resulting in an average cost of \$0.01 per MG treated.

**Treatment Schematic**

**Use and Applications** Ozone is both a rapid and effective disinfectant. It is generally believed to be more effective than chlorine. Besides inactivating viruses and killing bacteria, ozone is also reported to be effective in removing taste and odor.

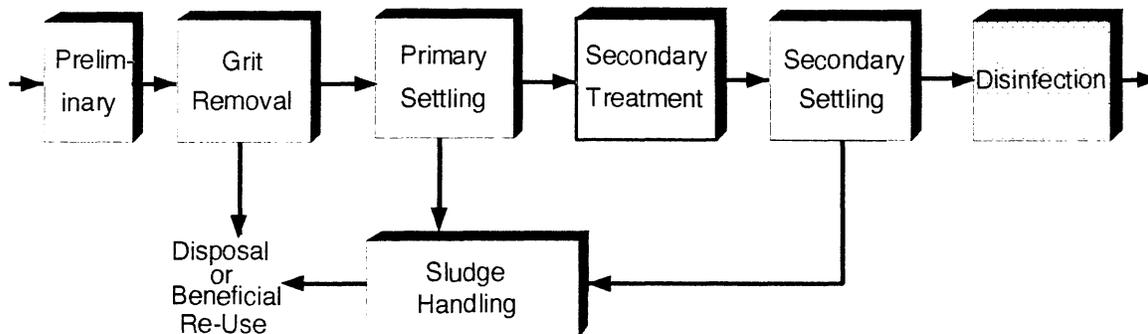
**Process Description** Ozone is toxic and corrosive. Therefore it cannot be stored and must be produced on site. Ozone is produced by passing air or oxygen between oppositely charged plates or through tubes in which a core and the tube walls serve as the oppositely charged surfaces. The air or oxygen is cooled and then passed through desiccants to dry the air or oxygen to minus 40-60 degrees celsius dewpoint.

For ozone to be used as a disinfectant, deep and covered contact chambers are normally installed. The ozone is generally diffused from the bottom of the chambers in fine bubbles that provide mixing of the wastewater as well as achieving maximum ozone transfer. Ozone is a harmful lung irritant. Therefore, unreacted ozone must be vented through a destruction unit (usually thermal destruction).

Ozonation does not produce dissolved solids, which may benefit facilities where water quality concerns limit the TDS level of a plant's discharge. Ozonation may be a viable alternative to either chlorination or hypochlorination, especially when de-chlorination may be required.

**Energy Consumption** Ozone may have an increased application in future wastewater treatment, although the cost of onsite generation remains higher than purchasing chlorine. The electrical requirement for an ozone system is approximately double the requirement of a ultraviolet system, yet total O&M costs are approximately 50% less than a conventional chlorination/de-chlorination system for a 3.5 mgd facility.

Per an equipment manufacturer, a typical dose of ozone ranges from 3 - 5 mg/l. Ozone generation utilizes 5.5 to 7.5 kWh/lb of ozone generated for an air fed system and 2.3 to 3.8 kWh/lb of ozone for an oxygen fed system

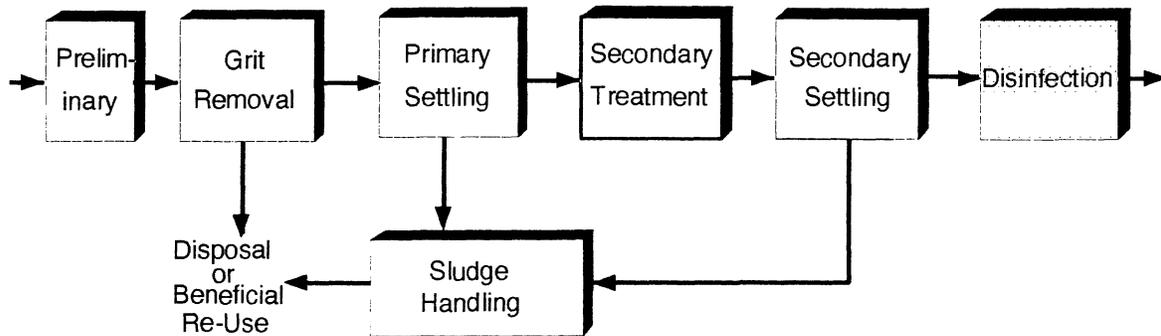
**Treatment Schematic**

**Use and Applications** Bromine chloride is not as powerful a disinfectant as chlorine and is not typically used for wastewater treatment plants. It does, however, appear to be a reliable, flexible, and effective disinfection chemical. It is absorbed into the bacterial cell and disrupts critical enzymatic activity.

**Process Description** In wastewater disinfection applications, bromine chloride is dispensed as a liquefied gas. The bromine chloride supply is artificially pressurized with nitrogen to discharge the liquid at a constant pressure to the feed module. The liquid feeder module adds the liquid bromine chlorine solution to the wastewater.

Bromine chloride residual decreases greatly in the contact tank; therefore, good mixing of the bromine chloride solution with the wastewater is required at the application point.

**Energy Consumption** Additional studies are needed to verify the bromine chloride dosage for a given wastewater effluent quality and to determine the most effective and efficient bromine chloride applications.

**Treatment Schematic**

**Use and Applications** The application of hypochlorite in wastewater treatment achieves the same result as that of chlorine gas. Its use is generally limited to smaller wastewater facilities or where there are significant health and safety concerns regarding the handling and use of chlorine gas.

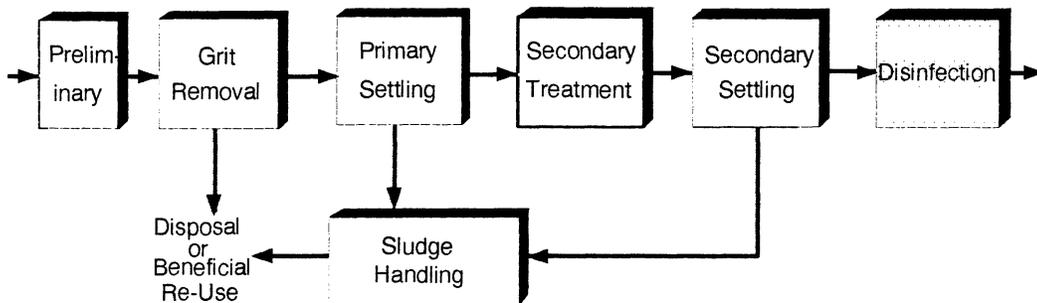
**Process Description** The handling of sodium hypochlorite requires special design considerations because of its corrosiveness and the presence of chlorine fumes. It is strongly alkaline and care is needed in handling. Hypochlorite tanks should be vented, and provision should be made for sampling the contents. Sodium hypochlorite solution can be purchased in bulk lots of 12 to 15% of available chlorine or manufactured on site. The solution decomposes more readily at high concentrations and is affected by exposure to light and heat.

**Energy Consumption** Onsite generation systems for sodium hypochlorite have been used only on a limited basis because of their complexity and high power cost. The purchase price of sodium hypochlorite may range from 150 to 200% of the cost of liquid chlorine.

Sodium hypochlorite is the preferred disinfection alternative for facilities in close proximity to residential housing or where safety concerns are paramount. As a liquid, it is significantly safer to handle and neutralize in the event of a spill or leak.

A sodium hypochlorite feed system for a 0.3 mgd facility, with an average flow of 0.09 mgd, uses one 0.2-hp feed pump which uses 1,303 kWh/year for operation. This results in an average cost of \$3.09 per MG treated.

### Treatment Schematic



**Use and Applications** A proper dosage of ultraviolet (UV) radiation has shown to be an effective bactericide and virucide while not contributing to the formation of toxic compounds. However, certain compounds may be altered by UV radiation. Because the effective distance of UV light is very limited, most UV disinfection occurs when the light penetration depth can be minimized, termed the thin film approach. The term "thin film" refers to the separation distance between the UV tubes.

Color and turbidity in the water can preclude the use of UV radiation. In the past, the practical problems of providing effective exposure of the wastewater effluent to UV rays have precluded its use as a disinfectant method except for selective use as tertiary treatment. With recent regulations concerning disinfection by-products, UV radiation may become more commonly used.

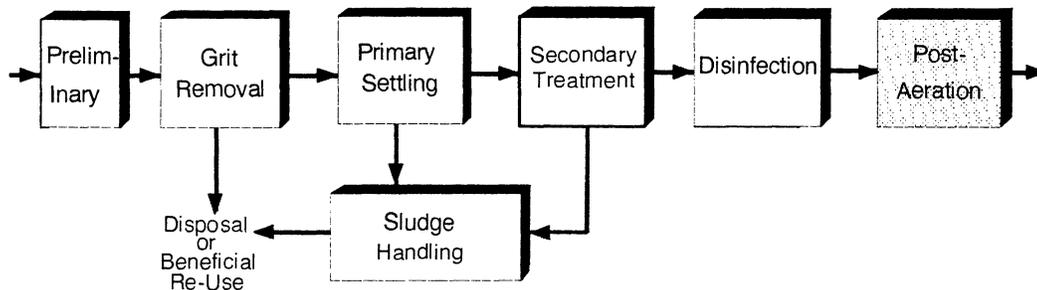
**Process Description** Most ultraviolet units are constructed with an array of ultraviolet lamps installed in a wastewater channel. No contact tank is needed. Space requirements are smaller than conventional chlorine contact tanks.

**Energy Consumption** The use of UV radiation is relatively energy intensive when compared to conventional chlorination systems. This additional energy requirement can be offset by the fact that UV disinfection does not require chemicals or create chlorinated organics, and would preclude the need for a de-chlorination facility.

Overall annual O&M costs for a UV system can be as much as 80% less than a chlorination/de-chlorination system for a 1.0 mgd facility and 55% less for a 10 mgd facility.

For example, a 0.4 mgd facility, with an average flow of 0.169 mgd, that uses a UV system 5 months out of the year, has two 3.2-hp units that utilize 8,820 kWh/5-months. This results in an average cost of \$9.16 per MG treated.

## **POST-AERATION**

**Treatment Schematic**

**Use and Applications** Because of the more stringent water quality standards being adopted by various regulatory agencies, the practice of post-aeration has increased substantially in recent years. The introduction of water quality-based effluent standards and permits that include high dissolved-oxygen levels has made it necessary for many plants to post-aerate the wastewater effluent before discharge.

**Process Description** There are three major types of post-aeration:

Cascade aeration - Cascade aeration uses the available discharge head to create turbulence as the wastewater falls in a thin film over a series of concrete steps.

Mechanical aeration - Most installations of mechanical post-aeration consist of two or more aerators in rectangular basins.

Diffused-air aeration - In this type of treatment device, coarse bubble or fine bubble diffusers may be used. A higher oxygen transfer efficiency is gained by using fine bubble diffusers rather than coarse bubble diffusers.

**Energy Consumption** Site constraints and options should be evaluated when choosing the most beneficial method. If a site permits gravity flow, the most cost-efficient method is cascade aeration. However, in large treatment plants diffused-air aeration systems may be more appropriate, especially where diurnal flow variations may dictate varying amounts of oxygen. Mechanical aeration using low-speed surface aerators are usually the most economical method except where high oxygen-transfer rates are required.

Some examples of energy consumption include:

A 0.4 mgd facility, with an average flow of 0.169 mgd, with a 7.0 mg/l DO requirement has a fine bubble system that uses 31,319 kWh/year, this results in an average cost of \$32.52 per MG treated. While a 48 mgd facility, with an average flow of 36 mgd, uses a coarse bubble system four months out of the year, this system requires 112,750 kWh for the four months resulting in a cost of \$0.54 per MG treated.

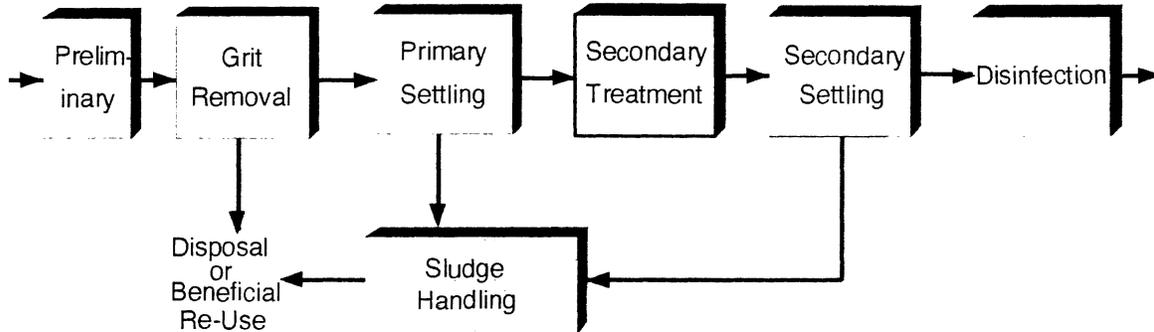
# **SLUDGE MANAGEMENT**

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## SLUDGE PUMPING - OVERVIEW

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### Treatment Schematic

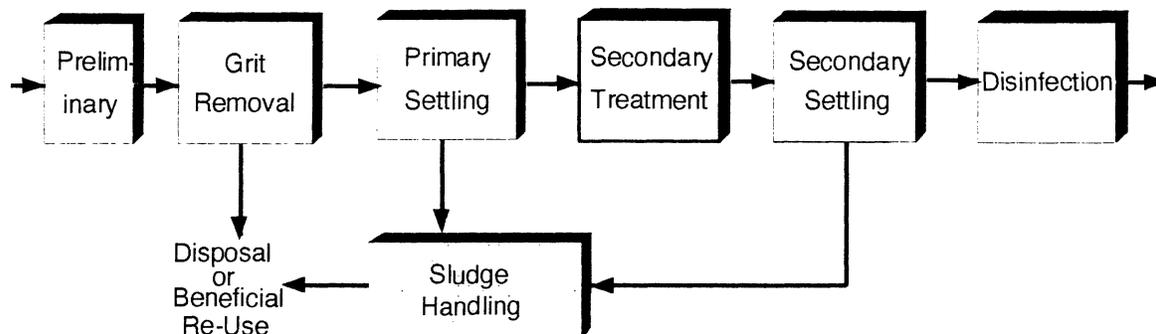


**Use and Applications** Sludge pumping is a vital part of plant operations. Typically, pumps are used to convey sludge (semi-liquid 4 to 8 % solids concentration to semi-solids 10 to 40% solids concentration) from one location to another location. Types of sludge that are pumped include primary, chemical, trickling-filter, activated, thickened, and digested sludges. Scum that accumulates at various points in a treatment plant is also often pumped.

**Process Description** Sludge pumps are used to transfer sludge from the primary and secondary treatment system to the sludge handling facilities. The pumping process subjects sludge to shear forces; the level of shear is determined by pump type and flow rate. Because of the fragile structure of sludge particles, some reduction in particle size will normally result from passing sludge through a pump. Pumps used most frequently for sludge include the plunger, progressive cavity, centrifugal, torque-flow, diaphragm, high-pressure piston, and rotary-lube types. Other types such as peristaltic pumps and concrete slurry pumps have also been used to pump sludge. Diaphragm and centrifugal pumps are used extensively for pumping scum.

**Energy Consumption** Sludge pumping can consume a large part of the overall amount of electricity used at a wastewater treatment plant. Therefore, the most economical energy efficient pumping system available should be installed. Pumps can vary in efficiency because of the design characteristics established by the manufacturer or to its position in the pumping sequence. The energy efficiency of pump motors varies with the load on the motor. Also, the quality of maintenance a pump receives has a major effect on its energy consumption.

### Treatment Plant Location



### Use and Applications

Sludge pumping systems play an important part in plant operations. Pumps are used to convey sludge or scum from one location to another. Because of the fragile structure of sludge particles, some reduction in particle size will result from passage of sludge through a pump.

### Description

There are a variety of different pumps. The plunger, progressive cavity, centrifugal, torque flow, diaphragm, high-pressure piston, and rotary-lube types are most commonly used in pumping sludge. Other types used for pumping sludge include peristaltic pumps and concrete slurry pumps. The types of pumps used for pumping scum include the centrifugal and diaphragm.

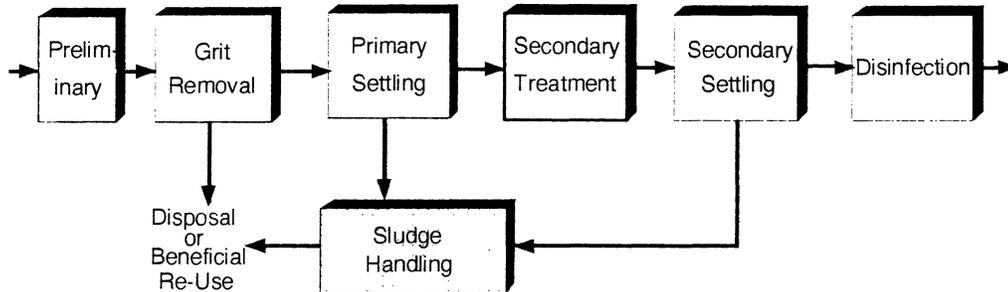
### Potential Energy Savings

Pump efficiency can be effectively monitored by periodically measuring the amperage drawn by each pump motor under normal flow and discharge pressure. The cost of the test equipment needed to perform these measurements is relatively small.

If a pump is to be operated at a reduced capacity for a considerable period of time, several alternative methods of energy conservation are available:

- Install a smaller impeller. This method reduces flow, as does throttling, but reduces power consumption to a greater extent than throttling .
- Partially close a pump discharge valve, which can create an artificial head resulting in lower flow and power usage. Such adjustments on centrifugal pumps can be made to compensate for low influent periods
- Install variable speed controls to improve energy efficiency, as well as smaller pumps better suited to the pumping application.
- Operate the more efficient pumps more frequently by reserving the less efficient units for standby use.

### Treatment Schematic



**Use and Applications** Sludge thickening is employed prior to subsequent dewatering processes to increase the efficiency of the dewatering equipment. Sludge may be thickened using primary clarifiers, sludge digesters, or specially designed thickening units.

**Process Description** There are a variety of separate thickening alternatives, including:

Gravity thickening - Tank design is similar to a conventional sedimentation tank. Dilute sludge is fed to a center-feed well. The feed sludge is allowed to settle and compact, and the thickened sludge is withdrawn.

Flotation thickening - There are many variations of the flotation thickening process but the most widely used is the dissolved-air flotation (DAF). In this process, air is introduced into liquid sludge that is being held at an elevated pressure. When the sludge is depressurized, the dissolved air is released as finely divided bubbles carrying the solids to the top, where they are removed.

Centrifuge thickening - Water is forced out of the sludge placed in a spinning drum.

Gravity belt thickening - Sludge is conditioned with a polymer and fed into a feed/distribution box. The sludge distributes evenly on the moving belt as water drains through and the sludge is discharged.

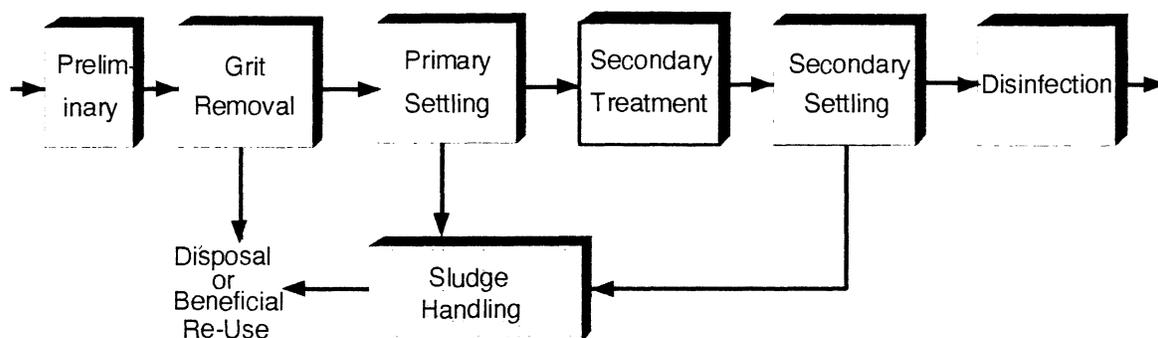
Rotary drum thickening - Polymer is mixed with dilute sludge, and the conditioned sludge is then passed through rotating screen drums, which separate the flocculated solids from water. Thickened sludge rolls out the end of the drums, while separated water decants through the screens.

**Energy Consumption** Centrifuge thickening is usually the most energy intensive option. DAF also requires a significant amount of energy for air pressurization. Gravity and gravity belt thickening are less energy intensive. The specific process selected depends on site-specific needs, including the type of sludge to be thickened.

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## AEROBIC SLUDGE DIGESTION

### Treatment Schematic



**Use and Applications** Aerobic sludge digestion is typically used in small to medium WWTPs (usually 5 mgd or less) to stabilize excess activated sludge. The major objectives of aerobic digestion are reducing odors, reducing biodegradable solids, and improving sludge dewaterability. Aerobically digested sludge is usually dewatered on a sludge drying bed or applied in liquid form to farmland.

**Process Description** Aerobic digestion, similar to the activated sludge process, is the biological destruction of degradable organic matter in the presence of molecular oxygen. Biodegradable matter is oxidized to carbon dioxide and water. Oxygen must be supplied in direct proportion to the mass of volatile solids (VS) destroyed.

Stabilization is not complete until there has been an extended period of primarily endogenous respiration (15 to 20 days).

**Energy Consumption** Aerobic digestion requires a significant amount of energy to operate the blower and mixing systems. Both mixing and minimum oxygen requirements must be met to achieve acceptable results. For example, a 0.64 mgd facility, with an average flow of 0.75 mgd, uses 197,062 kWh/year for the aerobic sludge digestion system. This results in an average cost of \$12.92 per MG treated (municipal utility authority).

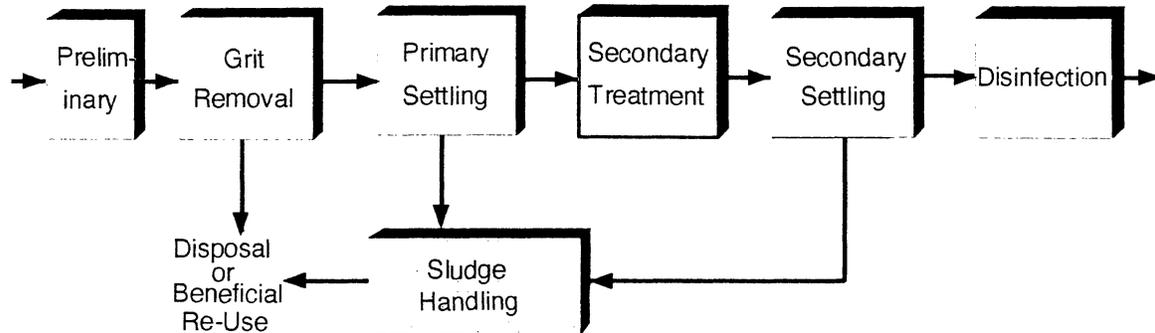
The energy efficiency of digesters can be improved by incorporating the following:

- Pre-thickening of the feed sludge
- Complete mixing of the digester
- Adequate control of operating variables.

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## ANAEROBIC SLUDGE DIGESTION

### Treatment Schematic



**Use and Applications** Anaerobic sludge digestion is a stabilization procedure used in medium to large WWTPs (greater than 5 mgd) or when sludge is reused or landfilled. The anaerobic digestion process reduces volatile solids and thereby reduces the overall mass of the sludge, lowering disposal costs. The anaerobic digestion process produces an energy form (biogas) that can be harnessed and used for various heating applications.

**Process Description** Anaerobic digestion - the biological destruction of degradable organic matter in the absence of molecular oxygen - is a three-stage process consisting of:

- Hydrolysis - breakdown of particulate matter and large macromolecules
- Acid formation - fermentation of the soluble organic matter formed in the first reaction to volatile acids
- Methanogenesis - conversion of the volatile acids to the stable end products: methane, carbon dioxide, and water.

Four anaerobic digestion operational modes are available:

- Standard rate digestion - one stage (unheated and unmixed)
- High rate digestion - one stage (heated and mixed)
- Two-stage digestion
- Anaerobic contact process.

Anaerobic digestion can occur in two temperature ranges: mesophilic (80 -110 F) and thermophilic (113 -149 F). Most digesters operate in the mesophilic range because of process stability, although operation in the thermophilic range typically offers improved dewatering.

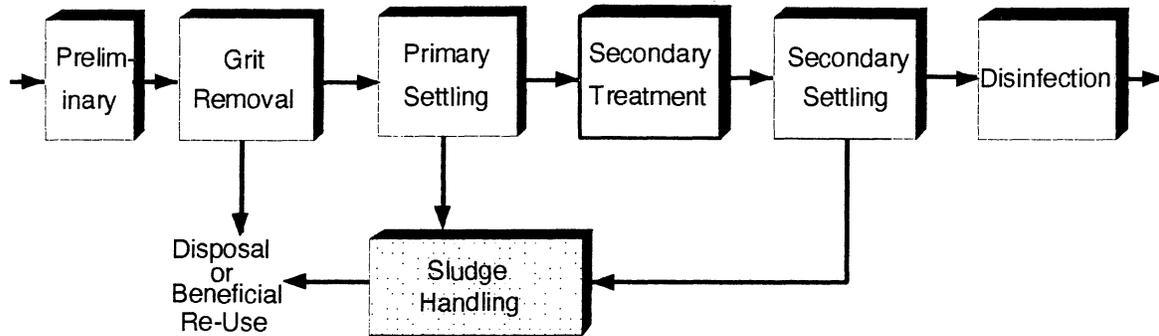
**Energy Consumption** The energy requirements of anaerobic digestion are significantly less than aerobic digestion since anaerobic digestion is usually a net generation of energy when biogas is taken into consideration. Energy is required for heating and mixing the sludge. For example, a 9.0 mgd facility, with an average flow of 10.7 mgd, requires 86,268 kWh/year to operate the anaerobic digesters, this results in a cost of \$1.45 per MG treated. This energy requirement can often be offset if biogas from the digester is recovered and used.

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## SLUDGE DEWATERING - OVERVIEW

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### Treatment Schematic



**Use and Applications** Sludge dewatering is required for all facilities that do not dispose of their sludge in liquid form. Dewatering is a physical (mechanical) process to reduce the moisture content of sludge. The purpose is to reduce disposal costs. A sludge with a high moisture content is more expensive to dispose of. Dewatering is usually required prior to incineration.

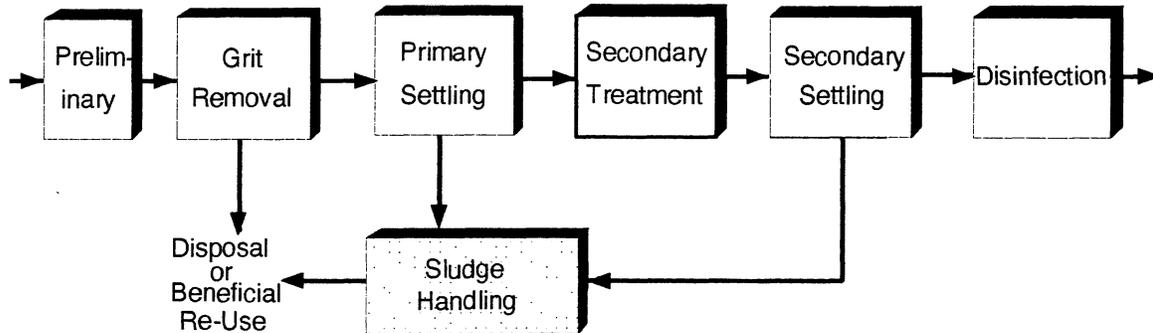
**Process Description** There are a variety of dewatering techniques available. These techniques include:

- Vacuum filtration
- Centrifuge
- Belt filter press
- Plate and frame press
- Drying beds
- Lagoons.

The decision to use one type of dewatering over another depends upon a variety of factors: plant size and location, electrical costs, chemical costs, residual disposal costs, and plant personnel experience. Sludge drying beds are simple to operate and are typical for plants smaller than 2 mgd. Vacuum filtration is not commonly used.

**Energy Consumption** The energy requirements for the different dewatering techniques vary greatly. Sludge drying beds are the least energy intensive, typically only a sludge pumping system is required. Vacuum filters can require as much as 50 hp to dewater sludge from a 2.5 mgd facility.

Additional energy consumption information will be provided in separate dewatering technique sections.

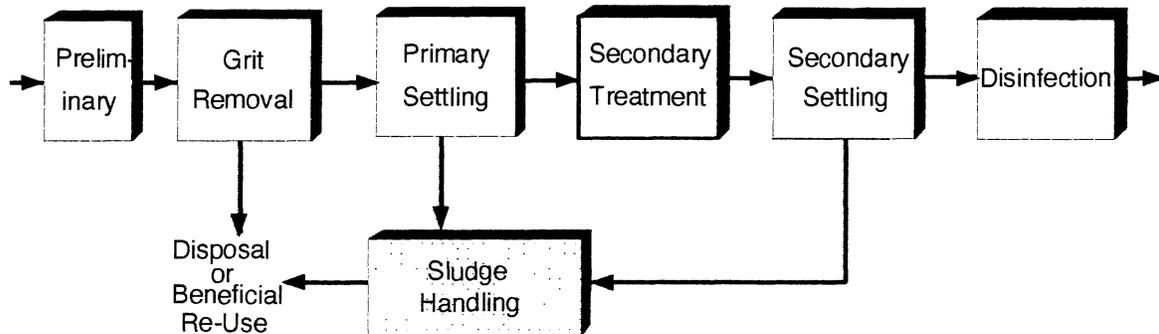
**Treatment Schematic**

**Use and Applications** Belt filter presses are continuous-feed sludge-dewatering devices that use chemical conditioning, gravity drainage, and mechanically applied pressure to dewatered sludge. The belt filter press has become one of the chief sludge-dewatering devices and is a practical dewatering method for many types of municipal wastewater sludges.

**Process Description** Conditioned sludge is first placed on a gravity drainage section where it is allowed to thicken. In this section, the bulk of the free water is removed from the sludge by gravity. On some units, this section is equipped with a vacuum assist, which enhances drainage and may help to reduce odors. Following gravity drainage, pressure is applied in a low-pressure section, where sludge is squeezed between opposing porous cloth belts. On some units, the low-pressure section is followed by a high-pressure section, where the sludge is subjected to shearing forces that induce the release of additional quantities of water from the sludge. The final dewatered sludge cake is removed from the belts by scrapper blades.

**Energy Consumption** The belt press has low energy requirements and most installations do not require either a vacuum or pressure pump. However, since these units generally require large quantities of high-pressure water for belt cleaning, this cost must also be factored in.

A belt filter press dewatering system for a 21 mgd facility, operating at an average flow of 8.2 mgd, requires about 20 hp to operate the polymer transfer pump, sludge feed pump, belt drive, and sludge collector system. This system uses 46,241 kWh/year for an average cost of \$1.04 per MG treated.

**Treatment Schematic****Use and Applications**

Centrifuges are used for separating liquids of different density, thickening slurries, or removing solids.

**Process Description**

There are two main types of centrifuges: the solids bowl and the basket centrifuge.

In the solids bowl centrifuge, sludge is fed at a constant flowrate into the rotating bowl where it is separated into a dense cake and a dilute stream called "centrate". The units can be used with no prior chemical conditioning, but solids capture and centrate quality are improved considerably when the sludge is conditioned with polymer.

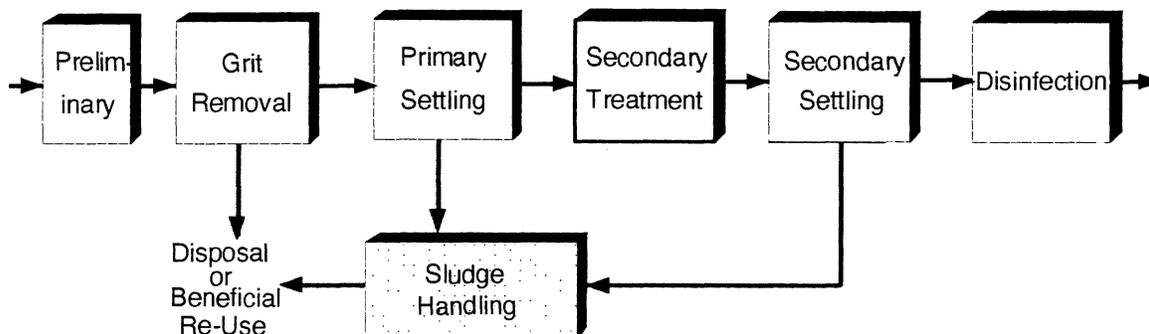
Basket centrifuges are particularly suitable for small plants. It is a semi-batch type operation. Sludge cake is collected on the sides of the spinning bowl while the centrate overflows the bowl rim. Once solids have built up to a maximum thickness, the feed sludge is stopped and scrapper blades peel the sludge from the walls. The process is then resumed.

**Energy Consumption**

The centrifuge has a significant energy requirement, especially when compared to sludge drying beds or a belt filter press. The centrifuge can often achieve a higher solids content, so the savings from reduced residual disposal costs may offset the additional energy requirement.

Based upon information from a centrifuge manufacturer, a centrifuge capable of handling 100 gpm requires a 40-hp main drive and a 5-hp backdrive. A 0.2 mgd facility would need to operate this system an average of six hours per day, five days a week, which would require 52,350 kWh/year. At an average cost of \$0.08/kWh, the system has a total energy cost of \$57.37 per MG treated.

### Treatment Schematic



### Use and Applications

Infrared sludge dryers have proven capable of drying dewatered sludge from a solids content of as little as 13% to a final solids content of 90%. The drying is done without adding polymers, lime, or bulking material. The infrared radiation is absorbed by the sludge and heat is generated; this, in turn, drives off the moisture.

### Process Description

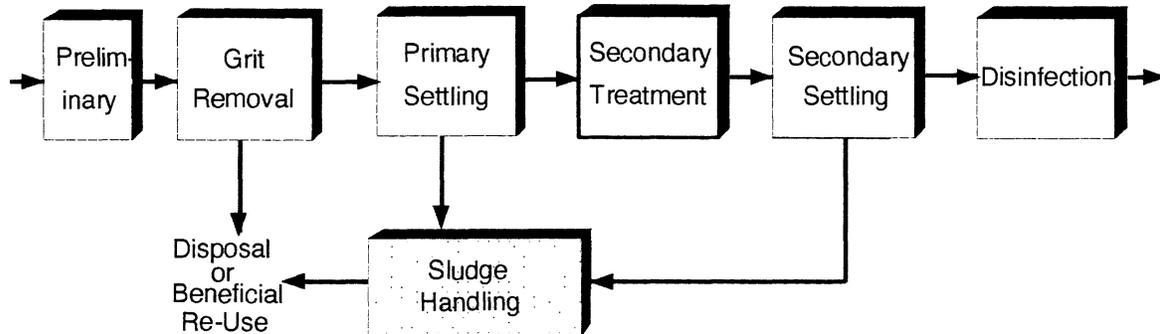
Dewatered sludge is transferred from the dewatering equipment to the dryer by a conveyor belt. The sludge then drops into the augers, where the auger blades agitate the sludge while infrared heating elements heat the sludge. This process then repeats once the sludge is dropped into the secondary drying zone.

A beneficial side effect of infrared drying is a reduction of pathogens since pathogens contained in the sludge are killed by the infrared radiation.

### Potential Benefits

An infrared sludge dryer is a direct dryer using radiant energy, which is the most efficient heat transfer method and results in a highly effective water removal process. Because the dryer uses radiant energy, the air flow rate is much lower and the size and capital cost of the air emission system is lower. The sludge dryer is easily adapted for automated operation using computer controls to minimize operator attention.

Installing an infrared sludge dryer will actually increase overall electricity use at the plant. However, this additional cost typically is offset by reduced disposal costs. Residual disposal savings will vary based upon sludge production and the unit cost for disposal, although typical disposal savings are approximately 70%.

**Treatment Schematic**

**Use and Applications** Composting is a process that biologically degrades organic material to a stable end product. It is desirable to have a high quality sludge with a minimal industrial component in order to meet regulatory requirements for product use. Sludge that has been composted properly is a sanitary, nuisance-free, humus-like material. The end-product can be used as a soil additive (parks, etc.) or landfill cover component.

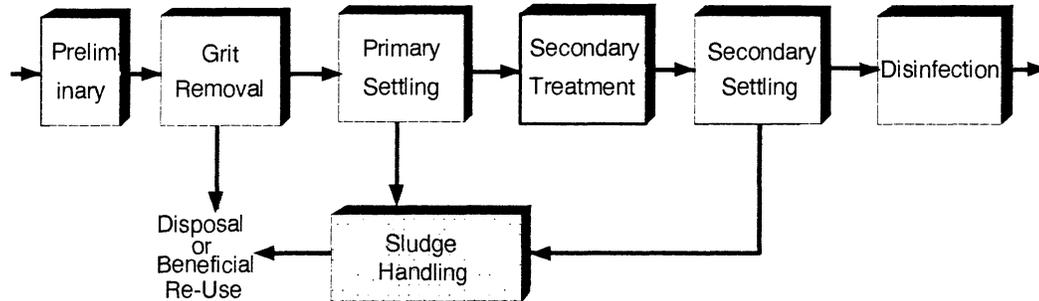
**Process Description** Composting is an aerobic biological process designed to reduce organic concentrations, reclaim nutrients, and eliminate pathogenic organisms in the sludge. There are three major types of composting systems: the aerated static pile; the windrow; and the in-vessel composting system.

Aerated static pile - The aerated stack pile consists of a grid of aeration or exhaust piping underlying a mixture of dewatered sludge and bulking agent. Material is composted for 21 to 28 days and then cured for another 30 days or longer.

Windrow - This composting system is similar to the aerated static pile. Piles are periodically turned for aeration and temperature control. The major drawback to this system is that turning the windrows is often accompanied by the release of offensive odors.

In-vessel composting systems - In this device, composting is accomplished inside an enclosed container or vessel. Mechanical systems are designed to minimize odors and process time by controlling environmental conditions such as air flow, temperature, and oxygen concentration. There are two types of in-vessel composting systems: the plug flow system and the dynamic system.

**Energy Consumption** Composting is a cost-effective and environmentally sound alternative for the stabilization and ultimate disposal of wastewater sludge.

**Treatment Schematic**

**Use and Applications** Incineration is dry combustion of sludge to produce an inert ash. This ash can then be beneficially used or disposed of in a sanitary landfill. Incineration is typically employed at larger (i.e., greater than 10 mgd) wastewater treatment facilities .

**Process Description** The incineration process must: dry the sludge cake; destroy the volatile content by burning; and produce a sterile ash. A variety of incinerator configurations exist. The most common include:

Multiple hearth furnace - Sludge passes downward through a series of hearths. Dewatered sludge is fed to the top hearth. In the upper hearths, the water content is vaporized and the sludge solids are dried. In the middle hearths, the sludge solids are ignited and burned. In the lower hearths, the slow-burning material is burned, and the ash undergoes cooling.

Fluidized bed - In the fluidized bed system, sludge is fed into a bed of hot sand fluidized by circulating air. There is rapid drying and combustion of the sludge. Ash is carried out of the incinerator by the combustion gases and is separated by a wet scrubber system.

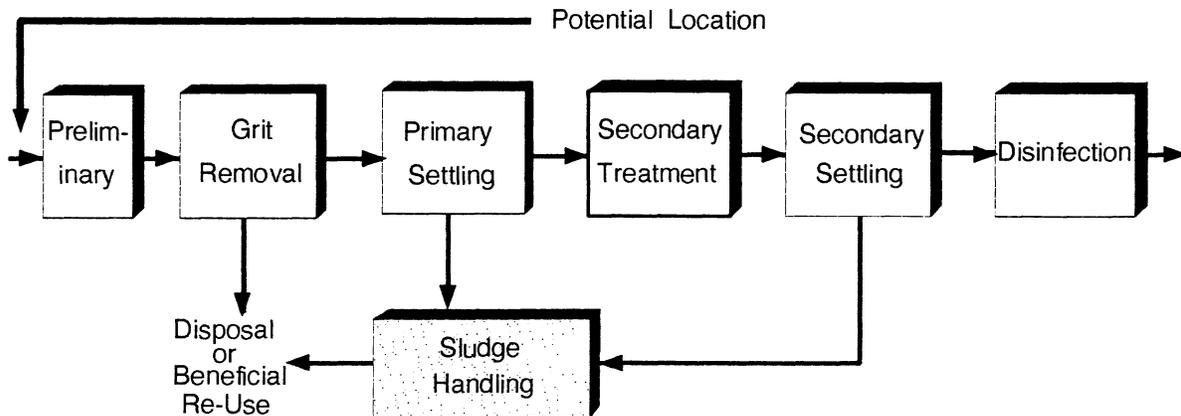
**Energy Consumption** The fuel requirements for the process depend on the fuel value of the sludge solids and the water content. If the incinerator is able to run autogenously (i.e., self-fueling) then an auxiliary fuel such as natural or digester gas or oil is required only during startup. While incineration offers the opportunity to reduce sludge volume, improper design and operation can cause a significant contribution to air pollution.

Some examples of energy consumption include:

A 30 mgd facility, operating at an average flow of 25.2 mgd, that utilizes a multiple hearth furnace uses 2,074,537 kWh/year for operation, this results in an average cost of \$19.24 per MG treated. While a 48 mgd facility, with an average flow of 36 mgd, with a fluidized bed incinerator uses 1,822,561 kWh/year for an average cost of \$8.80 per MG treated.

## **MISCELLANEOUS**

### Treatment Plant Location



### Use and Applications

Waste heat recovery can be employed in a variety of locations depending upon the facility. It can be used when a high temperature waste stream is available or to improve the thermal economy of a solids disposal system (incineration) and eliminate or reduce the requirement for supplemental fuel. Heat can be recovered from a high temperature water stream via heat pump or from the exit gases of a sludge incinerator by a waste heat recovery boiler or an air pre-heater.

### Description

A heat pump can harness heat from a wastewater stream via a water-to-air heat exchanger. This heat can be used for building heat or to heat other wastewater processes.

A recuperator is an air-to-air heat exchanger installed on an incinerator to recover energy (heat) from the exhaust gasses and pre-heat the incoming combustion air. The use of a recuperator can significantly reduce fuel costs of an incinerator.

A waste heat recovery boiler is used to capture heat from incineration systems. This is done by establishing a closed energy loop for the sludge handling system. The exiting gasses from the incinerator are passed through the waste heat boiler prior to the scrubbing system. The excess heat is converted to steam and can be used to pre-heat sludge, provide building heat, etc..

### Potential Energy Savings

The effectiveness of a waste heat pump depends upon the temperature and flow rate of the influent stream. Energy savings will depend upon the consistency of the temperature of the stream, but typically a building heating system can realize a savings of 50% or more. A waste heat pump is only effective when the waste stream has a consistently high temperature and a use for the heat exists on a continuous basis.

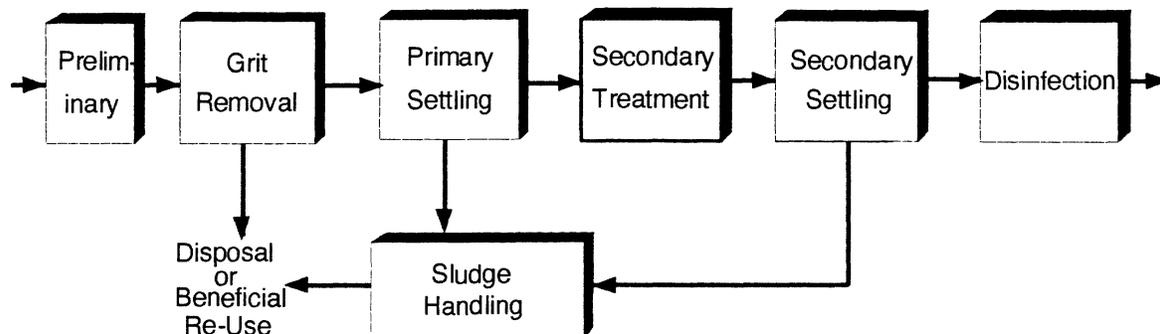
The use of a waste heat boiler or recuperator system can reduce the cost of incineration by 10 to 30%.

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## ELECTRIC DEMAND CONTROLLER

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### Treatment Plant Location



### Use and Applications

An electric demand controller can be installed at a facility that has large pieces of treatment equipment that are not continuously operated. The controller does not permit the cycling equipment to operate at the same time such that a large peak in demand would occur.

### Description

An electric demand controller can be installed in conjunction with a programmable logic controller (PLC) to automatically control the demand limit through load shedding.

When the electric demand at a facility reaches a pre-determined value the demand controller sends a signal to the PLC or computer indicating that load shedding should occur. Specific motors that are not crucial to plant operations can be automatically or manually shut off until the plant demand is lowered.

### Potential Energy Savings

Potential energy savings are site specific and will depend upon the size (horsepower) of non-critical equipment. Savings can be in the 5 - 10% range.

The following case studies summarize the results of the WWTP energy evaluations that were conducted as part of the overall Energy Authority program. The individual facility reports were quite detailed and these summaries summarize only the major points of the audit. Each summary presents:

- Facility information - project location, size, and type of treatment system
- Current treatment scheme - for both the wet stream and solids stream
- Proposed modifications - listing of proposed construction projects (if any)
- Energy consumption - estimated electrical usage (kWh) and cost per million gallons treated is presented for both the existing and proposed systems
- Energy conservation measures (ECMs) - already in place
- Energy conservation measures - proposed by the facility's engineer
- Energy conservation measures - evaluated by Malcolm Pirnie.

**Facility Information**

Location: Allegany County, New York  
 NYS Dept. of Environmental Conservation Region: 9  
 Population Code: B (3,501 - 2,000,000)  
 Population Served: 2,000 (summer), 10,000 (school year)  
 Facility Type: Trickling Filter/Solids Contact  
 Current Design Flow: 0.98 mgd

**Current Treatment Scheme**

Wet Stream	Solids Stream
Comminutor Aerated Grit Primary Clarification Trickling Filter Solids Contact Tank Final Clarification Sand Filtration Disinfection - Cl <sub>2</sub> Gas (Not Used)	Shredder Anaerobic Digester Sludge Drying Beds

**Proposed Modifications**

Increase treatment capacity to 1.2 mgd  
 Add second comminutor  
 Add bio-filter (ammonia removal)  
 Add two additional final clarifiers  
 Add de-chlorination system  
 Miscellaneous repairs to trickling filters, final clarifiers, and sand filters

**Energy Consumption**

Current treatment system uses an estimated 793,000 kWh/year.  
 Proposed treatment system will use an estimated 859,000 kWh/year.  
 Cost per MG (existing system): \$321.92 (based on 170 MG/year)  
 Cost per MG (proposed system): \$254.05 (based on 230 MG/year)

**ECMs Currently in Place**

None

**ECMs Proposed (Engineer)**

Unknown - specific equipment plans were incomplete.

**ECMs Evaluated  
 (Malcolm Pirnie)**

Variable frequency drives for:

- Trickling filter effluent screw pumps (recommended)
- Mixed liquor effluent pumps (recommended)
- Blowers (recommended)
- Sand filter backwash pumps (recommended)

Alternate ammonia removal - retrofit trickling filter with plastic media to negate need for bio-filter (evaluate further)  
 Alternate disinfection (evaluate further)

**Facility Information**

Location: Cayuga County, New York  
 NYS Dept. of Environmental Conservation Region: 7  
 Population Code: B (3,501 - 2,000,000)  
 Population Served: 37,488  
 Facility Type: Trickling Filter  
 Current Design Flow: 21 mgd

**Current Treatment Scheme**

Wet Stream	Solids Stream
Comminutor Aerated Grit Primary Clarification Trickling Filter Secondary clarification Disinfection	Sludge Thickener Belt Filter Press Incinerator

**Proposed Modifications**

Expand plant to handle peak hourly flow of 50.5 mgd  
 Add a mechanically cleaned trash rack  
 Add two mechanically cleaned bar screens  
 Add a manually cleaned bar screen  
 Add two aerated grit chambers  
 Construct three primary settling tanks  
 Use existing primary tanks as an overflow retention facility (ORF)  
 Add a rotating channel-mounted septage screen  
 Add a chemical oxidation and packed tower scrubber odor control unit  
 Rehabilitate trickling filters  
 Add a second-stage activated sludge system (with fine bubble diffusers)  
 Add two new 110-foot diameter final settling tanks  
 Use UV disinfection  
 Add a new 30-foot diameter gravity thickener  
 Make improvements on the incineration and ash system

**Energy Consumption**

Current treatment system uses an estimated 1,416,000 kWh/year.  
 Proposed treatment system will use an estimated 7,404,000 kWh/year.  
 Cost per MG (existing system): \$31.94 (based on 2,970 MG/year)  
 Cost per MG (proposed system): \$107.51 (based on 3,650 MG/year)

**ECMs Currently in Place**

Trickling filters

**ECMs Proposed (Engineer)**

Variable frequency drives for pumps and blowers  
 Overflow retention facility (for flow equalization)  
 Fine bubble diffuser system for activated sludge

## **CITY of AUBURN**

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### **ECMs Evaluated (Malcolm Pirnie)**

Use vortex-type grit chamber (evaluate further)  
Alternate second-stage biological treatment (not recommended)  
Cycling the incinerator (not recommended)  
Use a landfill or land application of sludge (not recommended)  
Accept dewatered sludge for incineration (recommended)  
Use an alternate fuel for the incinerator (evaluate further)  
Use a heat recuperator for the incinerator (evaluate further)  
Use a waste heat boiler (evaluate further)

**Facility Information**      Location: Steuben County, New York  
 NYS Dept. of Environmental Conservation Region: 8  
 Population Code: B (3,501 - 2,000,000)  
 Population Served: 11,300  
 Facility Type: Activated Sludge (Contact Stabilization)  
 Current Design Flow: 1.0 mgd  
 Municipal Utility Authority (MUA) Status

**Current Treatment Scheme**

Wet Stream	Solids Stream
Comminutor Grit Removal (Vortex) Primary Clarification Contact Stabilization Secondary Clarification Chlorine Contact Tank	Sludge Thickening

**Proposed Modifications**      Add a by-pass channel with an additional grinder  
 Replace primary effluent pumps with high-efficiency motors and variable speed controls  
 Add specialized nitrifying bacteria seed to the contact stabilization process  
 Construct a third contact stabilization unit with fine bubble aeration  
 Modify existing chlorine tank to allow for by-pass of one contact stabilization unit  
 Add new aerobic digester  
 Replace existing pumps with new positive displacement plunger pumps

**Energy Consumption**      Current treatment system uses an estimated 928,000 kWh/year.  
 Proposed treatment system will use an estimated 1,696,000 kWh/year.  
 Cost per MG (existing system): \$37.42 (based on 16 MG/year)  
 Cost per MG (proposed system): \$60.76 (based on 18 MG/year)

**ECMs Currently in Place**      None

**ECMs Proposed (Engineer)**      Primary effluent pumps will have adjustable speed drives and high-efficiency motors  
 The new contact stabilization unit will have fine pore diffusers and the existing units will be converted to fine pore diffusers

**ECMs Evaluated (Malcolm Pirnie)**      DO control system (recommended)  
 Replace existing centrifugal blowers with more energy efficient rotary blowers (recommended in future)

**Facility Information**

Location: Oneida County, New York  
 NYS Dept. of Environmental Conservation Region: 6  
 Population Code: A (less than 3,500)  
 Population Served: 2,220  
 Facility Type: Activated Sludge  
 Current Design Flow: 0.64 mgd  
 Municipal Utility Authority (MUA) Status

**Current Treatment Scheme**

Wet Stream	Solids Stream
Bar Screen Aerated Grit Bar Screen Aeration (Contact) Clarifier	Sludge Reaeration Aerobic Digester Sludge Drying Bed and/or Lagoon

**Proposed Modifications**

Replace pipe sections to reduce I&I contributors.  
 Upgrade the aerated grit removal system  
 Replace secondary clarifiers with two 42-foot diameter clarifiers  
 Install a chemical feed system  
 Replace coarse bubble diffusers with fine bubble diffusers  
 Add a new variable frequency drive to the existing blower  
 Install sludge dewatering equipment (Alar Auto-Vac Filter)

**Energy Consumption**

Current treatment system uses an estimated 609,000 kWh/year.  
 Proposed treatment system will use an estimated 522,000 kWh/year.  
 Cost per MG (existing system): \$39.91 (based on 270 MG/year)  
 Cost per MG (proposed system): \$27.59 (based on 335 MG/year)

**ECMs Currently in Place**

Sludge drying beds

**ECMs Proposed (Engineer)**

Fine bubble diffusers for contact and re-aeration sections  
 Variable frequency drives

**ECMs Evaluated  
 (Malcolm Pirnie)**

Dissolved oxygen control (recommended)  
 Install a smaller blower (recommended)  
 Evaluate alternate heating sources (evaluate further)  
 Aerobic digestion system not expanded (recommended)  
 Vortex grit removal (not recommended)  
 Overflow Retention Facility (evaluate further)  
 Anaerobic sludge digestion (not recommended)  
 Alternate sludge handling (evaluate further)

**Facility Information**

Location: Montgomery County, New York  
 NYS Dept. of Environmental Conservation Region: 4  
 Population Code: A (less than 3,500)  
 Population Served: 2,278  
 Facility Type: Activated Sludge (Oxidation Ditch)  
 Current Design Flow: 2.85 mgd

**Current Treatment Scheme**

Wet Stream	Solids Stream
Pump Station (Industrial)	Sludge Holding Tank
Vibrating Screen (Industrial)	Macerators
Detritor (Industrial)	Sludge Oxidizing Units
Equalization Tanks (Industrial)	Decant Tanks
Manual Screen Bar	Sludge Holding Tank
Comminutor	Mixing Tank
Primary Settling	Belt Filter Press (BFP)
Oxidation Ditch	
Final Settling	
Chlorination	

**Proposed Modifications**

Modify equalization tank piping to provide two distinct process trains  
 Add fine bubble membrane diffusers and blower  
 Replace BFP with two new BFPs  
 Add two positive displacement pumps with variable speed drives

**Energy Consumption**

Current treatment system uses an estimated 3,184,000 kWh/year.  
 Proposed treatment system will use an estimated 3,707,000 kWh/year.  
 Cost per MG (existing system): \$568.04 (based on 370 MG/year)  
 Cost per MG (proposed system): \$661.38 (based on 370 MG/year)

**ECMs Currently in Place**

Industrial waste stream has flow equalization

**ECMs Proposed (Engineer)**

Fine bubble diffusers

**ECMs Evaluated (Malcolm Pirnie)**

Install a fine bubble diffusion system for both aeration tanks or install a dissolved oxygen control system with current system (recommended)  
 Add variable frequency drives - three locations (recommended)  
 Rewire the Beech-Nut Pump Station to the WWTP to take advantage of the reduced usage rate (evaluate further)  
 Anaerobic digestion (not recommended)  
 Anaerobic pretreatment (evaluate further)  
 Waste heat recovery from industrial influent (not recommended)

## SOUTH and CENTER CHAUTAUQUA LAKE SEWER DISTRICTS

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**Facility Information**

Location: Chautauqua County, New York  
 NYS Dept. of Environmental Conservation Region: 9  
 Population Code: B (3,501 - 2,000,000)  
 Population Served: 30,000  
 Facility Type: Activated Sludge  
 Current Design Flow: 4.1 mgd  
 Municipal Utility Authority (MUA) Status

**Current Treatment Scheme**

Wet Stream	Solids Stream
Comminutor Aerated Grit Primary Settling Tanks Aeration Tanks Secondary Settling Tanks Nitrification Settling Tank Reaeration Tanks Disinfection	Vacuum Filters

**Proposed Modifications**

No specific plans have been established to modify the existing sludge handling system.

**Energy Consumption**

Current treatment system uses an estimated 2,003,000 kWh/year.  
 Cost per MG (existing system): \$67.48 (based on 920 MG/year)

**ECMs Currently in Place**

None

**ECMs Proposed (Engineer)**

None

**ECMs Evaluated  
 (Malcolm Pirnie)**

Install alternate grit removal (not recommended)  
 Install smaller grit blower (recommended)  
 Install fine bubble diffusion system (evaluate further)  
 Install dissolved oxygen control (recommended)  
 Install alternate sludge dewatering equipment (evaluate further)  
 Install infrared sludge dryer (evaluate further if sludge disposal options change)

**Facility Information**      Location: Steuben County, New York  
 NYS Dept. of Environmental Conservation Region: 7  
 Population Code: B (3,501 - 2,000,000)  
 Population Served: 13,000  
 Facility Type: Trickling Filter/Rotating Biological Contactor  
 Current Design Flow: 2.13 mgd

**Current Treatment Scheme**

Wet Stream	Solids Stream
Grinder and Bar Screens	Sludge Grinder
Aerated Grit	Raw Sludge Pump
Primary Settling Tank	Primary Anaerobic Digester
Trickling Filter	Secondary Anaerobic Digester
Secondary Settling Tank	Sludge Pit
Chlorine Contact Tank	Belt Filter Press

**Proposed Modifications**

- Replace the existing raw sewage pumps and controls
- Add two grit collectors, grit washer/conveyor, and comminutor
- Add two new rotary positive displacement belt driven blowers
- Construct cover for the trickling filter
- Add ten air-driven submerged rotating biological contactors
- Add coarse bubble diffuser system
- Replace vacuum filters with belt filter presses
- Install sludge pumps and sludge grinders
- Make repairs to the primary digester and the anaerobic digester
- Replace the final clarifier sludge pumps with three submersible pumps
- Add submersible chopper pump
- Replace sludge mixing pumps with axial flow pumps
- Install new digester gas equipment

**Energy Consumption**      Current treatment system uses an estimated 410,000 kWh/year.  
 Proposed treatment system will use an estimated 856,000 kWh/year.  
 Cost per MG (existing system): \$44.85 (based on 640 MG/year)  
 Cost per MG (proposed system): \$54.09 (based on 950 MG/year)

**ECMs Currently in Place**      None

**ECMs Proposed (Engineer)**      Digester gas recovery  
 High efficiency motors for all new equipment  
 Variable frequency drives for all new pumps  
 Variable frequency drives for new blowers

**ECMs Evaluated (Malcolm Pirnie)**      No other energy saving alternatives identified

**Facility Information**

Location: Tompkins County, New York  
 NYS Dept. of Environmental Conservation Region: 7  
 Population Code: A (less than 3,500)  
 Population Served: 4,000  
 Facility Type: Trickling Filter/Rotating Biological Contactor  
 Current Design Flow: 0.4 mgd

**Current Treatment Scheme**

Wet Stream	Solids Stream
Comminutor Primary Clarifier Trickling Filters (TF) Intermediate Clarifier RBCs Final Clarifier Chlorine Contact Tank	Anaerobic Digester Sludge Drying Beds

**Proposed Modifications**

Add aeration system to the RBC  
 Add a sludge digester and possibly a belt press for sludge dewatering

**Energy Consumption**

Current treatment system uses an estimated 146,000 kWh/year.  
 Cost per MG (existing system): \$74.80 (based on 127 MG/year)  
 Proposed electrical consumption is not given because there are currently no definite proposed modifications to the Dryden WWTP.

**ECMs Currently in Place**

Covered sludge drying beds

**ECMs Proposed (Engineer)**

Add a second digester and install a belt filter press

**ECMs Evaluated (Malcolm Pirnie)**

Install variable frequency drives for raw wastewater pumps (recommended)  
 Replace TF rock media with a synthetic material (evaluate further)  
 Retrofit RBC unit with coarse bubble diffused air (recommended)  
 Place gravity thickener between the primary clarifier and digester (evaluate further)  
 Place thickening centrifuge after the primary clarifier (evaluate further)  
 Use a separate thickener to thicken sludge from the intermediate and final clarifiers (evaluate further)  
 Add belt filter press (evaluate further)

## ERIE COUNTY SEWER DISTRICT No. 1

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### Facility Information

Location: Erie County, New York  
NYS Dept. of Environmental Conservation Region: 9  
Population Code: A (3,501 - 2,000,000)  
Population Served: 14,000 homes  
Facility Type: Pump Stations and Overflow Retention Facility  
Current Design Flow: 11.6 mgd (total pumps)

### Current Treatment Scheme

Wet Stream
Three Permanent Pump Stations: Cayuga Creek Road Azalea-Pebble Creek Eiffel Estates
Three Auxiliary Pump Stations: Eiffel Estates Brentwood Drive/French Road Azalea Drive/French Road
Temporary Pumps

### Proposed Modifications

Construct a relief sewer and several other sewer lines  
Add an overflow retention facility (ORF)  
Add two pump stations (ORF & Industrial Parkway)  
Decommission the existing pump stations

### Energy Consumption

Current treatment system uses an estimated 139,800 kWh/year.  
Proposed treatment system uses an estimated 1,034,400 kWh/year.  
Cost (existing system): \$11,040/year  
Cost (proposed system): \$74,760/year  
Cost per MG not calculated (difficult to determine MG treated because of intermittent nature of wet weather flows)

### ECMs Currently in Place

None

### ECMs Proposed (Engineer)

Variable frequency drives for Industrial Parkway Pump Station

### ECMs Evaluated (Malcolm Pirnie)

Install two sets of variable-speed pumps at the Industrial Parkway Pump Station, one set for dry weather flow and one set for wet weather flow (recommended - evaluate capital costs further)

## ERIE COUNTY SEWER DISTRICT No. 4

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### Facility Information

Location: Erie County, New York  
NYS Dept. of Environmental Conservation Region: 9  
Population Code: A (3,501 - 2,000,000)  
Population Served: (Unknown)  
Facility Type: Pump Stations and Overflow Retention Facility (ORF)  
Current Design Flow: 52.5 mgd Total Pump Station, 41.5 mgd for ORF

### Current Treatment Scheme

Wet Stream
Three Pump Stations: Broadway Vanderbilt Depew Additional Overflow Pumps Overflow Retention Facility

### Proposed Modifications

Replace Depew Pump Station with a new Storm Overflow Pump Station  
Construct an overflow chamber and influent sewer pipe  
Construct a force main from Storm Overflow Pump Station to the ORF  
Modify the ORF to increase capacity

### Energy Consumption

Current treatment system uses an estimated 679,060 kWh/year.  
Proposed treatment system uses an estimated 1,216,840 kWh/year.  
Cost (existing system): \$50,440/year  
Cost (proposed system): \$87,370/year  
Cost per MG not calculated (difficult to determine MG treated because of intermittent nature of wet weather flows)

### ECMs Currently in Place

Variable frequency drives at the three pump stations

### ECMs Proposed (Engineer)

Variable frequency drives at the proposed Storm Overflow Pump Station

### ECMs Evaluated (Malcolm Pirnie)

Install two sets of variable-speed pumps at the Storm Overflow Pump Station, one set for dry weather flow and one set for wet weather flow (recommended - evaluate capital costs further)

**Facility Information**                      Location: Warren County, New York  
 NYS Dept. of Environmental Conservation Region: 5  
 Population Code: A (less than 3,500)  
 Population Served: 1,400 (summer), 426 (winter)  
 Facility Type: None existing  
 Proposed Design Flow: 144,000 gpd (summer)

**Current Treatment Scheme**      The Town of Hague residents currently have individual septic disposal systems.

**Proposed Treatment Scheme**                      The recommended collection system is a combination of conventional gravity, low pressure, and small diameter gravity sewers.

Wet Stream	Solids Stream
Bar Screens Primary Settling Tanks Flow Equalization 4-Stage Rotating Biological Contactor Secondary Clarifiers Nutrient Film Technique (Possible) Rapid Infiltration/Percolation Basin	Sludge Drying Beds

**Energy Consumption**                      Proposed treatment system will use an estimated 568,000 kWh/year.  
 Cost per MG: not calculated (no established electric rate)

**ECMs Currently in Place**                      None

**ECMs Proposed (Engineer)**      Installation of RBC system

**ECMs Evaluated (Malcolm Pirnie)**                      Due to the unavailability of specific process and equipment details, Malcolm Pirnie was unable to make specific energy conservation recommendations. Malcolm Pirnie did present some ideas that would make the overall treatment scheme more efficient:

- Install variable frequency drives on the pumps in centralized pump station
- Install positive displacement blowers with variable frequency controls
- Install a denitrification filter
- Install an air diffusion system in the RBCs
- Delete the nutrient film technique
- Evaluate covering the sludge drying beds
- Evaluate alternative heating.

**Facility Information**

Location: Sullivan County, New York  
 NYS Dept. of Environmental Conservation Region: 3  
 Population Code: B (3,500-200,000)  
 Population Served: 970 households  
 Facility Type: Activated Sludge (Oxidation Ditch)  
 Current Design Flow: 0.4 mgd

**Current Treatment Scheme**

Wet Stream	Solids Stream
Manual Bar Screen Comminutor Grit Chamber Wet Well Splitter Box Oxidation Ditch Sedimentation UV Disinfection Post-Aeration	Sludge Well Sludge Holding Drying Beds

**Proposed Modifications**      None

**Energy Consumption**      Current treatment system uses an estimated 435,000 kWh/year.  
 Cost per MG (existing system): \$452.14 (based on 60 MG/year)

**ECMs Currently in Place**      Sludge drying beds

**ECMs Proposed (Engineer)**      None

**ECMs Evaluated (Malcolm Pirnie)**

- Install variable frequency drives for blower motors (recommended)
- Install a variable frequency drive on the 10-hp mixer (recommended)
- Use a fine bubble diffused air system, combined with horizontal mixers, in the oxidation ditches (not recommended)
- Use rotating biological contractors as an alternative treatment system (not recommended)
- Replace aerated grit chamber with vortex-type grit chamber (not recommended)
- Install a dissolved oxygen (DO) control system (not recommended)
- Compartmentalize the sludge holding tank and install smaller mixers in each compartment (not recommended)
- Cover and install insulated siding on the drying beds (evaluate further)

## NIAGARA COUNTY SEWER DISTRICT NO. 1

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**Facility Information**

Location: Wheatfield, New York  
 NYS Dept. of Environmental Conservation Region: 9  
 Population Code: B (3,501 - 2,000,000)  
 Population Served: 65,750  
 Facility Type: Activated Sludge  
 Current Design Flow: 14.1 mgd

**Current Treatment Scheme**

Wet Stream	Solids Stream
Comminutors Aerated Grit Chambers Aeration Tanks Secondary Clarifiers Chemical Mix & Flocculation Phosphate Settling Tanks Tertiary Filters Chlorine Contact Tanks	Sludge Mixing Chamber Sludge Thickening Sludge Storage Tanks Belt Filter Press

**Proposed Modifications**

Expand the interceptor system  
 Modify the heating system (as annual appropriations allow)

**Energy Consumption**

Current treatment system uses an estimated 3,965,000 kWh/year.  
 Cost per MG (existing system): \$109.60 (based upon 2,290 MG/year)

**ECMs Currently in Place**

Variable speed drives (VFD)  
 Belt filter presses  
 Occupancy sensors

**ECMs Proposed (Engineer)** None

**ECMs Evaluated  
 (Malcolm Pirnie)**

Install fine bubble diffusers in aeration tanks (recommended)  
 Install dissolved oxygen control system (recommended)  
 Install alternate grit removal system (not recommended)  
 Install infrared sludge dryer (not recommended)

**Facility Information**

Location: Oneida County, New York  
 NYS Dept. of Environmental Conservation Region: 6  
 Population Code: B (3,501 - 2,000,000)  
 Population Served: 125,000  
 Facility Type: Activated Sludge  
 Current Design Flow: 40 mgd (summer) 48 mgd (winter)

**Current Treatment Scheme**

Wet Stream	Solids Stream
Bar Screens	Cyclone/Classifier
Grit Tanks	Mixed Sludge Well
Primary Settling Tanks	Gravity Thickeners
Aeration Tanks	Grinder
Final Settling Tanks	Sludge Holding Tank
Chlorination	Belt Filter Presses
De-chlorination	Incinerator
Post-Aeration	Ash Holding Tanks

**Proposed Modifications**

Plans have not been made to modify the WWTP, but a carbon monoxide monitoring system will be installed in the near future.

**Energy Consumption**

Current treatment system uses an estimated 15,586,000 kWh/year.  
 Cost per MG (existing system): \$139.53 (based on 13,210 MG/year)

**ECMs Currently in Place**

Variable frequency drives on raw wastewater pumps  
 Fine bubble diffuser system in the aeration tanks  
 Belt filter presses for sludge dewatering

**ECMs Proposed (Engineer)** None

**ECMs Evaluated  
 (Malcolm Pirnie)**

Replace aerated grit chambers with vortex-type or cyclonic grit chamber (not recommended)  
 Determine if existing blowers are properly sized (evaluate further)  
 Conduct pilot testing of various dissolved oxygen control systems to select a reliable, easily maintainable system. (recommended)  
 Use a hot water rinse to clean belt filter presses (evaluate further)  
 Replace incinerator feed pumps with more energy efficient, higher solids-content pumps if modification to dewatering system increases the percent solids of the dewatered sludge (recommended)  
 Modify dewatered sludge conveyor system (recommended)  
 Convert incinerator burners to natural gas (not recommended)  
 Investigate alternative ash handling options (recommended)

**Facility Information**

Location: Otsego County, New York  
 NYS Dept. of Environmental Conservation Region: 4  
 Population Code: B (3,501 - 2,000,000)  
 Population Served: 16,884  
 Facility Type: Trickling Filter  
 Current Design Flow: 4.0 mgd

**Current Treatment Scheme**

Wet Stream	Solids Stream
Bar Screen Comminutor Wet Well Flocculation Settling Tanks Trickling Filters Final Settling Tanks Chlorine Contact Tank Effluent Chamber	Grit Separation Sludge Thickener Primary Digester Secondary Digester Sludge Drying Beds

**Proposed Modifications**

Install rotating biological contactors (RBCs)  
 Add two new 10-hp sludge pumps  
 Add new clarifier/thickener  
 Install belt filter press

**Energy Consumption**

Current treatment system uses an estimated 430,000 kWh/year.  
 Proposed treatment system will use an estimated 788,000 kWh/year.  
 Cost per MG (existing system): \$35.38 (based on 940 MG/year)  
 Cost per MG (proposed system): \$56.06 (based on 940 MG/year)

**ECMs Currently in Place**

Variable speed pumps  
 Trickling filters  
 Methane recovery

**ECMs Proposed (Engineer)**

RBCs for nitrification  
 Belt filter presses for dewatering

**ECMs Evaluated  
 (Malcolm Pirnie)**

Use of an electrical demand controller (evaluate further)  
 Time of use electrical rates (not recommended)  
 Operate the constant-speed raw sewage pump (not recommended)  
 Utilization of the flared methane (not recommended)

**Facility Information**

Location: Clinton County, New York  
 NYS Dept. of Environmental Conservation Region: 5  
 Population Code: B (3,501 - 2,000,000)  
 Population Served: 36,000  
 Facility Type: Activated Sludge  
 Current Design Flow: 16 mgd  
 Municipal Utility Authority (MUA) Status

**Current Treatment Scheme**

Wet Stream	Solids Stream
Bar Screen Grit Chambers Raw Waste Pumps Primary Clarifiers Aeration Tanks Secondary Clarifiers Disinfection	Sludge Dewatering Units Composting Facility (off site)

**Proposed Modifications**

Install a diesel-driven bypass pump at Cumberland Ave. Pump Station

**Energy Consumption**

Current treatment system uses an estimated 4,593,000 kWh/year.  
 Cost per MG: \$24.96 (based on 2,700 MG/year - treatment system)  
 The installation of the diesel driven backup pump will not affect the electric usage at the pump station.

**ECMs Currently in Place**

Composting

**ECMs Proposed (Engineer)**

None

**ECMs Evaluated  
 (Malcolm Pirnie)**

Note: Many ECMs were not cost effective due to MUA status  
 Modify current pump station operations (not recommended)  
 Install variable speed drives at pump station (evaluate further)  
 Install 7.5-hp blower, operate 1 aerated grit chamber (recommended)  
 Install vortex grit removal system (evaluate further)  
 Install fine bubble system for 1/2 of aeration tank (not recommended)  
 Install fine bubble system for entire aeration tank (not recommended)  
 Operate only one clarifier throughout the year (evaluate further)  
 Install an infrared dryer (recommended - conduct testing)  
 Market extra capacity to increase revenues (not recommended)  
 Trim the impeller of one raw wastewater pump (not recommended)  
 Install a smaller pump to handle the average flow (not recommended)  
 Install two smaller return sludge pumps (not recommended)

## ROCKLAND COUNTY SEWER DISTRICT No. 1 HACKENSACK RIVER & MAIN INFLUENT PUMP STATIONS

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### Facility Information

Location: Rockland County, New York  
 NYS Dept. of Environmental Conservation Region: 3  
 Population Code: B (3,501 - 2,000,000)  
 Population Served: 156,000  
 Facility Type: Pump Stations  
 Current Design Flow: 35 mgd

### Current Treatment Scheme

Hackensack River Pump Station (HRPS)	Main Influent Pump Station (MIPS)
Comminutors (nine) Raw Wastewater Pumps (six) two constant speed four variable speed 900 kW diesel generator Odor Control System (not operational) Air bubbler level control	Bar screens (three) Raw Wastewater Pumps (six) all variable speed 400 kW diesel generator Odor Control System Air bubbler level control

**Proposed Modifications**      None

**Energy Consumption**      Current HRPS system uses an estimated 1,752,000 kWh/year.  
    Cost per MG (HRPS system): \$67.87 (based on 2,555 MG/year)  
    Current MIPS system uses an estimated 1,780,000 kWh/year.  
    Cost per MG (MIPS system): \$20.53 (based on 6,935 MG/year)

**ECMs Currently in Place**      Variable speed drives

**ECMs Proposed (Engineer)**      None

**ECMs Evaluated  
(Malcolm Pirnie)**      Install new high efficiency motors (recommended)  
    Replace fixed impedance and liquid-rheostat drives with regenerative  
    drives (recommended)  
    Install new pump sequencing and level control system (recommended)

**Facility Information**

Location: Oneida County, New York  
 NYS Dept. of Environmental Conservation Region: 6  
 Population Code: B (3,501 - 2,000,000)  
 Population Served: 43,000  
 Facility Type: Activated Sludge  
 Current Design Flow: 9.0 mgd

**Current Treatment Scheme**

Wet Stream	Solids Stream
Bar Screens Grit Removal Primary Clarification Main Pump Station Aeration Tanks Secondary Clarification	Gravity Thickener Primary Digester Secondary Digester Belt Filter Presses

**Proposed Modifications**

Expand plant capacity from 9.0 mgd to 12.0 mgd  
 Add four 200,000-gallon aeration tanks  
 Add two 30-hp and two 40-hp surface aerators  
 Add 75-foot diameter final clarifier  
 Add a sodium hypochlorite odor control system that will include:  
   - one 12,000-gal sodium hypochlorite storage tank  
   - four 0.25 hp chemical feed pumps  
 Add gravity thickener

**Energy Consumption**

Current treatment system uses an estimated 2,512,000 kWh/year.  
 Proposed treatment system will use an estimated 3,436,000 kWh/year.  
 Cost per MG (existing system): \$42.19 (based on 3,900 MG/year)  
 Cost per MG (proposed system): \$51.39 (based on 4,380 MG/year)

**ECMs Currently in Place**

Raw sewage pumps have variable frequency drives  
 Digester gas produced is used to fuel boiler  
 Belt filter presses are used for dewatering sludge

**ECMs Proposed (Engineer) None**

**ECMs Evaluated  
 (Malcolm Pirnie)**

Install a fine bubble diffused air system (evaluate further)  
 Install a dissolved oxygen (DO) control system (recommended)  
 Reduce the number of clarifiers in operations (evaluate further)  
 Evaluate belt filter press operations for ways to increase sludge cake solids content (recommended)

**Facility Information**

Location: Hamilton County, New York  
 NYS Dept. of Environmental Conservation Region: 5  
 Population Code: A (less than 3,500)  
 Population Served: 400 (winter), 2,500 (summer)  
 Facility Type: Activated Sludge  
 Current Design Flow: 0.3 mgd

**Current Treatment Scheme**

Wet Stream	Solids Stream
Pump Stations Bar Screen Comminutor Aeration Clarifier Disinfection	Aerobic Digester Sludge Concentrator Sludge Drying Beds

**Proposed Modifications**

There are no formal proposed modifications. However, the Village issued a RFP for plant renovations such as painting structural steel, concrete repair work, installing fine bubble diffusers in conjunction with any blower/electrical modifications to conserve energy, and upgrading the pump stations with control panels and alarm systems.

**Energy Consumption**

Current treatment system uses an estimated 199,000 kWh/year.  
 Cost per MG (existing system): \$518.40 (based on 33 MG/year)  
 Proposed electrical consumption is not estimated because there are currently no definite modifications proposed for the WWTP.

**ECMs Currently in Place**

None

**ECMs Proposed (Village)**

Fine bubble diffusers

**ECMs Evaluated  
 (Malcolm Pirnie)**

Install fine bubble diffusers (recommended)  
 Install new positive displacement blower (recommended)  
 Install dissolved oxygen monitoring system (recommended)  
 Install variable frequency drives for raw sewage pumps (not recommended)  
 Install blower guide vane controls (not recommended)  
 Install trickling filters and rotating biological contactors (not recommended)

## SUFFOLK COUNTY SEWER DISTRICT NO. 3

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**Facility Information**

Location: Babylon, New York  
 NYS Dept. of Environmental Conservation Region: 1  
 Population Code: B (3,501-2,000,000)  
 Population Served: 375,000  
 Facility Type: Activated Sludge  
 Current Design Flow: 30 mgd

**Current Treatment Scheme**

Wet Stream	Solids Stream
Bar Screens Grit Chambers Primary Clarifiers Aeration Tanks Final Clarifiers	Chemical Settling Sludge Blending Belt Press Incineration

**Proposed Modifications**

Add screen facilities for the scavenger waste  
 Install fine bubble diffusers in the aeration tanks  
 Construct new final clarifiers  
 Install a new emergency generator

**Energy Consumption**

Current treatment system uses an estimated 32,767,000 kWh/year.  
 Proposed treatment system will use an estimated 22,681,000 kWh/year.  
 Cost per MG (existing system): \$787.97 (based on 9,250 MG/year)  
 Cost per MG (proposed system): \$718.20 (based on 9,250 MG/year)

**ECMs Currently in Place**

Adjustable speed drives

**ECMs Proposed (Engineer)**

Fine bubble diffusers

**ECMs Evaluated  
(Malcolm Pirnie)**

Variable frequency drives for Pump Station No. 12 (recommended)  
 Variable frequency drives for Pump Station No. 9 (not recommended)  
 Smaller pump at Pump Station No. 9 (evaluate further)  
 Dissolved oxygen control (recommended)  
 Evaluate variable frequency drive vs. electromagnetic variable speed drives (evaluate further)  
 Aeration blower evaluation (evaluate further)  
 Incineration afterburner operational changes (evaluate further)  
 Waste heat boilers - use steam for building heat (evaluate further)  
 Alternate fuel source (not recommended)

## SUFFOLK COUNTY DISTRICT NO. 4

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### Facility Information

Location: Farmingdale, New York  
NYS Dept. of Environmental Conservation Region: 1  
Population Code: B (3,501 - 2,000,000)  
Population Served: 1,200  
Facility Type: Activated Sludge  
Current Design Flow: 0.120 mgd

### Current Treatment Scheme

Wet Stream	Solids Stream
Onsite Pump Station Aeration Tanks Clarifiers	Sludge Holding Tank Off-site Sludge Management

### Proposed Modifications

Convert activated sludge system to a sequencing batch reactor (SBR)  
Install a 0.5-hp sewage grinder  
Add fine screen to treatment scheme prior to the SBR system  
Create two new aerobic sludge digesters  
Install a new centrifugal blower

### Energy Consumption

Current treatment system uses an estimated 301,000 kWh/year.  
Proposed treatment system will use an estimated 422,000 kWh/year.  
Cost per MG (existing system): \$661.23 (based on 43 MG/year)  
Cost per MG (proposed system): \$927.99 (based on 43 MG/year)

### ECMs Currently in Place

None

### ECMs Proposed (County)

SBR system

### ECMs Evaluated (Malcolm Pirnie)

Install fine bubble diffusers in existing activated sludge tanks  
(recommended)  
Variable speed drives for Influent Pump Station (evaluate further)

## SUFFOLK COUNTY SEWER DISTRICT NO. 5

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### Facility Information

Location: Huntington, New York  
 NYS Dept. of Environmental Conservation Region: 1  
 Population Code: B (3,501 - 2,000,000)  
 Facility Type: Activated Sludge  
 Current Design Flow: 0.236 mgd

### Current Treatment Scheme

Wet Stream	Solids Stream
Comminutor Aeration Tank Secondary Clarifier	Aerobic Digester Off-site Sludge Management

### Proposed Modifications

Convert activated sludge system to a sequencing batch reactor (SBR)  
 Add a fine screen  
 Add tank to increase total tank volume for the SBR system  
 Create an equalization tank from part of the existing aeration tanks  
 Install return and waste sludge pumping systems  
 Create two new aerobic sludge digesters

### Energy Consumption

Current treatment system uses an estimated 521,000 kWh/year.  
 Proposed treatment system will use an estimated 716,000 kWh/year.  
 Cost per MG (existing system): \$547.19 (based on 93 MG/year)  
 Cost per MG (proposed system): \$745.15 (based on 93 MG/year)

### ECMs Currently in Place

None

### ECMs Proposed (County)

SBR system

### ECMs Evaluated (Malcolm Pirnie)

Install fine bubble diffusers in existing activated sludge tanks  
 (recommended)  
 Variable speed drives for Pump Station No. 2 and 4 (evaluate further)

**Facility Information**

Location: Ontario County, New York  
 NYS Dept. of Environmental Conservation Region: 8  
 Population Code: A (less than 3,500)  
 Population Served: 2,300  
 Facility Type: Trickling Filter  
 Current Design Flow: 0.5 mgd

**Current Treatment Scheme**

Wet Stream	Solids Stream
Comminutor Aerated Grit Primary Clarification Trickling Filter (TF) Secondary Clarification Oxidation Pond Chlorine Contact Tank	Primary Digester Secondary Digester Drying Beds

**Proposed Modifications**

Replace comminutor and coarse bar screens  
 Rebuild and recondition grit chambers and Parshall fume  
 Make structural repair to primary clarifier, replace center mechanism  
 Extend existing trickling filter media and walls  
 Replace rock media with a high density, cross-flow synthetic material  
 Replace distributor mechanism and TF feed pumps and controls  
 Replace existing pumps and controls in the oxidation pond  
 Construct a sludge re-aeration and solids contact tank  
 Replace the secondary clarifier with a peripheral-feed, spiral flow unit  
 Convert the part of the chlorine contact tank into a post-aeration basin  
 Use sludge mixed-liquor pump as a waste sludge transfer pump

**Energy Consumption**

Current treatment system uses an estimated 380,000 kWh/year.  
 Proposed treatment system will use an estimated 438,261 kWh/year.  
 Cost per MG (existing system): \$277.13 (based on 100 MG/year)  
 Cost per MG (proposed system): \$188.19 (based on 170 MG/year)

**ECMs Currently in Place**

Trickling filters

**ECMs Proposed (Engineer)**

Variable speed drives for the recirculation pumps  
 High density synthetic media for trickling filters

**ECMs Evaluated  
 (Malcolm Pirnie)**

Adjustable speed drives for pumps and blowers (recommended)  
 Digester gas recovery (evaluate further)

**Facility Information**

Location: Wayne County, New York  
 NYS Dept. of Environmental Conservation Region: 8  
 Population Code: B (3,501 - 2,000,000)  
 Population Served: 4,760  
 Facility Type: Rotating Biological Contactors (RBCs)  
 Current Design Flow: 1.0 mgd

**Current Treatment Scheme**

Wet Stream	Solids Stream
Hydrosieve Screen Flow Equalization Rotating Biological Contactor Clarifier Tertiary Filters Reaeration	Aerobic Digesters Dissolved Air Floatation Sludge Conditioning Sludge Land Application (summer) Plate & Frame Press (winter)

**Proposed Modifications**

Add a coarse bubble aeration system and a 40-hp blower to Digester No. 2.  
 Install fine bubble diffusers in the aeration/equalization tanks and a new 60-hp blower.

**Energy Consumption**

Current treatment system uses an estimated 1,027,000 kWh/year.  
 Proposed treatment system will use an estimated 1,092,000 kWh/year.  
 Cost per MG (existing system): \$1,096.70 (based on 143 MG/year)  
 Cost per MG (proposed system): \$1,124.04 (based on 143/MG year)

**ECMs Currently in Place**

Rotating biological contactors

**ECMs Proposed (Engineer)**

Fine bubble diffusers

**ECMs Evaluated (Malcolm Pirnie)**

Install variable frequency drives on the influent raw wastewater pumps, RBC feed pumps, and on the filter feed pumps (recommended)  
 Monitor aeration operations and effluent quality, and potentially reduce RBC use (evaluate further)  
 Install a DO control system on the aeration blowers (recommended)

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**Wastewater Treatment and Sludge Management  
Energy Reference Guide**

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**New York State Energy Research and Development Authority  
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