A Workshop for Small System Wastewater Operators

Kansas Department of Health and Environment

Small System Wastewater

Kansas Department of Health and Environment
Bureau of Water
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### Appendix A - EPA Pond Manual

- Conversion Factors and Formulas
- Example Wastewater Permits
- What Does KDHE Expect From an Operator?
Common Abbreviations

Therefore
Area
Acre
BOD ... Biochemical Oxygen Demand
British Thermal Unit
°C ... Degrees Celsius
Cubic Feet Per Minute
Cubic Feet Per Second
Centimeter
Complete Mix Activated Sludge
Chemical Oxygen Demand
Cubic Feet
Cubic Yard
Day
Diameter
Dissolved Oxygen
Degrees Fahrenheit
Square Feet
Cubic Feet
Gallon
Gallons Per Capita Day
Gallons Per Day
Gallons Per Minute
Gram
Height
Water
Horsepower
Hour
Inside Diameter
Inch
Square Inch
Cubic Inch
Kilogram
Length
Liter
Pound
Natural Log
Common Log (base 10)
Maximum Contaminant Level
Mean Cell Residence Time
Milligram
Milligram Per Liter
Million Gallons Per Day
Million Gallons Per Acre Per Day
Mile
Minute
Milliliter
Mixed Liquor Suspended Solids
Mixed Liquor Volatile Suspended Solids
Millimeter
Normal
Outside Diameter
Ounce
Parts Per Billion
Parts Per Million
Flow
Quart
Radius
Return Activated Sludge
Rotating Biological Contactor
Second
Square Feet
Square Yard
Suspended Solids
Sludge Volume Index
Total Suspended Solids
Velocity
Volt
Volume
Watt
Width
Waste Activated Sludge
Yard
Square Yard
Cubic Yard
Year
Sludge Age
Small Wastewater Systems

I. Overview

A. Why we treat wastewater

1. To protect human health by reducing disease causing “pathogens”. Pathogens are bacteria and viruses that can cause disease.
   a. Water borne diseases
      i. Typhoid
      ii. Cholera
      iii. Dysentery
      iv. Polio
      v. Hepatitis
   b. May need to “disinfect” wastewater. Disinfection kills pathogens.

2. Protect the environment.
   a. Untreated wastewater can harm surface water organisms in two ways.
      i. May contain toxic materials that poison organisms.
      ii. May cause a depletion of the “dissolved oxygen” (D.O.) in the water. This in turn will cause fish and other organisms to suffocate.
   b. Minimize contamination of groundwater, thus providing a good source of drinking water.

3. Reclaim the water. Wastewater is mostly water with a little dissolved organic matter and solids. Treatment cleans it so it can be used again.

4. Other reasons.
   a. Protect game fishing.
   b. Provide a source of recreation.
   c. Increase property value.

B. Why we need certified operators

1. It is the law.

2. It indicates a standard level of competence, and competent operation ensures the public’s health.

3. It helps to protect the employer’s (often the taxpayer’s) large capital investment.

4. It heightens operator awareness of job safety and responsibility.
II. Wastewater Chemistry

A. **BOD or Biochemical Oxygen Demand** - a measure of the amount of dissolved oxygen that organisms will use in “eating” the organic matter in water or wastewater. The higher the value, the higher the strength of a wastewater. For most purposes we run a five-day BOD or \( BOD_5 \). We essentially measure the D.O. of a sample at the beginning of the test, and then five days later. The difference in the amount of D.O. present initially and at the end of five days is the “oxygen demand”. There are two types of BOD - carbonaceous BOD or CBOD and nitrogenous BOD or NBOD.

We are primarily interested in the CBOD because it measures organic matter in a sample where NBOD measures nitrogen compounds. We typically see NBOD after about a 10-day period, thus the reason for using \( BOD_5 \). However, if your plant has begun to nitrify (convert ammonia to nitrate) you can get NBOD in your analyses. Labs can inhibit (or eliminate) the NBOD component if necessary. However, your permit limit for BOD will be reduced by 5 mg/l. For instance, if your permit limit for \( BOD_5 \) is 30 mg/l, your \( CBOD_5 \) limit would be 25 mg/l.

B. **Total Solids** - The total amount of solids present in a sample of wastewater. Typical values in raw sewage range from 350 to 1200 mg/l. Total solids consist of the following:

1. **Total suspended or nonfilterable** - Solid particles that are composed of settleable and nonsettleable fractions. Also referred to as “TSS”. Typical values in raw sewage range from 100 to 350 mg/l. Primarily we are concerned with settleable solids that are measured in an Imhoff cone, or the TSS that are weighed on a scale after they are filtered and dried. TSS measurements form the basis for process control at a wastewater treatment plant. Suspended solids are further divided into two other categories:

   a. **Volatile or organic** - Volatile suspended solids (VSS) are the “organic” portion of the suspended solids. The organic portion is typically from plant and animal waste and can be used as a food source for bacteria. Typical values in raw sewage are 70 to 275 mg/l. VSS are measured by taking the dried solids on the filter media and burning off or “volatilizing” the organic solids in a muffle furnace set at 550 °C. The difference between the original weight of solids and the remaining weight is the VSS fraction. The remaining portion is the fixed or inorganic solids.
b. **Fixed or inorganic** - Non-volatile suspended solids are the “inorganic” portion of the suspended solids. The inorganic portion is typically from minerals (sand, iron, calcium, etc.) and cannot be used as a food source for bacteria. Typical values in raw sewage range from 30 to 75 mg/l.

2. **Total dissolved or filterable** - Dissolved particles that are composed of settleable and nonsettleable fractions. Also referred to as “TDS”. TDS measurements do not have much significance in wastewater treatment, they have more of a role in water treatment. Typical values in raw sewage range from 250 to 850 mg/l. TDS are measured by pouring a known volume of filtered liquid into a weighed evaporation dish. The liquid is evaporated and the dish reweighed. The difference in the beginning and final weights is the weight of dissolved solids. Dissolved solids are further divided into two other categories:

a. **Volatile or organic** - Volatile dissolved solids are the “organic” portion of the dissolved solids. The organic portion is typically from plant and animal waste and can be used as a food source for bacteria. Typical values in raw sewage range from 100 to 325 mg/l. Volatile dissolved solids are measured by taking the dried solids and in the evaporating dish and burning off or “volatilizing” the organic solids in a muffle furnace set at 550 °C. The difference between the original weight of solids and the remaining weight is the volatile fraction. The remaining portion is the **fixed or inorganic solids**.

b. **Fixed or inorganic** - Non-volatile dissolved solids are the “inorganic” portion of the dissolved solids. The inorganic portion is typically from minerals (sand, iron, calcium, etc.) and cannot be used as a food source for bacteria. Typical values in raw sewage range from 150 to 525 mg/l.

C. **Ammonia or NH₃** - Ammonia is present in all domestic wastewater primarily due to the breakdown of protein. We are concerned with ammonia because it is toxic to fish at fairly low concentrations and because it is a nutrient that can cause algae growth to be over-stimulated. When wastewater treatment plants are said to “nitrify”, they are converting ammonia to nitrate and nitrite. When they “denitrify” they are further converting the nitrate to nitrogen gas.

D. **Fecal Coliform for FC** - Coliform are a type of bacteria that are relatively easy to measure and are indicators of pollution. “Fecal” coliform are indicators of bacteria that can be found in fecal matter. While they alone are not a serious health problem, they indicate that bacteria that do cause health problems (typhoid, dysentery, hepatitis, etc.) may be present.

E. **Metals** - Often referred to “heavy metals”, these are found in many domestic wastewaters regardless of the presence of industrial sewer connections. At typical levels they are not of much concern. In fact many metals are essential to humans in low doses. However, if an industry does contribute significant amounts of these metals, they can cause the plant effluent to be toxic to humans or aquatic life. Some of the metals typically seen include copper, zinc, cadmium, lead, and chromium.
III. The Purpose of Pretreatment - The general purpose of pretreatment is to remove objects from the wastewater that may harm pumps and units downstream in the treatment process or that will not be biologically treated in a lagoon. Some package lift stations have screens incorporated directly into their wet wells.

A. Bar screens or racks -

1. A series of parallel bars that "strain" rags and large objects from the influent wastewater

2. Manually cleaned - usually with a rake once to several times per day so that water flows freely through the screen. The screenings should be allowed to drain. The removed "screenings" should be stored in a covered container and disposed of daily. Landfilling is the primary method of disposal.

3. Typical bar size - 1/4 to 5/8" wide x 1 to 3" deep

4. Bar spacing - 1 to 2"

5. Slope - 30 to 45"

6. Advantages
   a. Cheap
   b. Low mechanical maintenance

7. Disadvantages
   a. Labor intensive
   b. Dangerous

B. Comminutors - These are mechanical devices that grind up large solids like a garbage disposal. The solids are then allowed to go through the remainder of the treatment process. Due to their mechanical nature, comminutors are much more difficult to maintain than bar screens. Most comminutors have a bar screen available to back them up.

C. Grit Removal - Grit, which is composed of inorganic materials such as sand, eggshells, rock, etc., sometimes needs to be removed at the head of the plant because it can decrease pond life, and build up in piping. If this happens, it is difficult to remove. If grit is a problem, it needs to be settled out at the headworks of a plant. This will require design of a grit removal chamber.
IV. The Purpose of Secondary Treatment/How it is Accomplished - Secondary treatment, as the name implies, typically follows primary treatment. The purpose of secondary treatment is to aggressively remove dissolved material that causes high BOD values as well as additional suspended material beyond primary clarification. For our purposes, we will only consider biological processes. Biological processes involve providing microorganisms (bacteria or "bugs") an acceptable environment so that they "eat" the material found in wastewater. In doing so, we create sludge. Depending on the process, for every 100 gallons of wastewater treated, we produce around 0.5 to 2 gallons of sludge.

In Kansas, the approximate breakdown of secondary treatment types for municipal and commercial facilities is as follows:

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<thead>
<tr>
<th>Treatment Type</th>
<th>Percentage of Facilities</th>
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<td>46.6</td>
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<tr>
<td>Discharging ponds</td>
<td>34.4</td>
</tr>
<tr>
<td>Activated sludge</td>
<td>12.5</td>
</tr>
<tr>
<td>Trickling filters</td>
<td>5.5</td>
</tr>
<tr>
<td>RBCs</td>
<td>1.0</td>
</tr>
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</table>

A. Ponds - Ponds, lagoons, waste stabilization ponds are all the same name for the same type of secondary treatment process. Ponds are the simplest form of secondary treatment we see in Kansas. Properly designed, ponds are the simplest form of treatment in terms of operation, maintenance, and reliability. They can satisfactorily remove BOD, solids, fecal coliforms, and ammonia. That is the main reason that ponds are the most common type of treatment in the State.

Ponds are typically not preceded by any form of pre or primary treatment. If the treatment system consists of more than one pond, some type of distribution, or splitter box usually precedes the ponds so that the wastewater can be directed to any or all ponds at a given time.

1. Pond types -

   a. Discharging - these ponds treat wastewater and discharge the treated water to a surface water - a lake, stream, creek, or river. A small percentage of the wastewater evaporates and/or seeps into the ground.

   b. Non-discharging - these ponds treat wastewater and do not discharge the treated water to a surface water. The water evaporates, seeps into the ground, and/or is used for irrigation purposes. Therefore, these ponds must be designed such that evaporation and seepage approximately equal the amount of wastewater flow and precipitation entering the pond.
Due to minimal precipitation and high evaporation rates, these type of facilities work best in the central to western part of the state. In the eastern part of the state where precipitation is greater than evaporation, they typically do not work.

2. Oxygen requirements - See the drawings on the following page.
   a. Aerated - these ponds have air supplied by mechanical means such as surface aerators. Larger quantities of sludge (dead algae and bacteria) are generated from these operations.
   b. Facultative - these ponds have an upper layer that is aerobic (oxygen containing) and a lower layer that is anaerobic (no oxygen). In between is a gradient going from oxygen-rich to no oxygen. Sludge builds up slowly in these ponds. Typically, they would need to be de-sludged about once every 20 or so years. These are most common types of ponds in Kansas.
   c. Anaerobic - these ponds have no oxygen at all. Oxygen is typically excluded by some type of cover over the pond. In the case of slaughterhouses, solidified grease often covers the pond surface. These ponds treat high-strength waste and are followed by some type of aerated or facultative process.

3. Key Kansas Design Criteria -

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<th>Pond Type</th>
<th>Organic Loading (lb BOD/acre/day)</th>
<th>Detention Time (days)</th>
<th>Operating Depth (feet)</th>
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<tbody>
<tr>
<td>Non-discharge</td>
<td>≤ 34</td>
<td>infinite</td>
<td>≤ 5</td>
</tr>
<tr>
<td>Discharge - Facultative</td>
<td>≤ 34</td>
<td>120</td>
<td>≤ 5</td>
</tr>
<tr>
<td>Aerated</td>
<td>N/A</td>
<td>5 - 20</td>
<td>5 - 12</td>
</tr>
</tbody>
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**Side slopes:** 3 : 1 or 3½ : 1  
**Freeboard:** 2 feet minimum  
**Leakage rate:** ¼ inch per day  
**Dike top width:** 8 feet minimum
Note: Vertical scale is greatly exaggerated

Typical Waste Stabilization Ponds
(a) Aerated pond, (b) Anaerobic Pond, (c) Facultative Pond
In order to achieve acceptable leakage rates, the bottoms and side slopes of ponds need to be compacted, thus sealing the pond. This is one of the primary expenses involved in building a pond. Therefore, the operator needs to keep the dikes well maintained so that their seal is preserved. This means that trees, whose roots can break the seal, should not be allowed on the dikes. Additionally, the lagoon seal can be disrupted by burrowing muskrats. If muskrats are observed, call the Department of Wildlife and Parks to have them removed.

4. **Pond Mechanics** - Pond systems usually consist of two or more cells, or ponds. Raw wastewater typically enters the first, or primary cell. Then exits to the secondary cell. In each of these cells, bacteria and algae play the primary roles in treating the wastewater. Bacteria break down and absorb the organic matter in wastewater, while algae provide oxygen that some of the bacteria need to do their work. Dead algae and bacteria build up as sludge in the bottom of the pond.

Most ponds we deal with are facultative ponds. Facultative ponds contain two basic types of bacteria:

- **Aerobic**, or those that need oxygen to survive. The more organic matter consumed, the more oxygen needed.
- **Anaerobic**, or those that do not need oxygen to survive.

The aerobic bacteria thrive in the upper layers of a pond, while the anaerobic bacteria live in the bottom layers of a pond. Some of the oxygen needed by the aerobic bacteria comes from the atmosphere. The majority comes from algae. Algae produce oxygen through a process called photosynthesis. Photosynthesis is a process whereby organic matter is created from water, nutrients and carbon dioxide (CO₂) with sunlight providing the energy for the reaction. Oxygen is a byproduct of the process. Since sunlight is required for photosynthesis, we typically find our pond's aerobic layer being no more that 4 feet deep, or the depth to which sunlight can penetrate the water.

The types of algae typically seen in ponds are green and blue-green algae. Green algae indicate a healthy pond that is functioning properly. Therefore, green algae are **good** algae. Blue-green algae indicate an unhealthy pond. They are filamentous (stringy) and predominate when pH is low and nutrients (nitrogen and phosphorus) are in low supply. Therefore, blue-green algae are **bad** algae.

5. **Operation - Appendix A** contains a portion of the EPA manual titled **Operations Manual - Stabilization Ponds**. It is a good document and goes into some detail. We will cover the basics.

   a. **Wind** - Wind creates mixing and can drive oxygen into a pond. To maintain good wind action, weeds and trees should not be allowed to grow near the pond to the extent they block the wind. The combination of weed growth and lack of wind typically leads to excessive mosquito breeding. Therefore keeping weeds and grass cut is a major operational concern for a lagoon operator - it allows good wind action, and controls mosquitos and other insects.

   Too much wind action can cause dike erosion. If that happens, rip-rap may need to be placed on the dikes to maintain their stability.
b. Temperature - Water can hold more dissolved oxygen as temperatures get colder. As temperatures get colder, however, biological activity slows. The rule of thumb is that for every 10 °C drop in temperature, the biological activity is reduced by half. As an example, the biological activity at 32 °F is about 25% of the biological activity at 68 °F. Ponds perform best in warm, sunny, windy weather.

c. Sunlight - We have already stated that sunlight is required so that algae can produce oxygen. We want oxygen to penetrate as deep as possible so that algae can produce more oxygen. Therefore, the operator needs to keep algae blooms dispersed (use a motor boat), keep duckweed out of the pond, keep a minimum pond depth of 3 feet so that sludge in the bottom of the pond remains covered.

d. Short-circuiting - Short circuiting means that you are not using all of your pond's volume for treatment. What is meant by this is that due to piping arrangements, wastewater may not travel throughout a pond's volume before being discharged to the next pond or to the discharge. Remember that the pond is designed based on detention time. If you do not use all of a pond, your detention time is reduced, and your treatment will not be as good as it is supposed to be.

e. Configuration - Ponds are configured to operate in series or parallel. The series configuration routes wastewater to one pond at a time. This allows primary treatment to take place in the initial pond, while following ponds polish the effluent. This means the final pond usually contains less algae, therefore less algae is discharged to the receiving stream. Ponds are usually configured in series in the summer when biological activity is at its maximum.

The parallel configuration means that raw wastewater is directed to more than one pond at the same time. This allows the organic load to be distributed over a larger volume, thus reducing overloading of a single primary pond. Ponds are usually configured in parallel in the winter when biological activity is low. When the activity is low, you need as much volume as possible to treat the incoming waste.

f. Oxygen - As stated before the aerobic bacteria need oxygen in order to breakdown the incoming organic matter (BOD). Oxygen is measured in terms of dissolved oxygen (D.O.). When the amount of oxygen entering the water is the same as the amount used, the water is said to be saturated. When algae is active in a pond, it can produce more oxygen than is used. Water is then said to be super-saturated. Water that uses more oxygen than can be provided will lead to odors. If odors become a nuisance, a short term fix is to add about 100 pounds sodium nitrate per acre of pond in the wake of a motor boat. If odors persist, the ponds are overloaded, and need to be evaluated for proper sizing.

h. pH - A healthy pond usually has a pH above neutral (7.0) due to algae taking CO₂ out of the water. CO₂ is acidic. A high pH is usually indicated by a green color. A dingy yellow-green color indicates a low pH (acidic). Low pH is
usually the result of an acid being discharged to the pond, or a toxic material being discharged to the pond that kills algae and/or bacteria. If a low pH occurs, a pond can be taken out of service and be allowed to recover.

B. Trickling filters/RBCs/Biotowers - Trickling filters, rotating biological contactors (RBCs), and biotowers all belong to a group of treatment processes referred to as fixed film. These processes are referred to as fixed film because a layer, or film of bacteria grows on media in the units. As wastewater is passed over the film, the bacteria consume organic matter in the wastewater. The film is also referred to as a biological slime layer. The outside of the slime layer is aerobic, while the inside of the slime layer (closest to the media) is anaerobic. As the slime layer grows, the anaerobic bacteria cannot cling to the media and are periodically washed off, or sloughed.

1. Trickling filters - Trickling filters are essentially round tanks filled with rock or plastic media that has wastewater spread over the top of it. The wastewater is treated as it passes through the media and the treated wastewater is collected at the bottom. Typically in Kansas, the media is crushed rock. Various types of plastic media have also been used.

   a. Components
      i. Basin - Usually a round concrete basin with a solid floor and side walls.
      ii. Media - The media supports the biological slime. The media must be porous so that air and wastewater can move through the filter. The media must also be resistant to the material in the wastewater.

   iii. Distributor arms - The distributor arms spray wastewater on top of the media. The distributor arms receive wastewater from a center column. The reaction of wastewater flowing out of the trickling filter arms, causes them to revolve and distribute wastewater evenly over the entire filter surface. The arms contain nozzles which can be adjusted to control the rotation of the arms. Typical arm speed is about 1 RPM.

   iv. Underdrain - The underdrain system captures the treated wastewater and sloughed solids at the bottom of the filter and directs it to the effluent channel. It also allows air flow through the filter.
v. Seal - the center column seal keeps wastewater from leaking out from the base of the column. It ensures all wastewater is directed to the distributor arms.

b. Advantages
i. They are simple.
ii. They are relatively low cost, both initially and operationally.
iii. They are stable. In other words they can handle a variety of loading conditions without an upset.
iv. They produce an easily handled sludge.

c. Disadvantages
i. They can freeze up in cold weather.
ii. They can be odorous.
iii. They attract filter flies.
iv. They typically cannot provide good ammonia removal.
v. They typically cannot handle high-strength loads.
vi. The media can become plugged.

d. Operational concerns
i. Cold weather operation can be a concern in areas where freezing winter temperatures are encountered. The freezing can be controlled to some degree by building wind breaks, covering the filter, or adjusting the nozzles to increase flow velocity.

ii. Odors occur when the filter becomes overloaded. This can possibly be resolved by recirculating effluent with the influent wastewater.
iii. Filter flies are a warm weather problem. The flies breed under the filter media. They can be controlled by application of insecticide to the walls of the filter only - not to the media. Care should be taken not to over apply insecticide. Another solution may be to flood the filter and flush out fly larvae.
iv. Distribution of wastewater is a primary concern. If the wastewater is not distributed evenly over the entire surface, the entire filter is not being utilized for treatment. This can lead to unnecessary overloading. Distributor nozzles need to be kept in good condition, the distributor arms should be kept level to ensure a constant speed, and the seal should be kept in good repair so that wastewater does not short-circuit.

e. Design criteria - KDHE
i. Hydraulic Loading - 45 - 90 gal/ft²/day
   2 - 4 MGAD
ii. Organic Loading - 10 - 20 lb BOD/1000 ft³ media/day
   450 - 950 lb BOD/acre-ft media/day
iii. Distribution - <10% difference to any part of the filter surface
   12" clearance between arms and media
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2. Rotating Biological Contactors (RBCs) - RBCs consist of shafts holding circular plastic media that is partly submerged in wastewater. The shafts are mounted above a wastewater basin. As the shaft turns at a slow speed, the media is rotated into and out of the wastewater. The media is approximately 40% submerged in wastewater, and develops a microbial film on its surface. As the biological film is rotated out of the wastewater, it is exposed to oxygen which makes it in aerobic treatment process.

   a. Components
       i. Basin - Usually, rectangular concrete basins. The basins may contain baffles so that short circuiting is minimized. The basins are constructed with influent and effluent lines to move raw wastewater to the basin and remove treated wastewater from the basin.
       ii. Media - The media supports the biological slime. The media is comprised of circular plastic disks mounted perpendicular to the drive shaft. High density media is packed much more closely together and is used for polishing purposes. The media must contain passages so that air and wastewater can move through the disks. The media must also be resistant to the material in the wastewater.
       iii. Shaft - Supports the media disks and turns so that the media is alternately exposed to wastewater and air. The shafts are supported at their ends by bearing assemblies.
       iv. Drive mechanism - Typically an electric motor driving a sprocket and chain. The energy from the motor drives the shaft and rotates the media through the chain or belt. Some designs have motors directly driving the shaft through a speed reducer. Still other designs allow for “air drives.” Those systems utilize compressed air released through headers in the bottom of the basin to be “caught” by cups in the media. The force of the air in the cups causes the shaft to rotate.
       v. Underdrain - The underdrain system allows for removal of sloughed solids at the bottom of the RBC basin.

   b. Advantages
       i. They are simple - few moving parts.
       ii. They are relatively low cost, both initially and operationally.
       iii. They are stable. In other words they can handle a variety of loading conditions without an upset.
       iv. They produce an easily handled sludge.

   c. Disadvantages
       i. They can freeze up in cold weather - therefore they are typically covered.
       ii. Bearing replacement can be difficult.
       iii. The media can become plugged.
d. Operational concerns
   i. Cold weather operation can be a concern in areas where freezing winter
temperatures are encountered. In these types of climates, enclosures are needed for
the RBC units.
   ii. Odors occur when the filter becomes overloaded. This can possibly be resolved by
recirculating effluent with the influent wastewater.
   iii. Power loss will cause the shafts to stop turning. If the power is lost for more than
4 hours, the shafts should be turned manually about ¼ turn per hour. This will
keep the bacteria moist and provide aerobic conditions.
   iv. Excessive solids build up in the RBC basins can cause treatment efficiency
problems. Pre and primary treatment should be looked at as potential sources of
excess solids.

e. Design considerations
   i. Staging - RBCs are usually divided into four stages with wastewater contacting each
stage in a sequential manner. Four stages have proven most effective for treatment
due to the fact different types of microorganisms predominate in each stage and
provide better removal. Some RBCs consist of a single shaft in a single basin with
baffles providing the means for staging the unit. Other designs call for each stage
to consist of a single shaft in a single basin.
   ii. Parallel vs. perpendicular flow - RBC units can either be arranged so that flow into
and out of the basins is parallel to the shaft, or perpendicular to the shaft. Plants
where four or more shafts are required are usually arranged with perpendicular flow
in order to maximize efficient use of space.

f. Design criteria - KDHE
   i. Must be covered or housed.
   
   ii. Must be preceded by pre and primary treatment - screening, grit removal, and
primary clarification.
   iii. No organic loading based criteria.

g. Design criteria - performance-based
   i. Hydraulic loading - 0.75 - 2 gpd/ft² of media
   ii. Organic loading - 1.5 lb/1000 ft²/day soluble BOD
   iii. Organic loading - 3.0 lb/1000 ft²/day total BOD
   iv. Max first stage organic loading - 6 lb/1000 ft²/day soluble BOD
   v. Max first stage organic loading - 12 lb/1000 ft²/day total BOD
   vi. Add 15% more media for each 5°F decrease in water temperature below 55°F
   vii. Basin volume - 0.12 gal/ft² of media

RBC Staging and Flow
3. Biotowers - Biotowers can simply be thought of as above-ground trickling filters. In fact, many people do not differentiate between trickling filters and biotowers. Biotowers operate on the same principles as trickling filters. Biotowers typically use plastic media, or a redwood media that consists of rough sawed redwood slats. Since towers usually have a metal frame with metal or fiberglass panel walls, they cannot structurally support rock media.

Biotowers usually range from 14 to 40 feet high, which does not differentiate them from standard trickling filters. They can be round or rectangular and have fixed or rotating distribution systems. Rectangular towers with fixed are the simplest to construct and typically have the lowest cost.

C. Activated sludge - Activated sludge is probably the most complex secondary treatment process. To add to the complexity, there are a number of variations on the process. We will try to keep the explanations of the various process simple, and not dwell on too many details.

Regardless of the variations the processes operate under the same principal - growing microorganisms in an aerobic suspension that utilize wastewater as a food source. The suspended microorganisms are referred to as the mixed liquor suspended solids, or MLSS. As the microorganism population grows, some of the microorganisms must be removed, or wasted to maintain the proper balance between the food and the microorganisms. This is referred to as the food-to-microorganism ratio (F/M). It is also important to provide sufficient air to the microorganisms to provide aerobic conditions.

The F/M is important in the activated sludge process. Maintaining the proper ratio will dictate not only the degree of BOD removed, but also how well the sludge can be settled and further managed. At a very high F/M microorganisms are in an "exponential growth phase". This means they are growing very fast and rapidly metabolizing the organics in the wastewater. The problem with operating an activated sludge in this phase is that the sludge settles poorly and some BOD carries through the process untreated.

At the other end of the spectrum is the "endogenous growth phase". In this phase there is an initial rapid growth, but the microorganisms are maintained in a state of near starvation. They are starved to the point that the bacteria began to metabolize themselves. This means that most all BOD added to the system is readily consumed. This also produces a good settling sludge.

Between endogenous and exponential phases is the "declining growth phase." At the beginning of the declining growth phase, the reproduction rate of microorganisms equals their death rate. Some activated sludge systems are operated at the low end of this phase. BOD removal is good, however the settleability of the sludge decreases.
In order to maintain the F/M, sludge not only must be wasted routinely, but there must also be provisions made for recycling sludge to the aeration tank where the sludge is kept in suspension. This is typically provided for by pumping settled microorganisms from a clarifier back to the aeration tank. The wasted sludge is referred to as WAS, or waste activated sludge, while the recycled sludge is referred to as RAS, or return activated sludge. The measure of how long sludge is actually in the system when taking into account its initial time in the aeration tank and time spent in the aeration tank as RAS is referred to as sludge age (θc). The sludge age increases as the F/M decreases.

The variations on the activated sludge process are as follows:

1. Conventional activated sludge - This process involves the use of a long rectangular tank with air diffusers on one side of the bottom of the tank. These operate in the lower end of the declining growth phase.

2. Complete mix activated sludge (CMAS) - CMAS involves keeping the activated sludge and air intimately mixed by adding air with or without additional mechanical mixing. Due to the intense mixing, this process can handle a BOD load around three times higher than the conventional process. These operate in the upper end of the declining growth phase.

3. Extended aeration activated sludge - This process is similar to the CMAS, however the BOD loading is much less and the final clarifier is designed to have a low surface loading. The low loading gives a low F/M, thus the process operates in the endogenous phase. The extended aeration process can take place in traditional round or rectangular tanks, however, oxidation ditches are a version of the extended aeration process.

4. Contact stabilization activated sludge - Contact stabilization allows for reaeration of the return activated sludge in a reaeration tank. Since the return sludge has a high oxygen content, the initial aeration basin can be smaller than in the conventional process.

5. Sequencing batch reactor (SBR) activated sludge - This process is a variation of the complete mix process. The difference that aeration and settling take place in the same tank. Therefore, there must be multiple tanks in the SBR process. The typical sequencing in a three tank process would involve one tank being filled with a "batch" of wastewater, one tank aerating a "batch" of wastewater, and the third tank settling a "batch" of treated wastewater and solids and decanting the effluent.
The following table provides some of the important operational parameters for the various activated sludge process.

<table>
<thead>
<tr>
<th>Process</th>
<th>F/M</th>
<th>MLSS (mg/l)</th>
<th>Sludge Age (days)</th>
<th>Aeration Period (hrs)</th>
<th>RAS Rate (%)</th>
<th>BOD Removal (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional</td>
<td>0.2-0.5</td>
<td>1000-3000</td>
<td>3-15</td>
<td>6.0-7.0</td>
<td>30</td>
<td>80-90</td>
</tr>
<tr>
<td>CMAS</td>
<td>0.2-1.0</td>
<td>1000-6500</td>
<td>1-15</td>
<td>2.5-3.5</td>
<td>100</td>
<td>70-85</td>
</tr>
<tr>
<td>Extended Aeration</td>
<td>0.05-0.2</td>
<td>1500-5000</td>
<td>20+</td>
<td>20-30</td>
<td>100</td>
<td>85-95</td>
</tr>
<tr>
<td>Contact Stabilization</td>
<td>0.2-0.5</td>
<td>1000-3000(^a) 4000-9000(^b)</td>
<td>20+</td>
<td>6.0-9.0</td>
<td>100</td>
<td>75-90</td>
</tr>
<tr>
<td>SBR</td>
<td>0.05-0.3</td>
<td>1500-5000</td>
<td>NA</td>
<td>6.0-20.0</td>
<td>NA</td>
<td>85-90</td>
</tr>
</tbody>
</table>

\(^a\) Aeration basin (contact)  
\(^b\) Reactor basin (stabilization)
Conventional Activated Sludge

Complete Mix Activated Sludge

Extended Aeration Activated Sludge - Oxidation Ditch

Contact Stabilization Activated Sludge

Activated Sludge Process Variations
D. Secondary clarification - Regardless of the secondary process used, secondary clarification is necessary both to settle solids escaping from the system and to provide return sludge to the system. Secondary clarifiers are similar in design to primary clarifiers, however they are sized somewhat differently. Some of the design parameters are:

<table>
<thead>
<tr>
<th>Treatment Type</th>
<th>Overflow Rate (gal/ft²/day)</th>
<th>Weir Loading Rate (gal/ft/day)</th>
<th>Depth (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activated Sludge</td>
<td>400-800</td>
<td>10,000-20,000</td>
<td>12-20</td>
</tr>
<tr>
<td>Extended Aeration</td>
<td>200-400</td>
<td>10,000-20,000</td>
<td>12-20</td>
</tr>
<tr>
<td>Trickling Filter</td>
<td>400-600</td>
<td>10,000-20,000</td>
<td>10-15</td>
</tr>
<tr>
<td>RBC</td>
<td>400-800</td>
<td>10,000-20,000</td>
<td>10-15</td>
</tr>
</tbody>
</table>
V. A "Primer" on Pumping

A. Common types of pumps used in wastewater treatment

1. Positive displacement - These pumps are so named because they discharge a fixed volume with each stroke or revolution.

   a. Types of positive displacement pumps.

      i. Reciprocating pumps. These typically employ pistons, plungers or diaphragms. Liquid is drawn into the closed chamber as a piston or plunger draws back then is expelled under pressure as the piston pushes forward. Energy is added by these pumps on an intermittent basis - in the case of a piston pump, every time the piston forces liquid out of the chamber.

      ii. Rotary action pumps. These pumps typically employ screws or progressing cavities. Progressing cavity pumps are sometimes referred to as Moyno™ pumps due to the popularity of that particular brand.

   b. Typical uses

      i. Sludge pumping - typically progressive cavity and piston pumps.

      ii. Raw wastewater pumping - screw pumps.

      iii. Chemical feed - diaphragm and plunger pumps.

2. Centrifugal - These are also known as "kinetic" pumps because they convert the kinetic energy of water to pressure.

   a. Pump components - To understand how a centrifugal pump works, we need to understand the components of a centrifugal pump.

      i. Impeller - This portion of the pump spins and throws water to the outer casing of the pump. Water enters the impeller at the hub, or eye, and flows radially out to the casing as it is flung by the impeller vanes. The outward flow is referred to as centrifugal force.

      ii. Casing - The casing houses the impeller and keeps the water from flying in every direction.

      iii. Inlet or suction line - The opening on the suction side of the pump.

      iv. Outlet - The opening on the discharge side of the pump.

      v. Packing - The material around the impeller shaft that keeps water from leaking out around the shaft.
b. Typical uses - used for large volumes of wastewater not requiring fine control. They pump at a steady flow.
   i. Pumping raw wastewater in pump stations.
   ii. Pumping of wastewater within a treatment facility.
   iii. Pumping treated wastewater.
   iv. Typically not used for pumping thicker liquids like sludge.

B. Head - Head is another way to express pressure. It has units of feet and is specific to the density of the fluid that you are dealing with. For instance, you may be familiar with the conversion factors:

\[
\begin{align*}
2.31 \text{ ft of water} &= 1 \text{ psi} \\
2.04 \text{ in mercury} &= 1 \text{ psi}
\end{align*}
\]

Head has several components. The first major division is between its static and total dynamic components. Static means that a system is stationary - there is no movement of fluid. Dynamic is the opposite, there is fluid movements. The following drawings express the static components.

1. **Static discharge head** is the distance between the centerline of the pump and the free surface of a liquid in a tank or its point of free discharge. This is typically the elevation difference between a pump and the water level in the structure to which it discharges.

2. **Static suction head** is the distance between the centerline of the pump and the free surface of a liquid in a tank. If the free level of the liquid is below the centerline of the pump, the static suction head is negative, and referred to as static suction lift.

3. **Total static head** is the distance between the free surface of a liquid in a supply tank and the free surface of a liquid in a discharge tank or its point of free discharge.

Dynamic head, incorporates the components of static head in its computation, but must also take into account friction head - friction encountered in pipes and fittings - as well as discharge velocity head. The discharge velocity head is the amount of energy (or head) required to accelerate water to
its specific velocity. Typically, the discharge velocity head is negligible. The friction head is often negligible except where you have long runs of pipe or lots of bends and turns. The components of dynamic head are:

1. **Total dynamic discharge head** is the sum of the static discharge head \( h_s \), the friction head \( h_f \), and the discharge velocity head \( h_{vd} \).

\[
H_d = h_{sd} + h_t + h_{vd}
\]

You can see that the dynamic head is always greater than the static head. Therefore, to lift water say 10 feet, you will need to have a pump that can overcome the 10 feet, plus some additional head from friction and velocity head losses.

2. **Total dynamic suction head** is the static suction head minus the friction head in the suction line. If the free level of the liquid is below the centerline of the pump, the dynamic suction head is always negative, and referred to as total dynamic suction lift.

\[
H_s = h_{s} - h_f
\]

3. **Total dynamic head** (TDH) is the total discharge head minus the total dynamic suction head.

\[
TDH = H_d - H_s
\]

Since we have stated that if suction lift is involved, \( H_s \) is negative. Therefore, because we would be subtracting a negative, the equation would be written

\[
TDH = H_d + H_s
\]

C. Piping and valving.

1. Friction loss. We have already stated that piping and valving can be a source of friction head or friction loss in a pumping system. This friction loss is a function of the pipe roughness, its diameter, and the velocity of the fluid in the pipe. Valves and other fixtures cause friction loss due to the more tortuous path of flow in comparison to straight pipe. In other words there is less resistance to flow in a piece of straight pipe than there is through a valve, an elbow, a tee, etc. There are graphs available that estimate the length of straight pipe that is equivalent to a fitting in terms of head loss. There are tables available that provide the amount of friction loss in a straight pipe based on its diameter and the flow rate through the pipe.

2. Piping arrangements. All centrifugal pumps should be followed by a check valve then a gate valve. The check valve will ensure fluid discharged from the pump will not be allowed to run back through the pump. Gate valves allow for a positive means for eliminating backflow through the pump when it is removed from service for repair or replacement.
If a pump has positive static head (the supply is above the pump centerline), a gate valve also should be placed on the suction side of the pump so that it can be removed.
VI. Safety

The most important consideration for any operator should be safety. Statistics show that being a wastewater operator is a very dangerous profession. Extreme caution should be observed in every facet of the job. The main thing to guide your thinking in the area of safety is that NO JOB IS WORTH PUTTING YOURSELF IN A POSITION TO BE MAIMED OR KILLED! The most important general topics to discuss include:

A. Confined Space Entry (Note: This is an overview. Specialized training is required by OSHA for entry into permit confined spaces)

1. What is a confined space?
   a. The space is large enough to physically enter.
   b. The space has a limited means for entry and exit.
   c. The space is not designed for continuous human occupancy.

2. What is a permit required confined space? It means that the Confined Space has one or more of the following characteristics.
   a. The space contains or has the potential to contain a hazardous atmosphere.
   b. The space contains a material that has the potential for engulfing an entrant.
   c. The space’s internal configuration is such that the entrant could be trapped or asphyxiated.

3. Non-permit Confined Space is a confined space that does not contain, or have the potential to contain, any hazard capable of causing death or serious physical harm.

4. Types of Confined Spaces
   a. Enclosed Spaces: Storage tanks, tank cars, process vessels, bins, etc.
   b. Opened Top Spaces: Bins, pits, vats, tubs, vaults, silos, etc.
   c. Utilities: Ventilation and exhaust ducts, manholes, sewers, etc.

5. Types of Hazards
   a. Toxic substance in toxic or fatal concentrations.
   b. Flammable or combustible gases or vapors.
   c. Oxygen deficiency.
   d. Exposure to adverse physical environments such as noise, temperature, etc.
6. Causes of Workplace Accidents
   a. Entering confined space without testing.
   b. Entering a space without providing adequate ventilation.
   c. Using welding hoses and valves without periodically checking for leaks.
   d. Stirring up potentially hazardous sludges in a confined space.
   e. Using air-purifying respirators in oxygen deficient atmospheres.
   f. Not checking for possible nearby release of toxic or flammable material.
   g. Re-entering a confined space after leaving it, and not retesting it.
   k. Toxic vapors or gases in concentrations that are health or life threatening.
   l. Flammable gases or vapors with the potential for fire or explosion.
   m. Oxygen deficiency.
   n. Electric shock from portable lights, tools, or associated equipment.
   o. Mechanical equipment that may be defective, incorrectly operated, or not properly deactivated and locked out.

7. Preliminary Steps for Entry
   a. Precautions
      *Barricading or posting the work area.
      *Review Material Safety Data Sheet for any material taken into the space.

   b. Fire Protection
      *Prohibit hot work.
      *Intrinsically safe electrical equipment.
      *Prohibit smoking in work area.
      *Store flammable liquids in safety cans.
      *Keep fire extinguishers on hand.
      *Use of pressurized cylinders containing fuel gases is prohibited.
      *Inside the space, pre-plan for a fire.

   c. Isolation
      *Lines leading into the vessel that may contain hazardous gases or liquids must be disconnected.
*Blanking or Capping the line.
*Best method is "Daylight between the flanges."

d. Lock-Out and Tag-Out
  *A lock and/or tag must be placed on an open circuit or line switch.
  *A mechanical linkage may be disconnected.
  *Once de-energized, try to restart it.

c. Cleaning/Purging the Space
  *The space should be emptied and the residual pumped out.
  *Flush the space.
  *Purging the space with an inert gas such as nitrogen may be necessary.
  *ventilate the space.

f. Air Monitoring
  * Oxygen content
  * Flamability

B. Lock Out/Tag Out - OSHA requires that any equipment that could unexpectedly release energy during its repair or renovation be locked out (prevented from releasing energy). This could include both electrical or hydraulic energy (spring-loaded valve for instance).

Switches and valves must be designed to accept a lockout device such as a combination or keyed padlock. The lock must prevent the device from accidentally starting or releasing energy. A tag must be prominently displayed that states the equipment being locked out to indicate the tagged equipment should not be operated until the tag is removed.

Typical lockout/tagout procedures include:

a. Notify all employees affected by a lockout piece of equipment why it is locked out and the consequences of unauthorized removal of the lockout device.

b. If equipment is currently operating, follow normal shut-down procedures.

c. Operate valves or switches to isolate a device from it energy source. Check valves, or air relief valves may have to be bled down to release energy.

d. Lockout and tagout the switch or valve with the assigned lock and tag.

e. Check switches and valves to ensure the lockout device is working. Return the switch or valve to the OFF or NEUTRAL position when done.

f. The equipment can now be worked on.

g. After work is complete, tools have been removed, safety shields replaced, and employees are clear, remove the tag and lockout device. Follow normal start up procedures for the equipment.
Small Wastewater System Workshop

C. Personal Hygiene/Health - Although you probably do an excellent job of treating your wastewater, it can still carry pathogens. Therefore, you should:

1. Never eat food, smoke, or put your hands near your mouth without first washing them after having worked with the treatment system. You may directly transmit pathogens to your body.

2. Don’t wear your work clothes home. You can spread pathogens if your clothing has been exposed to wastewater.

3. Clean your equipment when you are finished with it. It can harbor disease.

4. Keep your fingernails short and clean. Disease can be carried under your nails.

5. Treat exposed cuts or scrapes immediately. Remember, a cut provides for direct exposure of your body to disease.

6. See a doctor for all injuries.

7. Be up-to-date on innoculations and boosters for waterborne diseases - particularly diphtheria and tetanus.

You should also carefully review the Safety Around Ponds section of the EPA manual titled Operations Manual - Stabilization Ponds included in Appendix A.
VII. Math

Math problems have traditionally given operators problems (no pun intended). However, with an understanding of the types of math problems presented to operators, an understanding of how math is performed on units of measurement, and some practice, math problems can be fairly simple. We will focus on the common types of problems faced by wastewater operators, and how mathematic calculations are applied to units of measure.

A. Units of measure This is probably the most overlooked part of solving math problems encountered by operators. Each term in a mathematical calculation must be in the correct units. For instance, if you want to know the area of a channel in square feet, but you are given the measurements of the channel as 2 feet long by 18 inches wide, you need to get the width in units of feet in order to make a correct calculation. You always need to write down the units with the numbers when performing your calculations. You also need to understand that units can be multiplied and divided just like numbers.

As an example, take the 2 foot by 18 inch channel discussed above. To compute the area we multiply the length by the width. We also need to get the width in terms of feet.

\[ 2 \text{ ft} \times 18 \text{ inches} \div 12 \text{ inches} = 3 \text{ square feet} \]

NOTE: A table of conversion factors and formulas is included in Appendix B.

B. Common types of problems

1. **Areas** - these types of problems are found when you want to compute the surface area of a basin, a wall, or the cross-sectional area of a rectangular channel, or a circular pipe. This is also the first step in computing volumes of tanks and pipes. You would need to know this type of information if you were painting a basin or wall - the paint can generally states that a gallon of paint will cover so many square feet of area. You might also use this information to find the area of a rectangular channel or pipe so that velocity or flow could be computed.

   a. Rectangles - Area \( A = \text{Length} \times \text{Width} \)

   **Note:** a square is a special kind of rectangle where the length and width are equal.

   See page VII-4 for example problems.

   b. Circle - Area \( A = \pi \times \text{diameter}^2 \div 4 \), or
      \[ A = \pi \times \text{radius}^2 \], or
      \[ A = 0.785 \times \text{diameter}^2 \]

      **Notes:** \[ \pi = 3.1416 \]
      \[ 0.785 = \pi \div 4 \]

      See page VII-5 for example problems.
2. **Volumes** - these types of problems are found when you want to compute the volume of a basin, a rectangular channel, or a circular pipe. You would need to know this type of information if you were going to figure how much wastewater a basin or pipe would hold, computing flow rates, how much sludge was on a drying bed, output from a piston pump, etc. You might also use this information to find the area of a rectangular channel or pipe so that velocity or area could be computed.

   a. Rectangles - Volume (V) = Length (L) x Width (W) x Height (H)

      
      Volume (V) = Area (A) x Height (H)

   
   See page VII-6 for example problems.

   b. Circle -

      Volume (V) = π x diameter (d)² / 4 x Height (H), or

      Volume (V) = π x radius (r)² x Height (H), or

      Volume (V) = 0.785 x diameter (d)² x Height (H), or

      Volume (V) = Area (A) x Height (H)

   Notes:  

   π = 3.1416

   0.785 = π / 4

   See page VII-7 for example problems.

3. **Perimeter or Circumference** - these types of problems are found when you want to compute the length around the edge of a round or rectangular basin, a rectangular channel, or a circular pipe. You would need to know this type of information if you were going to figure how much weir length you had around a basin, the amount of insulation needed to wrap a pipe, the amount of fence needed to enclose a facility, or the surface area of a round tank.

   a. Rectangles - Perimeter = L + L + W + W

      Perimeter = 2 x (L + W)

   
   Note: a square is a special kind of rectangle where the length and width are equal.

   See page VII 7 for example problems.
b. Circle - Circumference = \( \pi \times \text{diameter} \), or
Circumference = \( \pi \times \text{radius} \times 2 \)

Notes: \( \pi = 3.1416 \)

*See page VII-8 for example problems.*

4. **Milligrams per liter/Pounds per day** - these type of problems are found when you want to compute pounds of a certain material given its concentration in mg/l, or the concentration of a material given how many pounds are added to a liquid. You would need to know this information if you need to calculate the pounds of solids under aeration or for disposal given their concentration. Likewise, you may want to know the dose of a chemical in mg/l based on the number of pounds fed - chlorine is a good example.

a. Weight - lb/day = concentration (mg/l) \( \times \) flow (MGD) \( \times \) 8.34

b. Concentration - \( \frac{\text{mg/l}}{\text{lb/day}} = \frac{\text{lb/day}}{\text{flow (MGD)} \times 8.34} \)

*See page VII-8 for example problems.*

5. **Flow rate** - these type of problems are found when you want to compute the flow in a pipe or a channel. You would need to know this information to compute the flow or velocity through a pipe or channel.

Flow \( (Q) = \text{Velocity (V)} \times \text{Area (A)} \)
Velocity \( (V) = \frac{\text{Flow (Q)}}{\text{Area (A)}} \)

*See page VII-9 for example problems.*

6. **Detention time** - these type of problems are found when you want to compute the amount of time water will be held in a basin or pipe. You would need to know this information to determine how long it would take a basin to fill, how long a plugged sewer pipe could hold flow until it discharged, or how long wastewater would be detained in treatment unit such as a clarifier.

Detention Time \( (DT) = \text{Tank or Pipe Volume (V)} + \text{Flow (Q)} \)

*See page VII-10 for example problems.*
Area Problems

Rectangles

1. You need to make a stop plate for one of the sides of your influent splitter box. The opening is 20 inches wide by 2 feet high. You find out that the 1/4" steel plate you want to use weighs about 30 pounds per square foot. How much will your stop plate weigh?

GIVEN: PLATE 20" WIDE & 2' LONG

\[
\text{WEIGHT} = 30 \text{ LB/FT}^2
\]

\[
A = L \times W = \frac{2 \text{ FT}}{12 \text{ IN}} \times \frac{20 \text{ IN}}{1 \text{ FT}} = 3.33 \text{ FT}^2
\]

\[
\text{WEIGHT} = \frac{30 \text{ LB}}{\text{FT}^2} \times 3.33 \text{ FT}^2 = 100 \text{ LB}
\]

2. You are given the job of painting the office building at the treatment plant. The building is square with each wall being 20 feet long by 10 feet high. The hardware store tells you that the paint you need to use covers 150 square feet per gallon. How many gallons of paint do you need? You can ignore windows and doors.

GIVEN: WALLS 20' LONG x 10' WIDE

\[
\text{#WALLS} = 4 \quad \text{PAINT} = 150 \text{ FT}^2/\text{gal}
\]

\[
A = L \times W = \frac{20 \text{ FT}}{10 \text{ FT}} = 200 \text{ FT}^2/\text{WALL}
\]

\[
4 \text{ WALLS} = 200 \text{ FT}^2 \times 4 = 800 \text{ FT}^2
\]

\[
\text{PAINT} = \frac{800 \text{ FT}^2}{150 \text{ FT}^2} = 5.3 \text{ GAL} \quad \bullet \bullet \text{ NEED 6 gal}
\]
3. The surface area of a lagoon is one-half acre. One side of the lagoon is 195 feet long. How long is the other side?

GIVEN: \( A = 0.5 \text{ AC} \)  \( L = 195' \)

\[ A = L \times W \]

\[ W = \frac{A}{L} \]

\[
W = \frac{0.5 \text{ AC}}{195 \text{ FT}} \times \frac{43.560 \text{ FT}^2}{\text{AC}} = 112 \text{ FT}
\]

---

Circles

1. What is the area of the opening of a 12-inch diameter pipe?

\( d = 12" = 1' \)

\[ A = \frac{\pi d^2}{4} \]

\[ A = \frac{\pi}{4} \times (1 \text{ FT})^2 = 0.785 \text{ FT}^2 \]
Volume Problems

Rectangles

1. You have an influent splitter box that is 10 feet wide, 10 feet long, and 15 feet deep. If you keep 2 feet of freeboard in the box, how much wastewater can it hold?

GIVEN: L = 10'  W = 10'  H = 15'

FREEBOARD = 2'

HEIGHT OF WATER = 15' - 2' = 13'

\[ V = L \times W \times H \]

\[ V = 10 \text{ FT} \times 10 \text{ FT} \times 13 \text{ FT} = 1300 \text{ FT}^3 \]

\[ V = \frac{1300 \text{ FT}^3}{7.48 \text{ gal/FT}^3} = 9724 \text{ gal} \]

2. Your pond is going to be de-sludged. The bottom area of the pond is 100 feet by 200 feet. The sludge has been measured as being 2 feet deep. Disregarding the sloped sides in the pond how many gallons of sludge do you have to dispose of?

HINT: Treat this as a rectangular volume.

GIVEN: L = 200 FT  W = 100 FT  H = 2 FT

\[ V = L \times W \times H \]

\[ V = 200 \text{ FT} \times 100 \text{ FT} \times 2 \text{ FT} = 40,000 \text{ FT}^3 \]

\[ V = \frac{40,000 \text{ FT}^3}{7.48 \text{ gal/FT}^3} = 299,200 \text{ gal} \]
Circles/Cylinders

1. You have to use water to leak test a length of sewer pipe. The pipe is 12-inch in diameter and 300 feet long. How much water would it take to completely fill this section of pipe?

\[
V = A \times L, \quad \text{WHERE } A = \frac{\pi d^2}{4}
\]

\[
V = \frac{\pi}{4} (1 \text{FT})^2 \times 300 \text{ FT} = 236 \text{ FT}^3
\]

\[
V = 236 \text{ FT}^3 \times 7.48 \text{ gal/FT}^3 = 1763 \text{ gal}
\]

Perimeter Problems

Rectangles

1. You need to fence your lagoon facility. Your facility covers 2 acres and is approximately square. How many linear feet of fencing will you need? You can ignore any gates.

\[
\text{GIVEN: } A = 2 \text{ AC}
\]

\[
\text{PERIMETER } = 2 \times (L + W) \quad \text{FOR A SQUARE, } L = W
\]

\[
\text{AREA } = L \times W = L \times L = L^2
\]

\[
L^2 = 2 \frac{\text{AC}}{43,560 \text{ FT}^2} = 87,120 \text{ FT}^2
\]

\[
L = \sqrt{87,120} = 295 \text{ FT}
\]

\[
\text{PERIMETER } = 2 (295 + 295) = 1180 \text{ FT OF FENCE}
\]
Circles/Cylinders

1. For safety precautions, you need to set up safety fence around a 10-foot diameter excavation. How many feet of fencing do you need?

GIVEN: \( d = 10' \)

CIRCUMFERENCE = \( C = \pi d \)

\[ = \pi \times 10 \text{ FT} = 31.4 \text{ FT} \]

Milligram per Liter/Pounds per Day Problems

Weight

1. You have a flow of 100,000 gpd at your non-discharging lagoon system. The influent BOD has been measured as 175 mg/l. How many pounds of BOD are being treated at your plant? BONUS: Knowing that your lagoon system should not be loaded any higher than 34 lbs/acre/day, how many surface acres of ponds would you need to comply with the loading requirement?

GIVEN: \( Q = 100,000 \text{ gpd} = 0.1 \text{ MGD} \) \( \text{BOD}_{\text{in}} = 175 \text{ mg/l} \)

\( \text{LB/DAY} = \frac{\text{Mg/l} \times \text{MGD} \times 8.34}{175 \text{ mg/l} \times 0.1 \times 8.34} = 146 \text{ LB/DAY} \)

Concentration

1. You have a flow of 0.5 MGD at your plant. You are feeding 15 pounds of chlorine per day to the effluent for disinfection. What is the dosage rate in mg/l?

GIVEN: \( Q = 0.5 \text{ MGD} \) \( \text{CHLORINE} = 15 \text{ LB/DAY} \)

\[ \text{Mg/l} = \frac{\text{LB/DAY}}{\text{MGD} \times 8.34} \]

\[ \text{mg/l} = \frac{15 \text{ LB/DAY}}{0.5 \text{ MGD} \times 8.34} = 3.6 \text{ mg/l} \]
Flow Rate Problems

Rectangles

1. You have a rectangular channel with a wastewater velocity of 1 fps. The channel is 2 feet wide and flowing at 1 foot in depth. What is the flow rate through the channel in cfs and gpm?

GIVEN: \( V = 1 \text{ fps} \quad L = 2', \quad W = 1' \)

\[
Q = VA \quad A = L \times W
\]

\[
A = 2 \text{ FT} \times 1 \text{ FT} = 2 \text{ FT}^2
\]

\[
Q = VA = 1 \text{ FT} \times \frac{2 \text{ FT}^2}{S} = 2 \text{ FT}^3/S = 2 \text{ cfs}
\]

\[
Q = 2.0 \text{ cfs} \quad \frac{448.83 \text{ gpm}}{\text{cfs}} = 898 \text{ gpm}
\]

Circles/Cylinders

1. You want to know the flow rate in an 8-inch sewer pipe running full. The velocity is 3 fps. What is the flow rate?

GIVEN: \( d = 8'' \quad V = 3 \text{ FT/S} \)

\[
Q = VA, \quad A = \frac{d^2}{4}
\]

\[
d = 8'' \times \frac{1 \text{ FT}}{12 \text{ IN}} = 0.67 \text{ FT}
\]

\[
A = \frac{\pi}{4} \left(0.67 \text{ FT}^2\right) = 0.35 \text{ FT}^2
\]

\[
Q = VA = 3 \text{ FT} \times \frac{0.35 \text{ FT}^2}{S} = \frac{1.05 \text{ FT}^3}{S} = 1.05 \text{ cfs}
\]
Detention Time Problems

Rectangles

1. You have a rectangular lagoon with bottom dimensions of 400 feet by 200 feet. At the operating depth of 5 feet, the surface area of the lagoon is 430 feet by 230 feet. At a flow of 20 gpm, what is the detention time of the lagoon in units of days?

GIVEN: \( \text{TOP} = 430' \times 230' \quad \text{BOTTOM} = 200' \times 400' \)

\[ Q = \text{gpm} \quad H = 5' \]

\[ DT = \frac{V}{Q}; \quad V = L \times W \times H = A \times H \]

FIND \( \overline{AVG} \) AREA OF LAGOON

\[ \overline{TOP} = \frac{430 \text{ FT} \times 230 \text{ FT}}{2} = 98,900 \text{ FT}^2 \quad \overline{BOTTOM} = \frac{200 \text{ FT} \times 400 \text{ FT}}{2} = 80,000 \text{ FT}^2 \]

\[ \overline{AVG} = \frac{(98,900 \text{ FT}^2 + 80,000 \text{ FT}^2)}{2} = 89,450 \text{ FT}^2 \]

\[ V = A \times H = 89,450 \text{ FT}^2 \times 5 \text{ FT} = 447,250 \text{ FT}^3 = 3,345,430 \text{ gal} \]

\[ DT = \frac{V}{Q} = \frac{3,345,430 \text{ gal}}{20 \text{ gal}} = 167,271 \text{ MIN} = 2788 \text{ HR} = 116 \text{ DAYS} \]

Circles/Cylinders

1. You have to temporarily shut down the pump station located at your lagoon to make a quick repair. The gravity line leading to the pump station is 12-inches in diameter. 1000 feet of line would have to be filled up before you would start to bypass the collection system. At a flow of 130 gpm, how long would you have to work on the pump station before bypassing would occur?

GIVEN: \( d = 1 \text{ FT} \quad L = 1000 \text{ FT} \)

\[ DT = \frac{V}{Q}, \text{ WHERE} \quad V = \frac{\pi \cdot d^2}{4} \times L \]

\[ V = \frac{\pi \cdot (1 \text{ FT})^2}{4} \times 1000 \text{ FT} = 785 \text{ FT}^3 \]

\[ V = 785 \text{ FT}^3 \times 7.48 \text{ gal/FT}^3 = 5872 \text{ gal} \]

\[ DT = \frac{5872 \text{ gal}}{130 \text{ gal}} = 45 \text{ MIN} \]
Appendix A

EPA Ponds Manual
THE PHENOMENON OF POND LIFE
The process that takes place in a pond or lagoon is an interesting one because it is a natural cycle, continuous and a living phenomenon. As with humans, conditions and life are always changing. It is difficult to predict, with certainty, what will be happening. Changes may be due to temperature, weather, changes in the kinds of algae, and other living organisms as well as changes in the types of wastes.

Life in a pond is made up of billions of tiny microscopic plants and animals co-existing and depending on each other. In fact, it is this relationship that makes a pond work. The plant forms are the many different forms of bacteria and algae which can use soluble substances as food by absorbing it through their skin or membrane. The animal forms are higher species of free-swimming creatures who use solid matter and bacteria and algae as food by ingesting it through their mouth.

\[Paramoecium\]
\[Vorticella\]

The microbiology of a lagoon system is important to its operation. An inexpensive microscope can be used by the operator to identify what is happening in the pond. For example, most of the work is done by microscopic bacteria which utilizes the organic substances as food and under the right conditions will come together, form floc and become heavy enough to settle. Other undesirable bacteria may also form which are stringy (filamentous) and are difficult to settle. These become more numerous at low pH's, 6.5 or lower, or in a carbohydrate waste. Green algae of the Chlorella species are desirable because they are mobile and stay near the surface. Filamentous algae have a bluish-green color and are undesirable. Various other algae with different colors can be found in ponds, such as:

- Pyrrophyta - greenish tan to golden brown
- Phaeophyta - brown
- Rhodophyta - red

The last two are found in marine lagoons. The color change is due to pigmentation.

The Role of Bacteria
Bacteria can be classified as those that must have oxygen to live (aerobic) and those that live in an environment without oxygen (anaerobic). Both types break down complex organic substances into soluble matter which passes through cell walls and is converted into energy, protoplasm and end products which diffuse out through the cell wall into the surrounding liquid. While the intake and conversion processes are much the same, the end products are not. Typical products produced by the aerobic bacteria are carbon dioxide, ammonia and phosphates. These are essential food elements for the oxygen producing algae. The anaerobic bacteria which live in the oxygen starved bottom layer of a pond produce carbon dioxide, hydrogen sulfide, ammonia and other soluble material which is diffused into the water as a gas or is used by the aerobic bacteria as food.

Rotifers and crustaceans are often found in ponds where they survive by feeding on the bacteria and algae. One of the most common forms are Daphnia. Oftentimes they can clean a pond of the green algae.
The Role of Algae
As stated earlier, the aerobic bacteria require oxygen for their respiratory system in order to stay alive. This use of oxygen is called oxygen demand and any oxygen remaining is measured as free dissolved oxygen (DO). Water will hold only a certain amount of dissolved oxygen, at which point it becomes saturated. Saturation is dependent upon water temperature. When more than this given amount is present in the water, the water is said to be supersaturated. Cold water can hold more oxygen than warm water per cubic foot.

The demand for oxygen increases as the bacteria and algae increase. And both the bacteria and algae increase as the food supply increases, i.e.: the organic loading.

There are two sources for oxygen. One source is diffusion of air into the water from the atmosphere. The other source is from algae.

Algae are microscopic plants and live in much the same manner as grass or your garden vegetables. They contain chlorophyll which converts sunlight into energy to degrade complex compounds into simpler products and for growth. This phenomenon is called photosynthesis. Other basic requirements are nutrients, principally carbon, nitrogen and phosphorus. And, like your garden vegetables, they grow best under warm temperatures and die off with cold temperatures. The most important role that algae perform in a pond is the production of the major portion of the oxygen.

Since algae need sunlight, they will be found near the surface of a pond. This is called the aerobic layer. The depth of this layer is dependent upon climate and density of algae. It is normally between 6 and 18 inches (15-46 cm), but this layer may extend down to 4 ft. (125 cm) in a well mixed pond. At night, algae will require oxygen in their respiratory system. Thus, when the sun goes down, the algae do not die, but continue to function and consume oxygen, although they have stopped oxygen production. This explains why the dissolved oxygen level will be at its lowest point immediately after sunrise.

There are many forms of algae to be found in ponds, however, two important classifications appear which can be related to the quality of the pond.

1. One is the so-called green algae which gives a pond a green color and indicates a good healthy condition. They are associated with a high pH and with a waste high in nutritional value.

2. The blue-green algae are filamentous and appear when the nutrient and pH levels are low or survive when the higher animal forms such as protozoa devour the green algae. Therefore, the appearance of blue-green algae in a pond is an indication of poor conditions.
shortly after the ice break up in the spring and shortly after the first frost in the fall. One reason these periods are selected is that the algae mass is at its lowest concentration. Deep ponds often experience a "spring turnover" problem when the ice melts and the pond warms up. This is due to increased biological activity and bottom sludge floating to the surface causing temporary odor problems. Most of the time, this will last between 2 to 15 days.

No discharge ponds are those designed to take advantage of an area's evaporation rate and/or ground percolation. In these cases the rate of evaporation and/or percolation equals or exceeds the inflow rate. Often one of the most difficult operating problems associated with these ponds is controlling water depth to discourage weed growth. This can be helped by deliberately adding water to the pond.

Regardless of type of pond, best operation is only achieved when the entire pond is used. When no water movement occurs in a portion of a pond, a condition called short-circuiting results. Short-circuiting can be caused by poor design of inlet and outlet piping arrangements or by uncontrolled growth of water weeds. If either of these conditions occur, they must be corrected.

As mentioned previously, the three major categories of ponds are aerobic, anaerobic, and facultative, other ways of describing them are found in textbooks or are in common use in different parts of the nation.

Some of these definitions are given below. The reader should remember that these are examples of one or more of the above major types.

**STABILIZATION PONDS**
Receive raw untreated wastes and usually consist of two or more cells (individual ponds). The first cell which receives the untreated waste is called a primary cell. The following cell is a secondary cell which is often followed by a polishing cell (or tertiary cell). Stabilization ponds are often designed with two or more primary cells so that they can be operated in parallel to prevent overloading problems.

**OXIDATION PONDS**
Ponds receiving treated waste and operated in series are called oxidation ponds. These may serve as secondary treatment following a standard primary plant.
Most stabilization and oxidation ponds stabilize organic wastes through a complex natural process involving sunlight, oxygen, water currents, algae and bacterial action. Stabilization and oxidation ponds require large surface areas, shallow depths and long detention times for natural stabilization to occur.

**FACULTATIVE PONDS**

Facultative ponds are the most common type of ponds used for stabilization and oxidation lagoons. They have two zones of treatment: an aerobic surface layer and an anaerobic bottom layer. Facultative ponds operate with 3 to 8 feet (1 to 2.4 m) of water depth and are usually loaded between 15 and 80 lbs. BOD per acre (17 and 90 kg per ha) per day. Oxygen for aerobic stabilization in the surface layer is provided by algae and wind action. Decomposition of the sludge in the bottom zone takes place anaerobically. The lagoons are usually designed to provide sufficient waste dilution and natural aeration to ensure that the surface liquid will remain aerobic.

An existing stabilization or oxidation pond can be upgraded by either increasing its detention time or decreasing its surface BOD loading or both. Another method is to deepen the pond and install mechanical aeration. Generally speaking, cold climates may favor the use of compressed air. Intermittent seasonal operation or high oxygen requirements usually favor mechanical aerators or diffused aeration pipelines.

Other ponds are built to serve special purposes.

**SPECIALTY PONDS**

These include high rate aerobic ponds, anaerobic ponds, tertiary ponds, and aerated lagoons.

**High Rate Aerobic Ponds** are usually limited to applications where a high algal mass is desired for harvesting. The algae is then used as food for cattle. These ponds are shallow (about 12-18 inches [30-46 cm]) and usually loaded from 60 to 200 lbs. of BOD per acre (67 to 224 kg per ha) per day.

---

**FACULTATIVE**

---

**ANAEROBIC**

---

**SCUM LAYER**

---

**SHALLOW AEROBIC**

---

**Anaerobic Lagoons** are ponds designed to treat high oxygen demand wastes such as slaughterhouse wastes. The organic loads are so high in these ponds that anaerobic conditions prevail throughout. These ponds are similar to anaerobic digesters or septic tanks.
**Tertiary Ponds** are used for polishing effluents from conventional secondary treatment processes. They are also often used as the last pond of a stabilization or oxidation pond system to remove algae before the effluent is discharged. These ponds are similar to facultative ponds except that they are very lightly loaded, usually less than 15 lbs BOD per acre (17 kg per ha) per day.

**Aerated Ponds** are employed in those cases where supplemental oxygen is needed due to high organic loadings. For example, when a facultative pond becomes overloaded it uses more oxygen than it produces and turns anaerobic. One method to increase oxygen is to install powered aeration equipment. Many ponds are being designed and operated with aeration systems to permit higher loadings in smaller spaces. These ponds then get essentially all of their oxygen by mechanical means and very little algal mass is formed.

**WHAT NATURAL FACTORS AFFECT THE PROCESS**

**Wind Action**
Wind action creates surface mixing on ponds increasing with surface area. Large ponds need riprap on dikes for protection. Wind also tends to remove oxygen from the water when the pond is supersaturated. When the dissolved oxygen is less than saturation, wind action helps to drive oxygen into the water.

**Temperature**
Water will hold more oxygen per cubic foot at a cold temperature than at a warm temperature. As an example, water in the winter time will hold almost twice as much oxygen as in the summertime. However, in colder climates, ice cover prevents adding DO by wind and snow cover prevents algal action for DO production.

Biological activity decreases with temperature, a 10-degree drop in temperature will reduce microbial activity by one half.

Best conditions are when it is warm with good sunlight and a moderate breeze. This produces the greatest bacterial activity and hence the highest BOD removals from the raw waste.
Normal slow changes in temperature produce long-term seasonal effects such as changes from spring to summer.

Abrupt or sudden temperature changes bring about short-term problems. For example, a sudden rise in temperature causes the bacteria to multiply at a rapid rate causing the oxygen demand rate to increase faster than the slower algae can supply the necessary oxygen. This may result in a more turbid effluent than is normal. A sudden drop in temperature can cause a pond to clear up. This occurs because the algae activity slows down and they settle out. An example of this is a sudden frost in the spring or fall. This is normally the time when ponds with controlled discharge are lowered.

Example: Jan. 6-10 mg/l
      May 3.0-0.1 mg/l

The concentration of phosphorus is greatest during cold weather. On the other hand, suspended solids is lowest during cold weather due to decreased algae activity.

Warm weather brings about a great increase in algae growth. Operators can expect to see clouds of "algae blooms" which stops light penetration and reduces oxygen production. The increase in algae growth also causes an increase in suspended solids plus an increase in oxygen demand (BOD) in the effluent of flow through ponds.

Warm weather increases evaporation rates which will change the detention time and may affect the amount of effluent that is discharged.

The arrival of spring also brings on heavy growth of water weeds which may change the pattern of water movement. Scum mats also form on the surface. Both scum and water weeds form excellent breeding grounds for mosquitoes and other insects.

Periods of heavy rainfall affect pond operations as the increased volume of water coming into the pond dilutes the organic waste, it may change pond temperature, will cause a sudden increase in water depth and may shorten detention time.

**Sunlight**

Sunlight is indispensable to effective operation of stabilization ponds through photosynthesis of algae in producing oxygen.

The percentage of available annual sunlight varies throughout the country which is governed by latitude (which governs seasons), elevation and cloud cover. The amount of available sunlight helps to determine how well
the pond operates and the area and depth needed for proper operation.

The depth of sunlight penetration determines the extent to which the pond volume participates in oxygen production and hence, the optimum pond operating depth. Loss of light by reflection increases up to 30 percent when the surface is roughened by the wind.

Algal density, which varies from season to season and pond to pond, determines the depth of light penetration and intensity. In general, with good algal growth and dispersion, oxygen production will be good up to about 24 inches (60 cm) in depth. Oxygen production does not meet the oxygen demand beyond this depth without vertical mixing by wave action. The pond operator can do much to maintain optimum oxygen production by removing duckweed or other materials that reduce light exposure.

All of the preceding remarks can be related to operation by the following summary.

A. Do not decrease water depth to less than three feet (1 m) for warm weather operation.

B. Keep algal blooms dispersed.

C. Keep pond free from duckweed hyacinth or similar weeds.

HOW PHYSICAL FACTORS AFFECT TREATMENT
Surface Area
Surface area is determined by organic loading (lbs. of BOD per acre per day) and is called the surface loading rate. Surface loading determines the type of pond. For example:
- Aerobic Ponds 60-200 lbs. BOD/Acre/Day (67-224 kg per ha)
- Facultative Ponds 15-30 lbs. BOD/Acre/Day (17-35 kg per ha)
- Anaerobic Ponds 200-1000 lbs. BOD/Acre/Day (224-1120 kg per ha)
- Tertiary Ponds 5-15 lbs. BOD/Acre/Day (6-17 kg per ha)

Sometimes surface loading is related to the connected population such as 100 persons per acre per day for facultative systems, but the type of pond will determine the exact figure.

As an example of surface loading, if the organic load is 300 lbs./day, (336 kg/day) on a facultative pond, a minimum of 10 acres (4 hectares) may be required.
Parallel Operation
Parallel operation is used to reduce organic loading in the primary cells. Parallel operation is especially advantageous during winter months so that sewage solids can be distributed over a wider area.

Winter month operation in parallel has the advantage of distributing the load over more surface pond area and this is particularly important when ice covers develop and activity is low. Again, for plants with three cells, the first two should be used in parallel and if the system operates on a controlled discharge, primary cells should be filled at the same time once both are at the 3-foot (9 m) depth and then alternately discharge 6 inches (0.15 m) at a time into the secondary cell until it reaches the same depth as both primaries.

Recirculation
Recirculation is a means of improving pond conditions. This allows oxygen that has been produced by the algae in one pond, or part of the pond, to be mixed with low oxygen areas of the system. Other advantages include a mixing to help prevent odors and anaerobic conditions in the feed zone.

The most common method of recirculation is to recycle effluent from a secondary cell to the effluent of the primary cell. This method obtains the greatest amount of dissolved oxygen.

HOW CHEMICAL FACTORS AFFECT TREATMENT
Oxygen
Oxygen is necessary for maintaining the life forms in an aerobic pond. It is used by the bacteria to stay alive. Oxygen combines with many substances to form oxides and break up many complex organic molecules into simpler molecules making them more available to the bacteria. Since oxygen is used to oxidize these organics, the DO (dissolved oxygen) will decrease in proportion to the amount of organic material present. This is known as the oxygen demand of the waste.

Water will only hold a certain amount of dissolved oxygen. When the amount of air/oxygen entering the water equals the amount leaving the water, it is said to be saturated. In ponds containing algae, the water can become super-saturated with oxygen (more oxygen enters water than is used).

Wind also tends to remove oxygen from the water when the pond is super-saturated. When the dissolved oxygen is less than saturation, wind action helps to drive oxygen into the water.

The strength of the waste can be indirectly measured by the biochemical oxygen demand
(BOD) test. The test measures the amount of oxygen used by the bacteria over a 5-day period. If the demand for oxygen is greater than the supply, the aerobic bacteria will die off and anaerobic conditions will develop along with operational problems. Low dissolved oxygen concentrations result in turbid effluents, bad odors, and the growth of filamentous type of bacteria.

**Nutrients**

Without a sufficient supply of nutrients (nourishment), the bacteria will not be able to grow and multiply. Although several elements are needed, nitrogen and phosphorus are the principal elements required. Domestic wastes usually contain enough of both. Nitrogen is in the form of ammonia (NH₃).

**pH**

This test indicates whether a pond is acid or alkaline. Both the aerobic and anaerobic systems require an alkaline environment for best operation. Operators should check pH of the pond effluent to determine if any toxic materials are entering the pond. The pond color is related to pond pH and should help operators to forecast any impending problems. Green shows a high pH (alkaline). Yellowish-green indicates a lowering pH (acidic). Color may not relate to pH when a strong wind stirs up silt from the bottom or highly colored industrial wastes influence the pond's color.

A lowering pH can be corrected by letting the cell rest for a few days. The pH will change throughout the day and will usually be at its lowest in the early morning and highest in the late afternoon, because algae are most active during daylight and cause chemical reactions that drive pH upward. (CO₂ produced by bacteria at night causes the pH to be lowered.)
As an indicator of pollution the presence of ammonia nitrogen indicates polluted waters, the presence of nitrates still shows pollution but nitrates indicate that nitrification has proceeded sufficiently to produce a stable nitrogen compound.

The following diagram illustrates the steps in nitrification.

![Diagram of nitrification process]

Some plants are also required to test for nitrates and ammonia. The significance of these tests are:

A. If nitrification is occurring, there will be an increase in nitrate with a corresponding decrease in ammonia-nitrogen.

B. In well-nitrified effluent all of the ammonia nitrogen will be converted to nitrates.

**IMPORTANT VISUAL INDICATORS**

**Color**
The color of the pond is directly related to pH and DO. Below are listed the usual general color characteristics.

- Dark sparkling green - good; high pH and DO
- Dull green to yellow - not so good, pH and DO are dropping; blue-green type algae are becoming predominant
- Gray to black - very bad; pond is septic with anaerobic conditions prevailing
- Tan to brown - OK if due to a predominance of a type of brown algae. Not good if due to silt or bank erosion.

In most oxidation ponds, nitrification does not appear, at least on a continuing level. The reason for this is explained by the fact that the nitrifying bacteria tend to settle or need to cling to some surface. Therefore, they are not exposed to compounds in solution.

It has been found that concentrations of more than 20 mg/L of nitrogen can be harmful to fish life, therefore, many pond discharges are required to test for total nitrogen.
3. Operation and Maintenance for Ponds

OPERATION AND MAINTENANCE GOALS FOR STABILIZATION PONDS

1. The pond effluent should:
   a. Meet the NPDES or other regulatory permit levels for BOD and SS for continuous flow systems.
   b. Discharge when it has the best quality and will effect the receiving stream the least.

2. The primary cells should have a deep green sparkling color which indicates high pH and DO.

3. Secondary or final cells should be high in DO and provide an effluent that will meet discharge limits.

4. The surface water should have wave action when wind is blowing. The absence of good wave action may indicate anaerobic conditions or an oily surface.

5. A good pond has no weeds growing in the water nor tall weeds on the bank to stop wave action.

6. Dikes are well seeded above the water line with grasses and kept mowed. This prevents soil erosion and insect problems.

7. Erosion of dikes is prevented at water’s edge by the use of riprap, broken concrete rubble or a poured concrete erosion pad.

8. Inlet and outlet structures are clean. No floating debris, caked scum, or other trash that might produce odors or be unsightly.

9. Mechanical equipment is well maintained with the help of a written schedule and records are kept on lubrication and maintenance.

10. A good pond operation includes a schedule for getting things done. An available plant record shows weather data and basic test results such as pH, DO, BOD, SS, and chlorine residuals.

OPERATION AND MAINTENANCE GOALS FOR ANAEROBIC PONDS

1. Anaerobic ponds operate with no DO.

2. A well-operating anaerobic pond is covered entirely with a dense scum blanket which helps to keep the pond anaerobic and minimizes foul odors.

3. Two important operation considerations:
   a. Keep the pond pH at or near neutral (7.0) to keep the bacteria in balance.
   b. Control of odors by maintaining no DO and a heavy scum blanket.

4. Normally, the anaerobic pond is followed by additional treatment, such as
an aerated pond and polishing cells or a discharge to a separate municipal wastewater treatment plant. Records should be kept on:

a. Detention time

b. Load (BOD and SS)

c. Effluent quality (BOD, SS and pH)

d. Pond content information (pH, SS, alkalinity, volatile acids, scum and sludge depth)

5. The major on-site attendance will be needed mostly in:

a. Maintaining mechanical equipment

b. Keeping pipelines, diversion boxes and screens clean

c. Collecting samples

d. Running lab tests

e. Performing housekeeping

a. Monitor DO at aerated cell outlet daily.

b. Keep logs and large pieces of wood out of the pond to prevent damage to the aerator.

4. For diffused air systems that use a blower and pipelines to diffuse air over entire bottom of pond:

a. Check blower daily

b. Visually inspect aeration pattern for “dead spots” or line ruptures. Repair if necessary to maintain even distribution of air.

c. Measure DO at several points in the pond weekly and adjust air to maintain even distribution.

5. Periodic maintenance must be performed, such as lubrication, adjustment and replacement. The best procedure is to make a checklist of maintenance tasks and frequency from the manufacturer’s instructions bulletins.

OPERATION AND MAINTENANCE GOALS FOR AERATED PONDS

1. Aerated ponds will require the same daily inspections and maintenance used for stabilization ponds plus special attention to the aeration equipment.

2. Maintain a minimum of 1 mg/L DO throughout the pond at heaviest loading periods.

3. Surface mechanical aerators should produce good turbulence and a light amount of froth.

PLANT CHECKLIST

A checklist is a handy tool for the plant operator to schedule activities. Most of the items are visual observations or maintenance needs that take little time if performed according to schedule. With regular attendance, the operator will develop ways to combine some of the duties. In many installations that are looked after regularly by a conscientious operator, the scheduled items can be accomplished in one to two hours a day, allowing the balance of the time for lab and other duties.

The blank form in the Appendix may be used as a guide.
4. Troubleshooting for Ponds

How to control water weeds
How to control burrowing animals
How to control dike vegetation
How to control scum
How to control odors
How to control blue-green algae
How to control insects
How to obtain best algae removal in the effluent
How to correct lightly loaded ponds
How to correct a low dissolved oxygen (DO)
How to correct overloading
How to correct a decreasing trend in pH
How to correct short-circuiting
How to correct anaerobic conditions
How to correct a high BOD in the effluent
How to correct problems in aerated ponds
How to correct problems in anaerobic ponds
4. Troubleshooting for Ponds

## HOW TO CONTROL WATER WEEDS

<table>
<thead>
<tr>
<th>INDICATORS/OBSERVATIONS</th>
<th>PROBABLE CAUSE</th>
<th>SOLUTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weeds provide food for burrowing animals,</td>
<td>Poor circulation, maintenance, insufficient</td>
<td>1. Pull weeds by hand if new growth.</td>
</tr>
<tr>
<td>cause short-circuiting problems, stop wave action so that scum</td>
<td>water depth.</td>
<td>2. Mow weeds with a sickle bar mower.</td>
</tr>
<tr>
<td>can collect and make a nice home for mosquitoes, and odors</td>
<td></td>
<td>3. Lower water level to expose weeds, then burn with gas burner.</td>
</tr>
<tr>
<td>develop in the still area. Duckweed stops sunlight penetration</td>
<td></td>
<td>4. Allow the surface to freeze at a low water level, raise the water level</td>
</tr>
<tr>
<td>and prevents wind action thus reducing the oxygen in the pond.</td>
<td></td>
<td>and the floating ice will pull the weeds as it rises. (Large clumps of</td>
</tr>
<tr>
<td>Root penetration causes leaks in pond seal.</td>
<td></td>
<td>roots will leave holes in pond bottom, best results are obtained when</td>
</tr>
<tr>
<td></td>
<td></td>
<td>weeds are young.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. Increase water depth to above tops of weeds.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6. Use riprap. Caution: If weeds get started in the riprap, they will be</td>
</tr>
<tr>
<td></td>
<td></td>
<td>difficult to remove but can be sprayed with acceptable herbicides.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7. To control duckweed, use rakes or push a board with a boat, then</td>
</tr>
<tr>
<td></td>
<td></td>
<td>physically remove duckweed from pond.</td>
</tr>
</tbody>
</table>

## HOW TO CONTROL BURROWING ANIMALS

<table>
<thead>
<tr>
<th>INDICATORS/OBSERVATIONS</th>
<th>PROBABLE CAUSE</th>
<th>SOLUTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burrowing animals must be controlled because of the damage they</td>
<td>Bank conditions that attract animals. High</td>
<td>1. Remove food supply such as cattails and burr reed from ponds and adjacent</td>
</tr>
<tr>
<td>do to dikes. Rodents such as muskrats and nutria dig partially</td>
<td>population in area adjacent to ponds.</td>
<td>areas.</td>
</tr>
<tr>
<td>submerged tunnels into dikes. If the water level is raised, they</td>
<td></td>
<td>2. Muskrats prefer a partially submerged</td>
</tr>
<tr>
<td>will burrow further and may go on out the top thus weakening the</td>
<td></td>
<td>tunnel, if the water level is raised it</td>
</tr>
<tr>
<td>dike.</td>
<td></td>
<td>will extend the tunnel upward and if lower-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ed sufficiently, it may abandon the tunnel</td>
</tr>
<tr>
<td></td>
<td></td>
<td>completely. They may be discouraged by</td>
</tr>
<tr>
<td></td>
<td></td>
<td>raising and lowering the level 6-8 inches</td>
</tr>
<tr>
<td></td>
<td></td>
<td>over several weeks.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. If problem persists, check with local</td>
</tr>
<tr>
<td></td>
<td></td>
<td>game commission officer for approved</td>
</tr>
<tr>
<td></td>
<td></td>
<td>methods of removal, such as live trapping, etc.</td>
</tr>
</tbody>
</table>
## HOW TO CONTROL DIKE VEGETATION

<table>
<thead>
<tr>
<th>INDICATORS/OBSERVATIONS</th>
<th>PROBABLE CAUSE</th>
<th>SOLUTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>High weed growth, brush, trees and other vegetation provide nesting places for animals, can cause weakening of the dike and presents an unsightly appearance. Also may reduce wind action on the pond.</td>
<td>Poor maintenance.</td>
<td>1. Periodic mowing is the best method.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Sow dikes with a mixture of fescue and blue grasses on the shore and short native grasses elsewhere. It is desirable to select a grass that will form a good sod and drive out tall weeds by binding the soil and “out compete” undesirable growth.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Spray with approved weed control chemicals. Note: Be sure to check with authorities. Some states do not allow chemical usage. All others require that chemicals be bio-degradable. Examples of some herbicides that are used are: Dow Dalapon for cattails Dow Silvex for willows and emergent weeds Ortho Endo-thal for suspended weeds Copper sulfate for filamentous algae Simazine for weeds</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Some small animals, such as sheep, have been used. May increase fecal coliform, especially to the discharge cell. Practice “rotation grazing” to prevent destroying individual species of grasses. An example schedule for rotation grazing in a 3-pond system would be: Graze each pond area for 2 months over a 6-month grazing season.</td>
</tr>
</tbody>
</table>

## HOW TO CONTROL SCUM

<table>
<thead>
<tr>
<th>INDICATORS/OBSERVATIONS</th>
<th>PROBABLE CAUSE</th>
<th>SOLUTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>It is necessary to control scum formations to prevent odor problems and to eliminate breeding spots for mosquitoes. Also, sizeable floating rafts will reduce sunlight.</td>
<td>Pond bottom is turning over with sludge floating to the surface. Poor circulation and wind action. High amounts of grease and oil in influent will also cause scum.</td>
<td>1. Use rakes, a portable pump to get a water jet or motor boats to break up scum formations. Broken scum usually sinks. 2. Any remaining scum should be skimmed and disposed of by burial or hauled to landfill with approval of regulatory agency.</td>
</tr>
</tbody>
</table>
## HOW TO CONTROL ODORS

<table>
<thead>
<tr>
<th>INDICATORS/OBSERVATIONS</th>
<th>PROBABLE CAUSE</th>
<th>SOLUTIONS</th>
</tr>
</thead>
</table>
| Odors are a general nuisance to the public. | The odors are generally the result of over-loading, long periods of cloudy weather, poor pond circulation, industrial wastes or ice melt. | 1. Use parallel feeding to primary cells to reduce loading.  
2. Apply chemicals such as sodium nitrate, Dibrom or Micro-Aid to introduce oxygen. Application rate: 5-15 percent of sodium nitrate per pound of BOD on a pound-for-pound basis. Or apply 200 pounds sodium nitrate per million gallons. See literature for commercial products. Repeat at a reduced rate on succeeding days. Or use 100 pounds sodium nitrate per acre (112 kg/hectare) for first day, then 50 pounds per acre (56 kg/hectare) per day thereafter if odors persist. Apply in the wake of a motor boat.  
3. Install supplementary aeration such as floating aerators, caged aerators, or diffused aeration to provide mixing and oxygen. Daily trips over the lagoon area in a motor boat also helps. Note: Stirring the pond may cause odors to be worse for short periods but will reduce total length of odorous period.  
4. Recirculate pond effluent to the pond influent to provide additional oxygen and to distribute the solids concentration. Recirculate on a 1 to 6 ratio.  
5. Eliminate septic or high-strength industrial wastes. |

## HOW TO CONTROL BLUE-GREEN ALGAE

<table>
<thead>
<tr>
<th>INDICATORS/OBSERVATIONS</th>
<th>PROBABLE CAUSE</th>
<th>SOLUTIONS</th>
</tr>
</thead>
</table>
| Low pH (less than 6.5) and dissolved oxygen (less than 1 mg/L). Foul odors develop when algae die off. | Blue-green algae is an indication of incomplete treatment, overloading and/or poor nutrient balance. | 1. Apply 3 applications of a solution of copper sulfate.  
   a. If the total alkalinity is above 50 mg/L apply 10 pounds of copper sulfate per million gallons in cell (1200 kg/m³).  
   b. If alkalinity is below 50 mg/L reduce the amount of copper sulfate to 5 pounds per million gallons (600 kg/m³).  
   Notes: Some states do not approve the use of copper sulfate since it is toxic to certain organisms and fish.  
2. Break up algal blooms by motor boat or a portable pump and hose. Motor boat motors should be air cooled as algae may plug up water cooled motors. |
## HOW TO CONTROL INSECTS

<table>
<thead>
<tr>
<th>INDICATORS/OBSERVATIONS</th>
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<th>SOLUTIONS</th>
</tr>
</thead>
</table>
| Insects present in area and larvae or insects present in pond water. | Poor circulation and maintenance. | **Solution for Mosquito Control**  
1. Keep pond clear of weeds and allow wave action on bank to prevent mosquitoes from hatching out.  
2. Keep pond free from scum.  
3. Stock pond with Gambusia (Mosquito Fish).  
4. Spray with larvicide as a last resort. Check with state regulatory officials for approved chemicals. (Some that have been used are Durban, Naked, Fenthion and Abate in dosages of 1 mg/L.)  
**Solution for Controlling Midge**  
1. Stock pond with Gambusia.  
2. Spray with approved insecticide. (Fenthion, Abate and Surbisan have been used based on directions on the package.) |

## HOW TO OBTAIN BEST ALGAE REMOVAL IN THE EFFLUENT

<table>
<thead>
<tr>
<th>INDICATORS/OBSERVATIONS</th>
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<th>SOLUTIONS</th>
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</thead>
</table>
| Most of the suspended solids present in a pond effluent are due to algae. Because many single-celled algae are motile and are also very small they are difficult to remove. | Weather or temperature conditions that favor particular population of algae. | 1. Draw off effluent from below the surface by use of a good baffling arrangement.  
2. Use multiple ponds in series.  
3. The use of intermittent sand filters and submerged rock filters may also be used but will require modification and the services of a consulting engineer.  
4. In some cases, alum dosages of 20 mg/L has been used in final cells used for intermittent discharge to improve effluent quality. Doses at or below this level are not toxic. |

## HOW TO CORRECT LIGHTLY LOADED PONDS

<table>
<thead>
<tr>
<th>INDICATORS/OBSERVATIONS</th>
<th>PROBABLE CAUSE</th>
<th>SOLUTIONS</th>
</tr>
</thead>
</table>
| Lightly loaded ponds may produce filamentous algae and moss which limits sunlight penetration. These forms also tend to clog pond outlets. | Overdesign, low seasonal flow. | 1. Correct by increasing the loading by reducing the number of cells in use.  
2. Use series operation. |
# HOW TO CORRECT A LOW DISSOLVED OXYGEN (DO)

<table>
<thead>
<tr>
<th>INDICATORS/OBSERVATIONS</th>
<th>PROBABLE CAUSE</th>
<th>SOLUTIONS</th>
</tr>
</thead>
</table>
| A low, continued downward trend in DO is indicative of possible impending anaerobic conditions and the cause of unpleasant odors. Treatment becomes less efficient. | Poor light penetration, low detention time, high BOD loading or toxic industrial wastes. (Daytime DO should not drop below 3.0 mg/L during warm months.) | 1. Remove weeds such as duckweed if covering greater than 40 percent of the pond.  
2. Reduce organic loading to primary cell(s) by going to parallel operation.  
3. Add supplemental aeration (surface aerators, diffusers and/or daily operation of a motor boat).  
4. Add recirculation by using a portable pump to return final effluent to the head works.  
5. Apply sodium nitrate (see How to Control Odors for rate).  
6. Determine if overload is due to industrial source and remove it. |

# HOW TO CORRECT OVERLOADING

<table>
<thead>
<tr>
<th>INDICATORS/OBSERVATIONS</th>
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</tr>
</thead>
</table>
| Overloading which results in incomplete treatment of the waste. Overloading problems can be detected by offensive odors, a yellow green or gray color. Lab tests showing low pH, DO, and excessive BOD loading per unit area should also be considered. | Short-circuiting, industrial wastes, poor design, infiltration, new construction (service area expansion), inadequate treatment and weather conditions. | 1. Bypass the cell and let it rest.  
2. Use parallel operation.  
3. Apply recirculation of pond effluent.  
4. Look at possible short-circuiting.  
5. Install supplementary aeration equipment. |

# HOW TO CORRECT A DECREASING TREND IN pH

<table>
<thead>
<tr>
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</tr>
</thead>
</table>
| pH controls the environment for algae types, as an example, the green chlorella needs a pH from 8.0 to 8.4. pH should be on the alkaline side, preferably about 8.0 to 8.4. Both pH and DO will vary throughout the day with lowest reading at sunrise and highest reading in late afternoon. Measure pH same time each day and plot on a graph. | A decreasing pH is followed by a drop in DO as the green algae die off. This is most often caused by overloading, long periods of adverse weather or higher animals, such as Daphnia, feeding on the algae. | 1. Bypass the cell and let it rest.  
2. Use parallel operation.  
3. Apply recirculation of pond effluent.  
4. Check for possible short-circuiting.  
5. Install supplementary aeration equipment if problem is persistent and due to overloading.  
6. Look for possible toxic or external causes of algae die-off and correct at source. |
## HOW TO CORRECT SHORT-CIRCUITING

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Odor problems, low DO in parts of the pond, anaerobic conditions and low pH found by checking values from various parts of the pond and noting on a plan of the pond. Differences of 100 percent to 200 percent may indicate short-circuiting. After recording the readings for each location, the areas that are not receiving good circulation become evident. These areas are characterized by a low DO and pH.</td>
<td>Poor wind action due to trees or poor arrangement of inlet and outlet locations. May also be due to shape of pond, weed growth or irregular bottom.</td>
<td>1. Cut trees and growth at least 500 feet (150 m) away from pond if in direction of prevailing wind. 2. Install baffling around inlet location to improve distribution. 3. Add recirculation to improve mixing. 4. Provide new inlet-outlet locations, including multiple inlets. 5. Clean out weeds. 6. Fill in irregular bottoms.</td>
</tr>
</tbody>
</table>

## HOW TO CORRECT ANAEROBIC CONDITIONS

<table>
<thead>
<tr>
<th>INDICATORS/OBSERVATIONS</th>
<th>PROBABLE CAUSE</th>
<th>SOLUTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facultative pond that turned anaerobic resulting in high BOD, suspended solids and scum in the effluent in continuous discharge ponds. Unpleasant odors, the presence of filamentous bacteria and yellowish-green or gray color and placid surface indicate anaerobic conditions.</td>
<td>Overloading, short circuiting, poor operation or toxic discharges.</td>
<td>1. Change from a series to parallel operation to divide load. Helpful if conditions exist at a certain time each year and are not persistent. 2. Add supplemental aeration if pond is continuously overloaded. 3. Change inlets and outlets to eliminate short-circuiting. See How to Correct Short-Circuiting. 4. Add recirculation (temporary-use portable pumps) to provide oxygen and mixing. 5. In some cases temporary help can be obtained by adding sodium nitrate at rates described elsewhere in this manual. 6. Eliminate sources of toxic discharges.</td>
</tr>
</tbody>
</table>
## HOW TO CORRECT A HIGH BOD IN THE EFFLUENT

<table>
<thead>
<tr>
<th>INDICATORS/OBSERVATIONS</th>
<th>PROBABLE CAUSE</th>
<th>SOLUTIONS</th>
</tr>
</thead>
</table>
| High BOD concentrations that are in violation of NPDES or other regulatory agency permit requirements. Visible dead algae. | Short detention times, poor inlet and outlet placement, high organic or hydraulic loads and possible toxic compounds. | 1. Check for collection system infiltration and eliminate at source.  
2. Use portable pumps to recirculate the water.  
3. Add new inlet and outlet locations.  
4. Reduce loads due to industrial sources if above design level.  
5. Prevent toxic discharges. |

## HOW TO CORRECT PROBLEMS IN AERATED PONDS

<table>
<thead>
<tr>
<th>INDICATORS/OBSERVATIONS</th>
<th>PROBABLE CAUSE</th>
<th>SOLUTIONS</th>
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</thead>
</table>
| Fluctuating DO, fine pin floc in final cell effluent, frothing and foaming, ice interfering with operation. | Shock loading, overaeration, industrial wastes, floating ice. | 1. Control aeration system by using time clock to allow operation during high load periods, monitor DO to set up schedule for even operation, holding approximately 1 mg/L or more.  
2. Vary operation of aeration system to obtain solids that flocculate or "clump" together in the secondary cell but are not torn apart by excessive aeration.  
3. Locate industrial wastes that may cause foaming or frothing and eliminate or pre-treat wastes. Examples are slaughter house, milk or some vegetable wastes.  
4. Operate units continuously during cold weather to prevent freezing damage or remove completely if not a type that will prevent freeze-up. |

## HOW TO CORRECT PROBLEMS IN ANAEROBIC PONDS

<table>
<thead>
<tr>
<th>INDICATORS/OBSERVATIONS</th>
<th>PROBABLE CAUSE</th>
<th>SOLUTIONS</th>
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</thead>
</table>
| Odors  
Hydrogen sulfide, (rotten egg) odors or other disagreeable conditions due to sludge in a septic condition.  
Low pH  
pH below 6.5 accompanied by odors are the result of acid bacteria working in the anaerobic condition. | Lack of cover over water surface and insufficient load to have complete activity which eventually forms scum blanket.  
Acid formers working faster than methane formers in an acid condition. | 1. Use straw cast over the surface or polystyrene planks as a temporary cover until a good surface sludge blanket has formed.  
The pH can be raised by adding a lime slurry of 100 pounds of hydrated lime to 50 gallons (580 kg/200 liters) of water at a dosage rate of 1 pound of lime for every 10,000 gallons (120 g/10,000 liters) in the pond. The slurry should be mixed while being added. The best place to put the lime in is at the entrance to the lagoon so that it is well mixed as it enters the pond. |
5. Safety Around Ponds
5. Safety Around Ponds

PUBLIC HEALTH ASPECTS
Stabilization ponds, like other wastewater treatment facilities, must be treated with caution and respect from a safety and public health standpoint by operators and the general public alike. This means that stabilization ponds must be utilized for their designed purpose only, and not for public recreation.

The relative amount of water surface of stabilization ponds is insignificant in comparison to the many natural bodies of open water in most localities. In some areas, however, stabilization ponds represent the only sizeable body of water and have been sources of attraction to children as well as adults for recreation purposes. Incidents of boating, ice-skating, extensive waterfowl hunting and even swimming in ponds have been reported. Recreational use should be discouraged and safety practices encouraged for several important reasons.

First, even though the efficiency of bacterial removal as measured by the MPN method is very high, the possibility of contamination or infection from pathogenic organisms does exist when one comes in contact with wastewater in a stabilization pond.

Second, although most stabilization ponds attain a depth of only 5 feet, there is still sufficient depth to drown a person. Also, clay liners used in sealing ponds become very sticky when water is added. Should anyone fall in the pond, this clay liner would make it extremely difficult for anyone to get out.

Another factor to be considered is the existence of mosquitoes. However, on a well-maintained pond system, mosquitoes usually are not a nuisance.

According to studies made by the U.S. Public Health Service, the density of the mosquito population is directly proportional to the extent of weed growth in the ponds. Where weed growth in the ponds and along the water line of the dikes is negligible and where wince action on the pond is not unduly restricted, the production of mosquitoes in stabilization ponds is low.

To discourage use of the ponds for recreation the entire area should be fenced and warning signs displayed.

Personal Hygiene
It is in the interest of your health and the health of your family that this list of Do’s and Don’ts for personal hygiene is made. Use it, don’t abuse it!

1. Never eat your lunch or put anything into your mouth without first washing your hands.

2. Refrain from smoking while working in manholes, on pumps or other parts of the operation where hands may become contaminated.

3. Don’t wear your coveralls or rubber boots in your car or home.
4. Always clean any equipment such as safety belts, harness, face masks, gloves, etc., after using. You or someone else may want to use it again.

5. Keep your fingernails cut short and clean as they are excellent carriers of dirt and germs.

Safety
Sewer Maintenance Safety Precautions
1. Remove and replace heavy manhole covers carefully and only with the proper tools.

2. Descend into any manhole cautiously to guard against defective steps or rungs.

3. See part regarding noxious gases that may be found in sewers.

Pumping Station and Stabilization Pond Safety Precautions
1. Maintain a high level of good housekeeping. This involves keeping floors, walls and equipment free from dirt, grease and debris. Keep tools properly stored when not in use.

2. Keep walkways clean and free from slippery substances. If ice forms on walks, apply salt or sand or cover with earth or ashes than can be removed later.

3. Be especially cautious when working with an electrical distribution system and related facilities. Never work on electrical equipment and wire with wet hands or when clothes or shoes are wet. Always wear appropriate safety gloves for electrical work. Never use a switchbox for anything other than a switchbox.

4. Keep all personnel safety conscious by reminding them of specific safety instructions. Such instructions should include information on how to contact the nearest medical center and fire station, rescue techniques, resuscitation and first aid techniques.

5. Make certain that a sufficient number of capable personnel with proper equipment are assigned and present whenever it is necessary to perform any hazardous work.

6. A life preserver must be used when using a boat on stabilization ponds. Also, never work alone around the ponds because of the danger of drowning and other accidents. One of the requirements for a pond operator should be that he can swim at least 100 feet in normal work clothing.

7. Sufficient fire extinguishers (Underwriter's Laboratories approved) should be placed in readily accessible locations.

Body Infection and Disease Safety Precautions
1. Treat all cuts, skin abrasions and similar injuries promptly. When working with wastewater, the smallest cut or scratch is potentially dangerous and should be cleaned and treated immediately with a 2 percent solution of tincture of iodine.

2. See a doctor for all injuries.

3. Provide first aid training for all personnel.

4. Be inoculated for waterborne diseases, particularly typhoid and para-
typhoid fever. Keep a record of all immunizations in an employee health record to assure yourself of receiving up-to-date boosters, etc.

5. In laboratory work, use pipet bulbs rather than the mouth so as not to introduce contamination to the mouth. Don't drink water from laboratory glassware. Paper cups should be provided in laboratories for drinking purposes. Never prepare food in a laboratory.

Noxious Gases, Explosive Mixtures and Oxygen Deficiency
1. The principal gas hazards associated with wastewater treatment are accumulations of sewer gas and its mixture with other gases or air which may cause death or injury through explosion or by asphyxiation as a result of oxygen deficiency. The term sewer gas is generally applied to the mixture of gases in sewers and manholes containing high percentages of carbon dioxide, varying amounts of methane, hydrogen, hydrogen sulfide and low percentages of oxygen. Such mixtures sometimes accumulate in sewers and manholes where organic matter has been deposited and has undergone decomposition. The actual hazards from sewer gas exist in the explosive amount of methane, hydrogen sulfide or in oxygen deficiency. Hydrogen sulfide is toxic at very low concentrations and one's sensitivity to the odor is quickly deacened.

2. Chlorine gas, which is irritating to the eyes, respiratory tract and other mucous membranes, may settle in low, still areas. The gas forms an acid in the presence of moisture.

The gas escapes by leakage from cylinders and feed lines and finds its way to these places.

Safety Equipment
The types of safety equipment which a wastewater facility should have are as follows:

1. Detection equipment (for gases and oxygen deficiencies).

2. Masks (self-contained air packs for oxygen deficiencies).

3. Safety harnesses, lines and hoists.

4. Proper protective clothing, footwear and head gear.

5. Ventilating equipment.


7. Communications equipment.

8. Portable air blower.


10. Warning signs and barriers.


12. Proper fire extinguishers.

13. Eye wash and shower stations in laboratory areas.

14. Safety goggles for work in laboratories and other dangerous areas.

Additional Sources of Information
· New York Manual, Ch. 14
· WPCF, MOP No. 1, Safety in Wastewater Works
· Texas Manual, Ch. 35
· Sacramento State Home-Study Course, Ch. 12
# CONVERSION FACTORS

## To Convert

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Multiply By</th>
</tr>
</thead>
<tbody>
<tr>
<td>1% or 0.01 grade</td>
<td>Feet/100 feet</td>
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</tr>
<tr>
<td>Acres</td>
<td>Square Feet</td>
<td>43560</td>
</tr>
<tr>
<td>Acre-foot</td>
<td>Gallon</td>
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</tr>
<tr>
<td>Atmospheres</td>
<td>In. of Mercury</td>
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</tr>
<tr>
<td></td>
<td>Psi</td>
<td>14.7</td>
</tr>
<tr>
<td>Barrels (US liquid)</td>
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<tr>
<td>Barrels (US oil)</td>
<td>Gallons</td>
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</tr>
<tr>
<td>Centimeters</td>
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<td>Feet/min</td>
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<td>Feet/sec</td>
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<tr>
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<td>Milliliters</td>
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<tr>
<td>Cubic feet</td>
<td>Cubic Inches</td>
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<tr>
<td></td>
<td>CubicYards</td>
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</tr>
<tr>
<td></td>
<td>Gallons</td>
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</tr>
<tr>
<td></td>
<td>Liters</td>
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## To Convert

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<tr>
<td>Square miles</td>
<td>Acres</td>
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MATH FORMULAS

AREAS

Rectangle
\[ A = \text{length} \times \text{width} \]

Circle
\[ A = \pi \times \text{radius}^2 \]
\[ \frac{A}{4} = \pi \times \text{diameter}^2 \]
\[ A = 0.785 \times \text{diameter}^2 \]

VOLUMES

Rectangle
\[ V = \text{length} \times \text{width} \times \text{height} \]

Cylinder
\[ V = \pi \times \text{radius}^2 \times \text{height} \]
\[ V = \frac{\pi \times \text{diameter}^2 \times \text{height}}{4} \]
\[ V = 0.785 \times \text{diameter}^2 \times \text{depth} \]

CIRCUMFERENCE
\[ C = \pi \times \text{diameter} \]

GALLONS/CAPITA/DAY
\[ \frac{\text{gpd}}{\text{Population}} \]

POUNDS OF MATERIAL
\[ \text{lb/day} = \text{mg/l} \times 8.34 \times \text{MGD} \]

DOSAGE
\[ \text{mg/l} = \frac{\text{lb/day}}{8.34 \times \text{MGD}} \]

DETENTION TIME
\[ DT = \frac{\text{volume}}{\text{flow}} = \frac{V}{Q} \]

FLOW RATE
Flow rate (Q) = velocity x area = VA

SURFACE LOADING RATE
\[ \text{SLR} = \frac{\text{flow}}{\text{area}} = \frac{Q}{A} \]

WEIR OVERFLOW RATE
\[ \text{WOR} = \frac{\text{flow}}{\text{weir length}} = \frac{Q}{L} \]

VELOCITY
\[ V = \frac{\text{distance traveled}}{\text{time}} \]
\[ V = \frac{\text{flow rate}}{\text{cross-sectional area}} = \frac{Q}{A} \]
WATER HORSEPOWER

$$HP = \frac{\text{flow (gpm) x head (ft.)}}{3960}$$

EFFICIENCY

$$\text{efficiency(\%)} = \frac{\text{in} - \text{out}}{\text{in}} \times 100\%$$

HYDRAULIC LOADING RATE

$$\text{HLR} = \frac{\text{flow} = Q}{\text{area} = A}$$

ORGANIC LOADING RATE

$$\text{OLR} = \frac{\text{lbs BOD/day}}{\text{volume}}$$

F/M RATIO

$$\frac{\text{F/M} = \frac{\text{lbs BOD/day}}{\text{lbs mixed liquor solids}}}{\text{}}$$

MCRT

$$\text{MCRT} = \frac{\text{SS in aerator (lbs)}}{\text{SS wasted + lost (lbs/day)}}$$

SOLIDS CONCENTRATION

$$\text{SS} = \frac{\text{weight of solids}}{\text{volume of water filtered}}$$

$$\text{SS (mg/l)} = \frac{\text{dry solids (mg) x 1,000}}{\text{ml sample}}$$

% VOLATILE SOLIDS

$$\% \text{VSS} = \frac{\text{dry solids - ash solids}}{\text{dry solids}} \times 100\%$$

SLUDGE VOLUME INDEX (SVI)

$$\text{SVI} = \frac{\text{Settleable solids (ml) x 1000}}{\text{MLSS (mg/l)}}$$

SLUDGE AGE

$$\Theta_c = \frac{\text{lbs mixed liquor solids}}{\text{lgs/day primary effluent solids}}$$

CHEMICAL DEMAND (MG/L)

$$\text{demand} = \text{dose (mg/l)} - \text{residual (mg/l)}$$

BIOCHEMICAL OXYGEN DEMAND

$$\text{BOD} = \frac{\text{initial DO - final DO} \times 300}{\text{ml of sample}}$$

TEMPERATURE CONVERSIONS

$$\text{°F} = \frac{\text{°C} \times 9}{5} + 32$$

$$\text{°C} = \frac{\text{°F} - 32}{9}$$
Appendix C

Example Wastewater Permits
KANSAS WATER POLLUTION CONTROL PERMIT

Pursuant to the provisions of Kansas Statutes Annotated 65-164 AND 65-165,

Owner: Garfield, City of
Owner's Address: P. O. Box 3
Garfield, Kansas 67529
Facility Name: Garfield Wastewater Treatment Plant
Facility Address: Garfield, Kansas 67529
Legal Description: SW1/4, SW1/4, SW1/4, Section 6, Township 23S, Range 17W
Pawnee County, Kansas

is authorized to operate the wastewater treatment facility described herein in accordance with the attached "Standard Conditions for Non-Overflowing Wastewater Treatment Facilities", dated May 1, 1996, and Supplemental Conditions listed below. Discharge of wastewater from this treatment facility to surface waters of the State of Kansas is prohibited by this permit.

This permit is effective November 1, 2007, supersedes the previously issued water pollution control permit M-UA15-NO01, and expires October 31, 2012.

FACILITY DESCRIPTION:
1. Three Cell Wastewater Stabilization Lagoon System
2. Total Surface Area = 2.26 Acres
3. Design P.E. = 305
4. Irrigation of effluent
5. Rated Flow = 0.020 MGD (without irrigation)

SUPPLEMENTAL CONDITIONS:

If effluent is irrigated onto surrounding grass or crop lands, the following conditions shall be observed:

1. Permittee shall control tailwater to prevent runoff to surface waters of the State.
2. Permittee shall draw water from only the final cell in the treatment process.
3. Permittee shall not irrigate crops produced for direct human consumption.

[Signature]
Secretary, Kansas Department of Health and Environment

October 18, 2007
Date
STANDARD CONDITIONS FOR
NON-OVERFLOWING WASTEWATER TREATMENT FACILITIES

1. Definitions:
   A. The terms "Director", "Division", and "Department" refer to the Director, Division of Environment, Kansas Department of Health and Environment, respectively.
   B. "Bypass" means any diversion of waste streams from any portion of a treatment plant or collection system.
   C. "Severe property damage" means substantial physical damage to property, damage to the treatment facilities which causes them to become inoperable, or substantial and permanent loss of natural resources which can reasonably be expected to occur in the absence of a bypass. Severe property damage does not mean economic loss caused by delays in production.

2. Monitoring Requirements: If the water level in the lagoon rises to within two feet of the top of the lagoon dikes, the permittee must notify the Division immediately.

   Land application of wastewater and/or wastewater sludges from this facility is authorized by this permit only if it is specifically stated in the permit or prior authorization from the Division is obtained.

   The municipal permittee shall promptly notify the Division by telephone upon discovering crude oil or any petroleum derivative in its collection system or wastewater treatment plant.

3. Schedule of Compliance: No later than 14 calendar days following each date identified in the "Schedule of Compliance," the permittee shall submit to the Division, either a report of progress or, in the case of specific action being required, an identified dates, a written notice of compliance or noncompliance. In the latter case, the notice shall include the cause of noncompliance, any remedial actions taken, and the probability of meeting the next schedule requirements, or, if there are no more scheduled requirements, when such noncompliance will be corrected.

4. Change in Operation: Any anticipated facility expansions, production increases, or process modifications which will result in new, different, or increased loadings, either hydraulic or pollutant, must be reported in writing to the Division at least 180 days before such change.

5. Facilities Operation: The permittee shall at all times maintain in good working order and efficiently and effectively operate all treatment, collection, control systems or facilities, to achieve compliance with the terms of this permit. The permittee shall take all necessary steps to minimize or prevent any adverse impact to waters of the State resulting from noncompliance with this permit. When necessary to maintain compliance with the permit conditions, the permittee shall halt or reduce those activities under its control which generate wastewater routed to this facility.

6. Immediate Reporting Required: Any diversion from, or bypass of facilities necessary to maintain compliance with the permit is prohibited, except: where no feasible alternatives to the bypass exist and 1) where necessary to prevent loss of human life, personal injury or severe property damage; or 2) where excessive stormwater inflow or infiltration would damage any facilities necessary to comply with this permit or 3) where the permittee notifies the Director seven days in advance of an anticipated bypass. The Director or Director's designee may approve a bypass, after considering its adverse effects, if any of the three conditions listed above are met. The permittee shall immediately notify the Division by telephone [(785) 296-5517 or the appropriate KDHE District Office] of each bypass and shall confirm the telephone notification with a letter explaining what caused this spill or bypass and what actions have been taken to prevent recurrence. Written notification shall be provided to the Director within five days of the permittee becoming aware of the bypass. The Director or Director's designee may waive the written report on a case-by-case basis.

7. Unless otherwise specified, all reports required by this permit, shall be submitted to: Kansas Department of Health & Environment, Bureau of Water-Technical Services Section, 1000 SW Jackson St., Suite 420, Topeka, KS 66612-1367.

8. Removed Substances: Solids, sludges, filter backwash, and other pollutants removed in the course of treatment or control of wastewaters shall be disposed of in a manner acceptable to the Division.
9. Power Failures: The permittee shall provide an alternative power source sufficient to operate the wastewater facilities or otherwise control pollution and all discharges upon the loss of the primary source of power to the wastewater facilities.

10. Right of Entry: The permittee shall allow authorized representatives of the Division upon the presentation of credentials, to enter upon the permittee's premises where the facility is located, or in which are located any records required to be kept by this permit, and at reasonable times, to have access to and copy any records required to be kept by this permit, to inspect any monitoring equipment or monitoring methods required in this permit, and to sample any influents to, discharges from, or materials in the wastewater facilities.

11. Transfer of Ownership: The permittee shall notify the succeeding owner or controlling person of the existence of this permit by certified letter, a copy of which shall be forwarded to the Division. The succeeding owner shall secure a new permit. The permit is not transferable to any person except after notice and approval by the Director. The Director may require modification or revocation and reissuance of the permit to change the name of the permittee and incorporate such other requirements as may be necessary.

12. Availability of Records: Except for data determined to be confidential, all reports prepared in accordance with the terms of this permit shall be available for public inspection at the offices of the Department. Knowingly making any false statement on any such report or tampering with equipment to falsify data may result in the imposition of criminal penalties as provided for in KSA 65-170c.

13. Records Retention: All records and information resulting from the monitoring activities required by this permit shall be retained for a minimum of 3 years, or longer if requested by the Division. The permittee shall also furnish upon request, copies of all records required to be kept by this permit.

14. Test Procedures: All analysis required by this permit shall conform to the requirements of 40 CFR Part 136 and shall be conducted in a laboratory certified by this Department.

15. Permit Modifications and Terminations: As provided by KAR 28-16-62, after notice and opportunity for a hearing, this permit may be modified, suspended or revoked or terminated in whole or in part during its term for cause as provided, but not limited to those set forth in KAR 28-16-62 and KAR 28-16-28b through f. The permittee shall furnish to the Director, within a reasonable amount of time, any information which the Director may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit or to determine compliance with this permit.

16. Operator Certification: The permittee shall ensure that the wastewater facilities are under the supervision of an operator certified by the Department. If the permittee does not have a certified operator or loses its certified operator, the appropriate steps shall be taken to obtain a certified operator as required by KAR 28-16-30 et seq.

17. Severability: The provisions of this permit are severable. If any provision of this permit or any circumstance is held invalid, the application of such provision to other circumstances and the remainder of the permit shall not be affected thereby.

18. Removal from Service: The permittee shall inform the Division at least three months before a pumping station, treatment unit, or any other part of the treatment facility permitted by this permit is to be removed from service and shall make arrangements acceptable to the Division to decommission the facility or part of the facility being removed from service such that the public health and waters of the state are protected.

19. Duty to Reapply: A permit holder wishing to continue any activity regulated by this permit after the expiration date, must apply for a new permit at least 180 days prior to expiration of the permit.

20. Property Rights: The issuance of this permit does not convey any property rights in either real or personal property, or any exclusive privileges, nor does it authorize any injury to private property or any invasion of personal rights nor any infringements of or violation of federal, state or local laws or regulations.
KANSAS WATER POLLUTION CONTROL PERMIT AND
AUTHORIZATION TO DISCHARGE UNDER
THE NATIONAL POLLUTANT DISCHARGE
ELIMINATION SYSTEM

Pursuant to the Provisions of Kansas Statutes Annotated 65-164 and 65-165, the
Federal Water Pollution Control Act as amended, (33 U.S.C. 1251 et seq; the
"Act"),

Owner: Fulton, City of
Owner's Address: 214 West Osage
Fulton, Kansas 66738
Facility Name: Fulton Wastewater Treatment Plant
Facility Location: NW4, SE4 Section 25, Township 23S, Range 24E
Bourbon County, Kansas
Receiving Stream & Basin: Little Osage River
Marais des Cygnes River Basin

is authorized to discharge from the wastewater treatment facility described
herein, in accordance with effluent limitations and monitoring requirements as
set forth herein.

This permit is effective July 1, 2008, supersedes the previously issued Kansas
Water Pollution Control permit M-MC12-0001, and expires September 30, 2009.

FACILITY DESCRIPTION:

1. Three Cell Wastewater Stabilization Lagoon System
   a. Cell 1 - 1.05 ac @ 5 ft.
   b. Cell 2 - 0.70 ac @ 5 ft.
   c. Cell 3 - 0.65 ac @ 8 ft.
2. Design P.E. = 350
3. Design Flow = 24,500 gpd

[Signature]
Secretary, Kansas Department of Health and Environment

June 1, 2008
Date
A. **EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS**

The permittee is authorized to discharge from outfall(s) with serial number(s) as specified in this permit. The effluent limitations shall become effective on the dates specified herein. Such discharges shall be controlled, limited, and monitored by the permittee as specified. There shall be no discharge of floating solids or visible foam in other than trace amounts.

The initial reporting period shall begin July 1, 2008 and end September 30, 2008. Each consecutive three month period thereafter shall constitute a reporting period. Monitoring reports shall be submitted on or before the 28th day of January, April, July and October. In the event no discharge occurs, written notification is still required.

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<tr>
<th>EFFLUENT LIMITATIONS</th>
<th>MONITORING REQUIREMENTS</th>
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<td><strong>Final Limitations</strong></td>
<td><strong>Measurement Frequency Sample Type</strong></td>
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<tr>
<td><strong>Upon Issuance</strong></td>
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**001AG- Influent to Treatment Plant**

- **Biochemical Oxygen Demand (5-Day)- mg/l** Monitor
  - Once Quarterly grab

- **Total Suspended Solids - mg/l** Monitor
  - Once Quarterly grab

**001A1- Effluent at Discharge Structure**

- **Biochemical Oxygen Demand (5-Day)**
  - **Weekly Average-mg/l**: 45
  - **Monthly Average-mg/l**: 30
  - Once Quarterly grab

- **Total Suspended Solids**
  - **Weekly Average-mg/l**: 120
  - **Monthly Average-mg/l**: 80
  - Once Quarterly grab

- **pH - Standard Units** 6.0-9.0
  - Once Quarterly grab

- **Ammonia (as N) - mg/l** Monitor
  - **Annually** grab

- **E. coli - Colonies/100 ml**
  - **April 1 through October 31**
  - **Monthly Geometric Average**: 160
  - **Annually** grab

* Minimum removal of 85% required for Biochemical Oxygen Demand (5-Day). If inhibited Biochemical Oxygen Demand (5-Day) test is used, limits are 5 mg/l less than shown.

** Sampling shall be conducted during July, August or September each year and monitoring results submitted to KDHE by October 28 each year.

B. **STANDARD CONDITIONS**

In addition to the specified conditions stated herein, the permittee shall comply with the attached Standard Conditions dated August 1, 1996.

C. **SCHEDULE OF COMPLIANCE**

None

D. **SLUDGE DISPOSAL**

This facility is subject to the EPA 40 CFR Part 503 regulations in effect when sludge is removed from the facility.
STANDARD CONDITIONS FOR
KANSAS WATER POLLUTION CONTROL AND
NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM PERMITS

1. Representative Sampling and Discharge Monitoring Report Submittals:

A. Samples and measurements taken as required herein shall be representative of the quality and quantity of the monitored discharge. Test results shall be recorded for the day the samples were taken. If sampling for a parameter was conducted across more than one calendar day, the test results may be recorded for the day sampling was started or ended. All samples shall be taken at the locations designated in this permit, and unless specified, at the outfall/monitoring location(s) before the wastewater joins or is diluted by any other water or substance.

B. Monitoring results shall be recorded and reported on forms acceptable to the Division and postmarked no later than the 28th day of the month following the completed reporting period. Signed and certified copies of these, prepared in accordance with KAR 28-16-59, and all other reports required herein, may be FAXed to 785.296.0036, e-mailed as scanned attachments to dmr4kdhe@kdheks.gov, or sent by U.S. mail to:

Kansas Department of Health & Environment
Bureau of Water-Technical Services Section
1000 SW Jackson Street, Suite 420
Topeka, KS 66612-1367

2. Definitions:

A. Unless otherwise specifically defined in this permit, the following definitions apply:

1. The "Daily Maximum" is the total discharge by weight or average concentration, measurement taken, or value calculated during a 24-hour period. The parameter, pH, is limited as a range between and including the values shown.

2. The "Weekly Average" is the arithmetic mean of the value of test results from samples collected, measurements taken or values calculated during four monitoring periods in each month consisting of calendar days 1-7, 8-14, 15-21 and 22 through the end of the month.

3. The "Monthly Average", other than for E. coli bacteria, is the arithmetic mean of the value of test results from samples collected, measurements taken or values calculated during a calendar month. The monthly average is determined by the summation of all calculated values or measured test results divided by the number of calculated values or test results reported for that parameter during the calendar month. The monthly average for E. coli bacteria is the geometric average of the value of the test results from samples collected in a calendar month. The geometric average can be calculated by using a scientific calculator to multiply all the E. coli test results together and then taking the nth root of the product where n is the number of test results. Non-detect values shall be reported using the less than symbol (<) and the minimum detection or reportable value. To calculate average values, non-detects shall be defaulted to zero (or one for geometric averages). Greater than values shall be reported using the greater than symbol (>) and the reported value. To calculate average values, the greater than reported value shall be used in the averaging calculation.

B. A "grab sample" is an individual sample collected in less than 15 minutes. A "composite sample" is a combination of individual samples in which the volume of each individual sample is proportional to the flow, or the sample frequency is proportioned to the flow rate over the sample period, or the sample frequency is proportional to time.

C. The terms "Director", "Division", and "Department" refer to the Director, Division of Environment, Kansas Department of Health and Environment, respectively.

D. "Severe property damage" means substantial physical damage to property, damage to the treatment facilities which causes them to become inoperable, or substantial and permanent loss of natural resources which can reasonably be expected to occur in the absence of an in-plant diversion. Severe property damage does not mean economic loss caused by delays in production.

E. "Bypass" means the intentional diversion of waste streams from any portion of the treatment facility.
3. Schedule of Compliance: No later than 14 calendar days following each date identified in the "Schedule of Compliance," the permittee shall submit via mail, e-mail or fax per paragraph 1.B above, either a report of progress or, in the case of specific action being required by identified dates, a written notice of compliance or noncompliance. In the latter case, the notice shall include the cause of noncompliance, any remedial actions taken, and the probability of meeting the next scheduled requirements, or, if there are no more scheduled requirements, when such noncompliance will be corrected.

4. Test Procedures: All analyses required by this permit shall conform to the requirements of 40 CFR Part 136, unless otherwise specified, and shall be conducted in a laboratory accredited by the Department. For each measurement or sample, the permittee shall record the exact place, date, and time of measuring/sampling; the date and time of the analyses, the analytical techniques or methods used, minimum detection or reportable level, and the individual(s) who performed the measuring/sampling and analysis and, the results. If the permittee monitors any pollutant at the location(s) designated herein more frequently than required by this permit, using approved procedures, the results shall be included in the Discharge Monitoring Report form required in 1.B. above. Such increased frequencies shall also be indicated.

5. Change in Discharge: All discharges authorized herein shall be consistent with the permit requirements. The discharge of any pollutant not authorized by this permit or of any pollutant identified in this permit more frequently than or at a level in excess of that authorized shall constitute a violation of this permit. Any anticipated facility expansions, production or flow increases, or production or wastewater treatment system modifications which result in a new, different, or increased discharge of pollutants shall be reported to the Division at least one hundred eighty (180) days before such change.

6. Facilities Operation: The permittee shall at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the permittee to achieve compliance with the requirements of this permit and Kansas and Federal law. Proper operation and maintenance also include adequate laboratory controls and appropriate quality assurance procedures. This provision requires the operation of back-up or auxiliary facilities or similar systems which are installed by a permittee only when the operation is necessary to achieve compliance with the requirements of this permit. The permittee shall take all necessary steps to minimize or prevent any adverse impact to human health or the environment resulting from noncompliance with any effluent limits specified in this permit, including such accelerated or additional monitoring as necessary to determine the nature and impact of the noncomplying discharge. When necessary to maintain compliance with the permit requirements, the permittee shall halt or reduce those activities under its control which generate wastewater routed to this facility.

7. Incidents:

“Collection System Diversion” means the diversion of wastewater from any portion of the collection system.

“In-Plant Diversion” means routing the wastewater around any treatment unit in the treatment facility through which it would normally flow.

“In-Plant Flow Through” means an incident in which the wastewater continues to be routed through the equipment even through full treatment is not being accomplished because of equipment failure for any reason.

“Spill” means any discharge of wastewater, sludge or other materials from the treatment facility other than effluent or as more specifically described by other “Incidents” terms.

“Upset” means an exceptional incident in which there is unintentional and temporary noncompliance or anticipated noncompliance with permit effluent limits because of factors beyond the reasonable control of the permittee, as described by 40 C.F.R. 122.41(n).

8. Diversions not Exceeding Limits: The permittee may allow any diversion to occur which does not cause effluent limits to be exceeded, but only if it also is for essential maintenance to assure efficient operation. Such diversions are not subject to the Incident Reporting requirements shown below.

9. Prohibition of an In-Plant Diversion: Any in-plant diversion from facilities necessary to maintain compliance with this permit is prohibited, except: (a) where the in-plant diversion was unavoidable to prevent loss of life, personal injury, or severe property damage; (b) where there were no feasible alternatives to the in-plant diversion, such as the use of auxiliary treatment facilities, retention of untreated wastes, or maintenance during normal periods of equipment downtime and (c) the permittee submitted a notice as required in the Incident Reporting paragraph below. The Director may approve an anticipated in-plant diversion, after considering its adverse effects, if the Director determines that it will meet the three conditions listed above.
10. Incident Reporting: The permittee shall report any unanticipated collection system diversion, in-plant diversion, in-plant flow through occurrences, spill, upset or any violation of a permitted daily maximum limit within 24 hours from the time the permittee became aware of the incident. A written submission shall be provided within 5 days of the time the permittee became aware of the incident. The written submission shall contain a description of the noncompliance and its cause, the period of noncompliance, including exact dates and times; and if the noncompliance has not been corrected, the anticipated time it is expected to continue; and steps taken or planned to reduce, eliminate, and prevent recurrence of the noncompliance. An Incident Report form is available at www.k dheks.gov/water/tech.html.

For an anticipated incident or any planned changes or activities in the permitted facility that may result in noncompliance with the permit requirements, the permittee shall submit written notice, if possible, at least ten days before the date of the event.

For other noncompliance, the above information shall be provided with the next Discharge Monitoring Report.

11. Removed Substances: Solids, sludges, filter backwash, or other pollutants removed in the course of treatment of water shall be utilized or disposed of in a manner acceptable to the Division.

12. Power Failures: The permittee shall provide an alternative power source sufficient to operate the wastewater control facilities or otherwise control pollution and all discharges upon the loss of the primary source of power to the wastewater control facilities.

13. Right of Entry: The permittee shall allow authorized representatives of the Division of Environment or the Environmental Protection Agency upon the presentation of credentials, to enter upon the permittee's premises where an effluent source is located, or in which are located any records required by this permit, and at reasonable times, to have access to and copy any records required by this permit, to inspect any facilities, monitoring equipment or monitoring method required in this permit, and to sample any influents to, discharges from or materials in the wastewater facilities.

14. Transfer of Ownership: The permittee shall notify the succeeding owner or controlling person of the existence of this permit by certified letter, a copy of which shall be forwarded to the Division. The succeeding owner shall secure a new permit. This permit is not transferable to any person except after notice and approval by the Director. The Director may require modification or revocation and reissuance of the permit to change the name of the permittee and incorporate such other requirements as may be necessary.

15. Records Retention: Unless otherwise specified, all records and information resulting from the monitoring activities required by this permit, including all records of analyses and calibration and maintenance of instruments and recordings from continuous monitoring instruments, shall be retained for a minimum of 3 years, or longer if requested by the Division. Biosolids/sludge records and information are required to be kept for a minimum of 5 years, or longer if requested by the Division. Groundwater monitoring data, including background samples results, shall be kept for the life of the facility regardless of ownership.

16. Availability of Records: Except for data determined to be confidential under 33 USC Section 1318, all reports prepared in accordance with the terms of this permit shall be available for public inspection at the offices of the Department. Effluent data shall not be considered confidential. Knowingly making any false statement on any such report or tampering with equipment to falsify data may result in the imposition of criminal penalties as provided for in 33 USC Section 1319 and KSA 65-170c.

17. Permit Modifications and Terminations: As provided by KAR 28-16-62, after notice and opportunity for a hearing, this permit may be modified, suspended or revoked or terminated in whole or in part during its term for cause as provided, but not limited to those set forth in KAR 28-16-62 and KAR 28-16-28b through g. The permittee shall furnish to the Director, within a reasonable amount of time, any information which the Director may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit or to determine compliance with this permit. The permittee shall also furnish upon request, copies of all records required to be kept by this permit. The filing of a request by the permittee for a permit modification, revocation and reissuance, or termination, or a notification of planned changes or anticipated noncompliance does not stay any permit condition.
18. Toxic Pollutants: Notwithstanding paragraph 17 above, if a toxic effluent standard or prohibition (including any schedule of compliance specified at such effluent standards) is established under 33 USC Section 1317(a) for a toxic pollutant which is present in the discharge and such standard or prohibition is more stringent than any limitation for such pollutant in this permit, this permit shall be revised or modified in accordance with the toxic effluent standard or prohibition. Nothing in this permit relieves the permittee from complying with federal toxic effluent standards as promulgated pursuant to 33 USC Section 1317.

19. Administrative, Civil and Criminal Liability: The permittee shall comply with all requirements of this permit. Except as authorized in paragraph 9 above, nothing in this permit shall be construed to relieve the permittee from administrative, civil or criminal penalties for noncompliance as provided for in KSA 65-161 et seq., and 33 USC Section 1319.

20. Oil and Hazardous Substance Liability: Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities or penalties to which the permittee is or may be subject to under 33 USC Section 1321 or KSA 65-164 et seq. A municipal permittee shall promptly notify the Division by telephone upon discovering crude oil or any petroleum derivative in its sewer system or wastewater treatment facilities.

21. Industrial Users: A municipal permittee shall require any industrial user of the treatment works to comply with 33 USC Section 1317, 1318 and any industrial user of storm sewers to comply with 33 USC Section 1308.

22. Property Rights: The issuance of this permit does not convey any property rights in either real or personal property, or any exclusive privileges, nor does it authorize any injury to private property or any invasion of personal rights nor any infringements of or violation of federal, state or local laws or regulations.

23. Operator Certification: The permittee shall, if required, ensure the wastewater facilities are under the supervision of an operator certified by the Department. If the permittee does not have a certified operator or loses its certified operator, appropriate steps shall be taken to obtain a certified operator as required by KAR 28-16-30 et seq.

24. Severability: The provisions of this permit are severable. If any provision of this permit or any circumstance is held invalid, the application of such provision to other circumstances and the remainder of the permit shall not be affected thereby.

25. Removal from Service: The permittee shall inform the Division at least three months before a pumping station, treatment unit, or any other part of the treatment facility permitted by this permit is to be removed from service and shall make arrangements acceptable to the Division to decommission the facility or part of the facility being removed from service such that the public health and waters of the state are protected.

26. Duty to Reapply: A permit holder wishing to continue any activity regulated by this permit after the expiration date, must apply for a new permit at least 180 days prior to expiration of the permit.
Appendix D

What Does KDHE Expect From an Operator?
BASIC EXPECTATIONS OF ALL OPERATORS

- HONESTY
- RESPONSIBILITY
- CERTIFICATION
- IMPROVEMENT OF KNOWLEDGE

HONESTY

- IN EFFORTS
- IN COMMUNICATIONS

RESPONSIBILITY

- DO THE BEST POSSIBLE JOB
- ARRANGE SUBSTITUTE COVERAGE

CERTIFICATION

- TO THE REQUIRED GRADE

IMPROVEMENT OF KNOWLEDGE

- SOUND UNDERSTANDING OF THE SYSTEM
- MEET ONGOING TRAINING REQUIREMENTS

WASTEWATER SYSTEM OPERATORS

ADDITIONAL EXPECTATIONS

- BYPASSES
  - PREVENT AND REDUCE SEVERITY
  - REPORT PROMPTLY
- MONITORING REPORTS
  - PREPARE RECORDS
  - EXPLAIN VIOLATIONS
**Wastewater Treatment**

**Facility Owner Responsibilities**

- Compliance with permit limits
- Keep facility fully operational
- Upgrade & replace as necessary
- Secure permits

**Defects to Avoid**

**Wastewater Stabilization Lagoon Systems**

- Maintenance
  - Dike erosion
  - Burrowing animals
  - Weeds and trees
- Security and access
  - Not properly fenced
  - Gate not locked
  - Warning signs not on all sides
  - Access road inadequate

**Defects to Avoid**

**Wastewater Stabilization Lagoon Systems**

- Operation
  - Short circuiting
  - Sludge accumulation
  - Industrial overloading
  - Lack of series operation
  - No depth gages

**Defects to Avoid**

**Mechanical Wastewater Treatment Plants**

- Maintenance
  - Mechanical wearout
  - No spare parts inventory
  - Trickling filter seal leakage
  - Trickling filter distributor arm

**Defects to Avoid**

**Mechanical Wastewater Treatment Plants**

- Operation
  - Basin sludge removal
  - Inadequate recirculation
  - Activated sludge aeration
  - Sludge management
  - Improper disposal (503 regulations)
  - Inadequate wasting