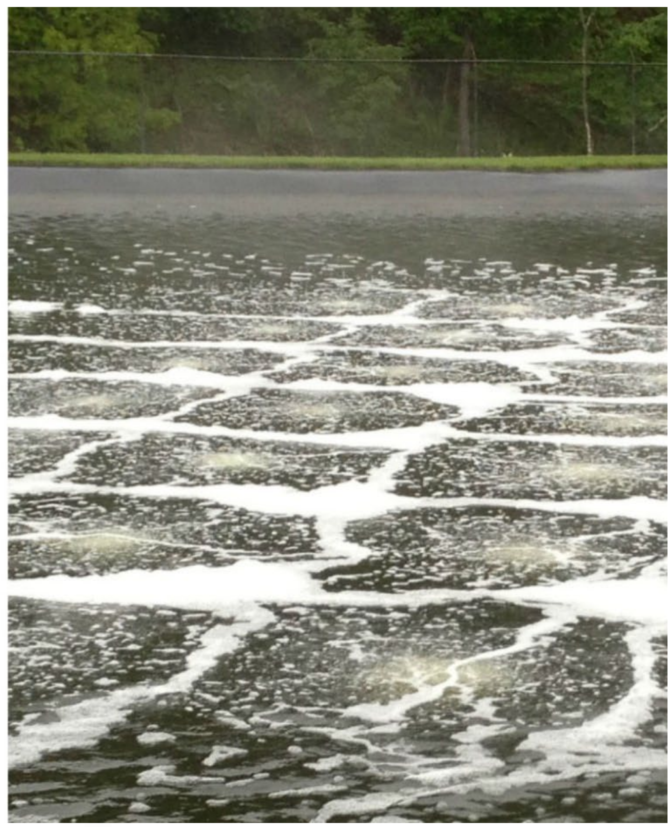
Pond

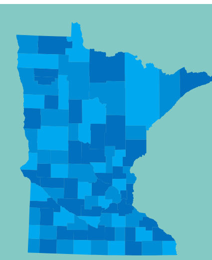
August 2023

Recommended Pond Design Criteria

Guide for design and evaluation of stabilization ponds for wastewater treatment.



MINNESOTA POLLUTION CONTROL AGENCY



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This report is available in alternative formats upon request, and online at www.pca.state.mn.us.

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Contents

Introduction

This document is intended to guide a designer through a step-by-step outline on how a pond system evaluation and design should be performed. However, it should be understood that designing a pond system is typically an interactive process. If, while working on a design, an unfavorable restriction becomes evident and a design change is necessary, it is suggested that you contact the Minnesota Pollution Control Agency (MPCA) staff engineer person assigned to the project to discuss any possible changes. These guidelines are intended to be used for all types of the following pond systems:

1. Stabilization pond systems – a controlled type of a facultative/aerobic pond system. The dissolved oxygen is generally supplied by algae and/or wind action. Detention time is from 180 to 210 days with a controlled discharge to avoid a release of water during the summer and winter months.
2. Spray irrigation pond system-treatment system is the same as a stabilization pond system however discharge is to the land with a cover crop not used for human consumption.
3. Aerated pond system – similar to a stabilization pond system, except the dissolved oxygen is supplied by mechanical aeration. Detention times will vary with the design of the overall system. It is constructed to provide either a continuous discharge or controlled discharge.
4. Pre-aeration pond system – an aerated pond system designed to reduce the influent Biochemical Oxygen Demand loading prior to a discharge to a secondary treatment system.
5. Polishing pond system – aerated or non-aerated pond system that follows a secondary form of mechanical treatment. The sole purpose is to provide storage prior to a discharge.
6. The following guidance is in addition to Recommended Standards for Wastewater Facilities (Ten State Standards) 2014 or most recent revised edition by the Great Lakes-Upper Mississippi River and Board of State and Provincial Public Health and Environmental Managers as well as the current applicable Federal Guidelines issued by the U.S. Environmental Protection Agency.

How to use this guidance document

It is recommended that the designer carefully review this guidance and submit the necessary application forms and supporting information to the MPCA. This ensures that MPCA staff has the necessary information to review, approve, process, and issue the permit in a timely manner. Where appropriate, this guidance recommends certain procedures, policies, formulas, etc. for the design and construction of a pond system. By applying these recommendations to the design, best available technology and principles are generally followed. The MPCA encourages implementation of pollution-prevention activities — eliminating or reducing pollutants at the source — in the operation of the pond system and through education of the users. Pollution prevention can often extend the life of the pond system. Pollution-prevention ideas and resources can be found at the Minnesota Technical Assistance Program Internet site at http://www.mntap.umn.edu/potw/index.htm.

If you have questions or need assistance, please contact the MPCA staff engineer assigned to the project. If you are unsure of whom to contact, call the MPCA at 800-657-3864 or 651-296-6300. A link to MPCA regional office locations can be found at http://www.pca.state.mn.us/about/regions/index.html.

1. Pond location

Along with the following concerns, it is important to picture the general environment around the pond in order that possible spring odors and potential seepage will have a minimal effect. A map showing elevations and contours of the site and adjacent area shall be provided. The location and direction of all residences, commercial development, parks, recreational areas, and water supplies within one mile of the proposed site shall be included as well as land use zoning adjacent to the proposed site. Consideration needs to be given to potential future development of adjacent land to the proposed pond site.

1.1 Flood plain considerations

The treatment works structures, electrical, and mechanical equipment shall be protected from physical damage of a one hundred year flood. Treatment works shall remain fully operational and accessible during a twenty five year flood. This requirement applies to new construction and existing facilities undergoing major modification. Flood plain regulations of state and federal agencies shall be considered.

1.2 Distances from habitation and property lines

It is recommended that a pond site should be located at least one-fourth mile from the high water elevation to the nearest dwelling or occupied residence. One-half mile setback is recommended from a city or cluster of residences, in order that a one-fourth mile set-back is maintained from habitation or any area which may be built up within a reasonable future period. A cluster of houses is basically a grouping of houses in an area of platted lots for development. A field inspection of the proposed site may be conducted by the Agency staff.

A new pond must be 150 feet from an existing drinking water well in accordance with Minn. R. 4725.4450 (https://www.revisor.mn.gov/rules/4725.4450/).

If the one-fourth mile setback from an individual dwelling or occupied residence cannot be maintained, then there must be an attempt to obtain a waiver from the homeowner(s). At a minimum, documentation of a personal invitation to the homeowner(s) to attend the public meeting along with a transcript of their comments should be provided. Information on ground water may be required to determine if the well on the home site(s) may be impacted by the potential pond. If one-half mile separation from a cluster of houses is maintained, the governing body should be advised that development in the direction of the pond site should not encroach upon the one quarter mile minimum.

For aerated pond systems with an alternate power source for the aeration equipment there is no set back distance requirement. If an alternate power system is not available, the minimum set back distance is one-fourth of a mile. In addition, if combinations of treatment units are utilized, the most stringent set back distance requirements must be considered.

1.3 Prevailing winds

The pond site should be located so that local prevailing winds during the spring will be in the direction of uninhabited areas. Preference should be given to sites which will permit an unobstructed wind sweep across ponds, especially in the direction of local prevailing winds.

1.4 Surface water hydrology

Adequate provisions must be made to divert stormwater around the ponds and protect the exterior pond embankments from erosion. A minimum 50-foot buffer zone around the outside toe of the dikes should be provided to allow for any drainage and maintenance.

1.5 Ground water hydrology

Construction of ponds near water supplies and other facilities subject to contamination should be avoided. A minimum separation of four feet between the top of the pond seal and the maximum high water table should be maintained. The four feet of separation includes the need for one and half feet of seal depth, one and a half feet for water pumping problems during seal application and a one foot safely factor for water table fluctuations; this includes synthetic lined ponds as high groundwater conditions will cause problems regarding an unstable base for pushing cover material onto a synthetic liner. The construction of a clay seal where high groundwater is present can cause the water to be “pumped” up and prevent proper compaction. If ground water rises above the seal, the seal can “float” and will not naturally re-compact.

Drain tile under a clay lined pond site cannot be used to permanently lower the groundwater table, although this is an option for synthetically lined ponds. If drain tile is installed as a means of permanently lowering groundwater under a synthetic lined pond there will be sampling requirements in the National Pollutant Discharge Elimination System permit and calculations will be required to verify groundwater distance will be maintained. Ditching around the pond site or some other method may be used to intercept groundwater and transfer it away from the pond site.

1.6 Karst areas

The pond site shall not be located on sites which show evidence of karstification (i.e., sink holes or solution channeling generally occurring in areas underlain by limestone or dolomite). Proposed pond sites as well as existing pond sites which are being upgraded shall be subject to intensive hydrogeologic site evaluation before approval can be given if they exist in a known or suspected Karst region. Before a pond site to be located in karst area can be approved, they may, be required to utilize additional lining materials beyond normal sealing requirements. An intensive hydro-geological site evaluation in karst areas would be required and include seismic and resistivity studies of the site.

1.7 Bedrock

A minimum separation of ten feet between the top of seal and bedrock formations is required.

1.8 Soil conditions

A preliminary investigation of the pond site should be undertaken to screen a study area for potential sites before a detailed site investigation is undertaken, The purpose of the investigation is to eliminate, when possible, sites which do not meet location requirements and to help in estimating what kind of detailed investigation should be done to meet the design requirements. The investigation should be done by using existing data such as Soil Conservation Service County Soil Surveys, U.S. Geological Survey well logs. Visual inspection of the area noting topography, wet areas, vegetation, and ditching is useful and may be necessary, particularly if maps are not detailed and/or soil maps do not exist.

Piezometers must be installed in at least three bore holes at the proposed pond site. An attempt shall be made to collect data for an extended period, particularly over the spring months. Elevations of the ground surface, casing top, and groundwater must be reported.

Information gathered from this investigation should be useful in evaluation of sites regarding (1) meeting habitation and groundwater separation distance requirements, and (2) estimating possible soil variability.

The detailed site investigation is needed to substantiate feasibility and design of a project at a selected site regarding location and design requirements. Quantity and quality of soil material on site (and borrow) must be identified and evaluated for use in pond and/or liner construction. This includes identification of (1) the spatial variability and variation of soil with depth and (2) groundwater conditions.

Since sites will vary in size and soils, it is necessary to have some concept of the design in mind (based on the preliminary evaluation) before carrying out the detailed investigation.

The design concepts and objectives of the investigation should be made clear by the design engineer to the qualified soil engineering party doing the field work, so that an investigation strategy can be developed, and sufficient data is collected. Consideration should be given to the following in determining the scope of the investigation.

A. Parameters which need to be defined and degree of detail necessary for the site design such as soils and groundwater with regard to proposed pond bottom elevation and type of liner.

B. What methods would be most suitable for explanation for the proposal such as: use of test pits, different types of borings and/or geophysical methods. Methods may vary when considering:

   1. Size and location of site.

   2. Topographic variability.

   3. Geology and possible soil variability determined during preliminary investigation.

   4. Identification of the volume of the soil needed for the liner if a soil liner is expected to be used.

C. If, during the investigation, data being collected begins to show the original design concept is not feasible, what course of action should be taken by the exploration party?

1.9 Water table

The depth to seasonally high groundwater on site shall be determined by mottled soil. Information on determining the depth to seasonally high groundwater table can be found at https://mnatlas.org/resources/water-table-depth/.

2. Basis of design

2.1 Organic loading

2.1.1 Non-aerated system

Pond design should insure a maximum five-day Biochemical Oxygen Demand (BOD) loading of 0.5 pounds per day per 1,000 square feet at the mean operating depth in the primary cells. This is equivalent to 22 pounds BOD5/acre/day.

2.1.2 Aerated system

Loading rates are to be determined on a peak monthly basis which may be characterized by industrial users or other sources.

2.2 Detention time

2.2.1 Non-aerated system

At least 180 days of detention time between the two and a maximum six foot depth ("operating range") in the entire pond system should be provided. For those facilities north of an east/west line approximately at Brainerd and spray irrigation facilities an average of 210 days of storage should be provided. If Total Maximum Daily Load studies required reduced discharge periods in the spring and fall, further evaluation of detention time requirements must be performed.

The storage capacity of all ponds should be calculated as the volume between two feet from the pond bottom and the six foot maximum elevation. ("operating range") unless a nonstandard operating range is used. The surface area at the mean operating depth should be used to determine storage volume. Design flow must be determined by following MPCA Design Flow Determination Guidelines https://www.pca.state.mn.us/sites/default/files/wq-wwtp5-20.pdf.

2.2.2 Aerated system

The aerated pond system design for minimum detention time for BOD removal may be estimated using the following formula:

This formula must be applied on a per cell basis:

$$T = \frac{E}{2.3\ K_T * (100 - E)}$$

T = Detention time, days in aerated cells

E = Percent of BOD5 to be removed in aerated pond

K_T = Reaction rate coefficient, per day for aerated ponds at temperature T (C) (BASE 10)

For treatment of normal domestic wastewater, the "K" value may be assumed to be 0.12/day and 0.06/day at 68° F (20° C) and 1° F (0.5° C) respectively, for preliminary design only. Pilot test data, obtained by incubating anticipated wastes at critical operating temperatures, shall be used to determine the "K" values as a basis for final design of all aerated stabilization pond systems.

In addition to domestic wastes for aerated ponds required to treat industrial wastes, septic wastes, or other non-domestic strength wastes the values of K and E shall be determined experimentally to arrive at optimum treatment efficiencies in the case of continuous discharge systems.

In no case shall the total detention time of the aerated cells be less than 25 days for systems required to meet 25 mg/L BOD or 36 days for systems required to meet 15 mg/L BOD.

A critical temperature of 1° F (0.5° C) shall be used to determine the detention time required in the system, unless otherwise justified and 68° F (20° C) is to be used to determine oxygen requirements of the aerated pond system.

Design flow determination shall be done as noted in the guidelines for non-aerated pond systems under Section 2.2.1.

2.3 Industrial waste

Consideration should be given to the type and effects of industrial wastes on the treatment facility and process, and in some cases, it may be necessary to pre-treat industrial or other discharges.

Industrial wastes should not be disposed of in waste stabilization ponds without assessment to the effect such substances may have upon the treatment facility and process or other discharge requirements in accordance with applicable regulations. These wastes include, but are not limited to, the following:

- Any toxic chemicals which may inhibit biological or bacteriological process.
- Any strong oxidizing agents or disinfectants in quantities sufficient to inhibit the growth of microorganisms.
- Metal plating wastes or other wastes containing heavy metals and/or toxic inorganic chemicals, such as cyanide, reduced sulfur compounds, arsenic, selenium, and free halogens.
- Detergent wastes or other wastes containing excessive phosphorus or surfactants.
- Plastics, pharmaceutical wastes and/or other synthetic organic chemicals not amenable to biological treatment.
- Any wastes containing excessive amounts of non-biodegradable oil, grease, or tar.
- Any wastes containing more than one mg/one phenol.
- Any acidic or alkaline wastes which because of quantity, strength or unequalized flow may upset the biological process or damage the physical facility.
- Any wastes containing radioactive chemicals.
- Nutrient deficient wastes (such as paper mill wastes).
- Any other waste which may be defined as an incompatible pollutant.
- If the pH is outside the range of 6.0 to 9.0 evaluate the possible impact on treatment.

2.4 Aerated system solids removal

Continuous discharging Aerated pond systems will generate algae during the treatment process which will likely exceed the Total Suspended Solids limit in the permit. To avoid violating the solids effluent limitation due to these algae, either the algae must be removed by some process (such as filtration, chemical treatment, etc.) or a 180 or 210 day controlled discharge must be provided, which does not entirely ensure compliance.

2.5 Aerated system oxygen and mixing capabilities

Oxygen requirements generally will depend on the BOD loading, the degree of treatment required, the concentration of suspended solids to be maintained, and the temperature of wastewater being treated. Aeration equipment shall be capable of supplying a minimum of two lb. oxygen/lb. BOD applied. A minimum of two mg/L to three mg/L of oxygen should be maintained in all ponds. Tapered aeration, in conjunction with influent configurations discussed (see MPCA process design checklist *Aerated Pond Review Checklist* at https://www.pca.state.mn.us/sites/default/files/wq-wwtp5-04.pdf) shall be considered in order to reduce the critical oxygen demand in localized areas. Data on pumping, circulation, and mixing capabilities shall be supplied. This data should include both direct and induced flows created by equipment.

2.6 Disinfection

Disinfection may be required for continuous discharging systems. The *Disinfection System – Review Checklist* (https://www.pca.state.mn.us/sites/default/files/wq-wwtp5-22.pdf) needs to be submitted with plans and specifications.

3. Pond layout

See Appendix C Figures 1-3

3.1 Pond shape

The shape of all cells should be such that there are no narrow or elongated portions. Baffles are permitted. Islands, peninsulas, and coves are not permitted. Dikes should be rounded at corners to minimize accumulation of floating materials. Common dike construction is encouraged when possible. The length to width ration should be no more than 4:1. Corners at angles of less than approximately 45 are discouraged.

3.2 Multiple units

3.2.1 Non-aerated system

At a minimum a pond system should consist of three cells, (two primary cells and one secondary), designed to facilitate both series and parallel operation. When the horizontal surface area of the dike(s), toe-to-toe, of a three-cell system would be greater than or equal to the mean pond surface area, a two-cell is permissible. However, two cell systems shall not exceed ten acres total pond(s) surface area at mean operating depth. Three cell systems provide more operational flexibility than two cell systems. The design of all systems shall provide for a secondary cell(s) with an absolute minimum hydraulic capacity of one-third the total hydraulic capacity of the total system. This is a very important factor in designing pond systems to allow adequate time to discharge enough water for the following storage period.

3.2.2 Aerated system

At a minimum, an aerated pond system shall consist of three aerated cells along with a non-aerated settling area. The non-aerated secondary cell or the non-aerated portion of the aerated cell used for settling should not be included in the volume calculation of the detention requirement. If a non-aerated settling area is used it must have a volume of at least one third of the total aerated pond system. For systems serving a population equivalent of less than 750 two aerated cells with a non-aerated settling area may be permitted. Flexibility shall be provided for both series and parallel operation. In the alternate/emergency mode of operation (usually parallel), the aeration capabilities should be adequate to prevent overloading. Design for cell isolation and/or de-watering should reflect considerations such as frost heaving of the seal, groundwater degradation of the seal while dewatered, aeration equipment preservation and general seal protection for whatever mode of isolation employed.

3.3 Pond bottom elevations differences

3.3.1 Non aerated system

The design must have adequate elevation difference between primary and secondary ponds to permit gravity filling of the secondary ponds from the primary. Secondary pond bottom elevations must be four feet lower than primary pond bottom elevations. Where this is not feasible, a portable pump and appropriate hoses must be provided. This pump shall have the capacity to refill the secondary cell at six inches per day. The capacity of the pump shall be such that the discharge is spread evenly over the 24-hour period and existing structures must be used to pump into and out of.

3.4 Pond depth

3.4.1 Non-aerated system

Liquid depths for pond systems shall be designed for a maximum of six feet. Six feet is the maximum depth for sunlight to penetrate to adequately maintain algae growth and thus aerobic conditions. Except for maintenance in no instance is it recommended to drain any pond below the minimum two foot level. Water levels less than two feet during the summer can promote aquatic weed growth which could impact the seal. Keeping at least two feet of water in the pond will also discourage vegetative growth, prevent scouring of the bottom deposits, and avoid freezing problems with piping, etc. The designed high water depth shall be at least 4.5 feet to discourage vegetative growth penetrating the bottom pond seal. To avoid freezing of piping after the fall discharge and prior to ice formation, the level in the secondary pond(s) should be increased to at least three feet by the retention of winter flows. In the spring, pond levels can be lowered again at a time when surface runoff dilution waters are generally at a maximum and increased once again to maximum depth with summer flows.

3.4.2 Aerated system

Aeration will be required when the water depth is above six feet to maintain 2 mg/L to 3 mg/L dissolved oxygen. Normal design water depth is 10-15 feet. This depth limitation may be altered depending on the aeration equipment, waste strength and climatic conditions.

4. Pond construction

4.1 Embankment and dike material compaction

Embankment and dike cores shall be compacted to at least 95 percent Standard Proctor Density to form a stable structure. Vegetation and other unsuitable materials should be removed from the area upon which the embankment is to be placed. Trees, boulders, rocks, etc. shall not be disposed of by burial on the pond site or in the pond dikes.

4.2 Dike top width and surface material

The minimum dike width is eight feet to permit access of maintenance vehicles. The surface must be compactable and able to support vehicle traffic around the perimeter of the pond(s). Acceptable material includes Class IV, or a combination of crushed concrete and Class I. Material used for top of dike construction must be comparable to Class IV and must be approved by the MPCA engineer.

4.3 Maximum and minimum dike slope

Inner slopes shall be no steeper than a 3:1 slope (run to rise). Mowing and other maintenance may not be possible on slopes greater than this and may be difficult on 3:1 slopes. Conversely, inner slopes shall be no flatter than a 4:1 (run to rise) slope. Slopes flatter than 4:1 are not allowed as the greater shallow water area is conductive to emergent vegetation. Outer dikes and maintenance roads need to be designed and constructed to preclude surface runoff from entering the ponds.

4.4 Freeboard

Minimum freeboard between the maximum water level and the top of the dike is three feet measured vertically (as opposed to slope length).

4.5 Dike erosion control and seeding

4.5.1 Erosion control – interior dike

Riprap is required on dikes from the pond bottom to the top of the interior dike for non-aerated ponds. Grass dikes are not allowed.

4.5.2 Erosion control – exterior dike

The exterior dikes shall have a minimum cover layer of four inches of fertile topsoil to promote establishment of an adequate vegetative growth. At the time of pre-fill inspection, the exterior dikes will be inspected for progress of vegetation. Adequate vegetation needs to be established prior to initiation of operation of the project. Perennial type, low growing, spreading grasses that withstand erosion and inundation and can be mowed are preferred for seeding of exterior dikes. In general, alfalfa and other long-rooted crops of this type are apt to impair water holding efficiency of the exterior dikes. The County Agricultural Extension Agency and Minnesota Department of Transportation can usually advise as to hardy, locally suited permanent grasses which would be satisfactory for exterior dike seeding.

4.5.3 Additional erosion protection

Additional erosion control may also be necessary on the exterior dike slope(s) to protect it from erosion if located in a floodway of an adjacent water course.

A discussion of the method of erosion control which encompasses all relative factors such as pond location, topography, size, prevailing winds, etc., should be provided. See MPCA *Riprap Criteria for Stabilization Ponds* at https://www.pca.state.mn.us/sites/default/files/wq-wwtp5-95.pdf for design criteria.

Whenever riprap material or acceptable equal is utilized, the location, type, size, source, application procedure and justification for its use should be discussed.

For aerated ponds, design should ensure erosion protection on the slopes and bottoms in the area where turbulence will occur because of aeration equipment or wind. In these cases, riprap or acceptable equal shall be placed one foot above the maximum water operating depth to two feet below the minimum water operating depth (measure vertically). The pond floor near the bottom of the aerators must be protected from erosion where the velocity can be expected to exceed one foot per second.

4.6 Pond bottom and dike core

Soil borings and tests to determine the characteristics of surface soil and sub-soil as in Section 1.8 shall be made part of the surveys to select pond sites.

Soil used in constructing the pond bottom (not including seal) and dike cores shall be relatively incompressible, tight, and compacted at or up to four percent above the optimum moisture content to at least 95 percent Standard Proctor Density. At least one test for moisture content and density shall be taken per 500 cubic yards of compacted dike material per dike side, and one test per acre of compacted pond bottom. The bottom should be cleared of vegetation and debris. Organic material that is removed shall not be used in the dike core construction. However, suitable topsoil relatively free of debris may be used as a cover material on the slopes of the embankment.

5. Pond seal

5.1 Seepage requirements

The permeability of the pond seal should be as low as possible and in no case should seepage loss through the seal exceed 500 gallons/acre/day.

5.2 Clay or other soil liner

Due to the impact of the pond seal on the cost-effectiveness and suitability of the pond alternative at different sites, it will be necessary that the results of the testing program which substantiates the adequacy of the proposed seal be incorporated into and/or accompany the engineering report.

Exploration to identify and define the quantities and quality of **soil liner materials** shall be done by using test pits, split barrel, or thin wall sampling techniques. A combination of these techniques may be used depending on the total area of investigation and the depth to which exploration is needed.

A minimum of three coefficients of permeability should be run on proposed liner material. Soils of differing classification (texture, dependent on particle size distribution) should not be mixed. A sufficient number of borings and (and/or test pits, etc.) should be made to define or establish confidence that the quantity of soil needed for construction of the liner is available. A minimum of five borings (and/or test pit) is required for even small and/or apparently homogenous site.

Systems utilizing clay soils, synthetic, or other materials will be considered adequate provided the permeability, durability, integrity, design life, etc. of such material can be satisfactorily demonstrated.

To achieve an adequate seal in systems using soil or other seal materials, the coefficient of permeability (k) in centimeters per second specified for the seal shall not exceed the value derived from the following expression:

$k = 2.58 \times 10^{-9} \times L$

L = the thickness of seal in centimeters.

The “k” obtained by the above expression corresponds to a percolation rate of less than 500 gallons per day per acre at a water depth of six feet.

For a seal consisting of a synthetic liner, seepage loss through the liner shall not exceed the same 500 gallons per acre per day seepage rate.

In addition to the specific quality control tests specified for each type of seal all ponds must be pre-filled (see MPCA Technical Criteria *Pre-fill and Water Balance Criteria* at https://www.pca.state.mn.us/sites/default/files/wq-wwtp5-61b.pdf) and checked for seepage as a final field determination of the quality of in-place seals.

Soil testing for proposed soil seals shall also include examination of the factors affecting seepage through the seal such as type(s) of soil, water content, density, thickness, Atterburg Limits and particle size distribution, and coefficient of permeability for the proposed seal and quantity required. This testing must be conducted for on-site material and for borrow area material. Borrow areas must be identified at the time of the engineering proposal. If the on-site clay is not adequate for a seal and borrow material will be used for a seal; the sub-soils at the pond site must be identified to assure the proposed borrowed area seal will be adequate.

The Engineer must estimate the quantity of clay needed to construct the seal and demonstrate, by calculation, how this quantity is available at the site. This applies equally to proposed borrow areas.

Specifications for a soil seal shall be based upon results of the preliminary testing program and at a minimum provide the type(s) of soil, optimum and acceptable range in water content, density, maximum coefficient of permeability, and maximum allowable boulder size. Requirements include:

1. The soil shall have high uniform fines (clay and silts) content.
2. The moisture shall be between optimum and the maximum workable moisture as determined by the soil test data for maximum compaction.
3. The coefficient of permeability shall not exceed the value derived in Section 1.8; and specifications for construction and/or placement of the soil seal shall be based upon results of a soil testing program. The specifications should indicate the seal density, the thickness and number of lifts and the parameters of the soil that may be used for a clay seal. Requirements include:
   a) the seal shall be compacted at the proper water content to at least 95 percent of Standard Proctor Density,
   b) the seal shall be at least 12 inches thick and applied in lifts no greater than six inches of compacted thickness,
   c) the completed seal shall be maintained at or above the optimum water content until the pond is pre-filled in accordance with MPCA Technical Criteria *Pre-fill and Water Balance Criteria*, and
   d) dike seals shall be covered as specified in Section 4.1.

Construction and/or placement of the soil seal shall be inspected and tested to ascertain compliance with specifications by an independent soils laboratory on-site, fulltime during seal placements. The specifications should state that if the field soil test data indicate a non-acceptable material, that the Engineer/Inspector will not allow placement of material.

Written certification that soil seal was constructed in accordance with plans and specifications shall be provided by the project engineer or an independent soils laboratory. At least one test for moisture content and density shall be taken per 200 cubic yards of compacted, in-place liner material for each lift. A minimum of one test per dike side per lift and four per cell bottom per lift will be required. Permeability testing of undisturbed core samples from the finished in-place seal shall also be provided. At least one core per acre should be tested. The tests for density and water content per acre per lift shall include the dike area. The tests for core samples per acre shall include the dike area. No pre-filling of the pond may take place until all required tests results have been approved by the MPCA and an inspection conducted by the MPCA.

5.3 Synthetic liners

See Figure 5 in Appendix C and appropriate MPCA technical criteria regarding polyvinyl chloride liners and high density polyethylene liners. Note that a pre-liner inspection is required for prior to covering of the sub-grade material for synthetic lined ponds; adequate notice (at least seven days) must be given to MPCA to conduct the inspection.

5.4 Uniformity

The pond bottom prior to seal placement shall be as level as possible to provide for uniformity of seal application and to prevent locally unsatisfactory conditions. Finished elevations of the pond bottom and six feet seal lifts shall not be more than two-tenths foot from the average elevation of the bottom. Pond bottom uniformity shall be verified by the submittal of a pond bottom survey at the time of either pre-fill inspection in the case of clay lined ponds or pre liner inspection in the case of synthetic lined ponds.

5.5 Pre-filling and water balance

The field soil test date must be summarized, approved by the consultant engineer and approved by the MPCA, and an inspection conducted by the MPCA, prior to the MPCA granting permission to pre-fill. All ponds shall be pre-filled at a minimum to the two-foot level (or to the level aeration equipment can effectively operate) to protect the liner, to prevent weed growth, to encourage rapid startup of the biological process and discourage odor, to reduce freeze-up problems for late fall startups, to confirm the seal's integrity and to maintain the water of the seal at or above optimum. However, the dikes must be completely prepared as described in Section 4.1 before the introduction of water. Water for pre-filling may be taken from the municipal water supply system, a nearby lake, or stream (permits must be obtained from the Department of Natural Resources) or using the effluent from an existing mechanical wastewater treatment level needed for a water balance. Raw wastewater shall not be used for pre-filling purposes.

Prior to placement of topsoil on the dike slope, the pond bottom only (not dikes) shall be sterilized to prevent vegetation growth. Ponds not refilled or completed prior to winter must be inspected by the consultant engineer and agency personnel in the spring for disturbances to the seal such as freezing and then thawing of the seal, dehydration, erosion, etc. See prefill and water balance criteria.

5.6 Water balance

A water balance must be conducted on all new ponds in accordance with MPCA Technical Criteria *Pre-fill and Water Balance Criteria*. The results of the construction soil tests, final seal permeability tests, and the water balance will be used to judge the adequacy of the finished seal.

6. Influent line and control structures

6.1 Pipe materials

Generally accepted material for underground sewer construction should be used for the influent line to the pond. Unlined corrugated metal pipe should be avoided due to corrosion problems. Other materials selected should be suited to local conditions.

Special consideration must be given to the character of the wastes, possibility of septicity, exceptionally heavy external loadings, abrasion, soft foundations, and similar problems.

6.2 Influent line and inlet control structure

6.2.1 Non-aerated

The portion of the influent line prior to the dike should be designed to maintain an adequate cleaning velocity throughout this line. Surcharging of the gravity sewer line upstream from the inlet manhole is not recommended. If surcharging is expected, justification must be submitted to include an evaluation of possible plugging problems and remedies.

All primary ponds must have individual influent lines. These lines should terminate approximately at the midpoint of the width and at approximately two-thirds the length away from the outlet structure to minimize short-circuiting.

Consideration should be given to multi-influent discharge points for primary cells of 20 acres or larger to enhance distribution of the load on the cell.

In most cases, maximum length of inlet pipe should be governed by available sewer cleaning equipment capabilities. Cleanouts shall be spaced at an adequate distance to access with cleaning equipment, length governed by available cleaning equipment.

6.2.2 Aerated pond system

Aerated stabilization ponds shall have multi-inlets to equalize the process loading factor, thereby reducing the peak oxygen demand in localized areas. Inlet configurations should be designed to balance the maximum utilization of the oxygen supplied and arrangement of aerators to disperse the incoming sewage and minimize solids build-up. In an aerated pond, up to 50 percent of the calculated sludge storage depth may be used to carry an influent line due to lower potential for freezing in an aerated pond, as well as not impede circulation.

All aerated ponds shall have influent lines which distribute the load evenly within the mixing zone of the aeration equipment.

Consideration of multiple inlets should be closely evaluated for any diffused air system.

6.3 Discharge apron

The influent line shall discharge horizontally. A horizontal discharge is required to eliminate the possibility of sludge settling back into a vertical discharging pipe. The end of the influent line should rest on a suitable concrete or riprap apron large enough such that the terminal influent velocity at the end of the apron does not exceed one foot per second. A minimum size apron of four feet square must be provided. The liner must have uniform thickness and/or cover material under the influent pad.

6.4 Influent flow monitoring

Provision to measure and record the influent flow shall be provided. Influent flow must be recorded via a flow measuring device. The use of pump run time clocks alone for flow measure is not acceptable. Pump run time clocks must still be used as a secondary form of flow measure and pump operation and maintenance.

For aerated ponds preceded by a lift station. Daily flow rates are typically acceptable, instantaneous flow rates may be necessary in specific cases.

6.5 Effluent flow monitoring

Provisions to accurately measure pond depth and calculate daily discharge volumes are required. Provision to measure and record effluent flow rates for continuous discharge systems and/or systems followed by additional treatment units is required.

7. Transfer and outlet piping and control structures

7.1 Control structures

See Figures 6, 7A, 7B and 7C

Control structures must reflect the best available technology available at the time of design. Telescoping valves or similar structures are preferred for operational flexibility. Slide gates are the absolute minimum although they are not preferred.

Pond design shall consider the use of multi-purpose control structures where possible, to facilitate normal operational functions such as drawdown and flow distribution, flow and depth measurement, sampling, pumps for recirculation, chemical addition and mixing, and to minimize the number of construction sites within the dikes. As a minimum, control structures shall be:

- Accessible for maintenance and adjustment of controls.
- Located such that dike maintenance and dike travel are not hindered.
- Adequately ventilated for safety and to minimize corrosion.
- Locked to discourage vandalism.
- Contain controls to allow variable water level and flow rate control and complete shut-off.
- Constructed of non-corrosive materials (metal on metal contact in controls should be of like alloys to discourage electro deposit reactions).
- Located to minimize short circuiting within the pond and discourage freezing and ice damage. Manhole covers over control structures should be grated rather than solid to provide ventilation (to prevent corrosion). Individual unit isolation, de-watering and transfer capabilities shall be designed to provide flexibility in operation and maintenance. Either elevation differential or pumping capabilities may be used to provide this flexibility.

Control structures between ponds or for a final discharge must provide a watertight mechanism for controlling the flow in increments of approximately six inches between the two foot and maximum of six foot level. At a minimum, dual slide gates will be required in each structure.

Slide gates and telescoping valves alone will not provide a watertight mechanism. Therefore, a shut off valve shall also be provided for the control structure. Access to operate this valve should be available from outside the structure.

If it is necessary to use slide gates it is recommended that the following gates be provided per structure: one 1-foot, 2-foot, 3-foot, a six inch, and a maximum water depth gate. Offset handles should be provided to facilitate removal.

Adjustable surface mounted guides are preferred over embedded guide frames to allow easy adjustment, repair, or replacement.

7.2 Inlet/outlet transfer piping

No piping shall be located under the pond seal. No piping shall be allowed to cross under one cell to another cell.

All piping shall be made of acceptable materials. Pipe design with diameters of greater than 24 inches shall address problems such as ice damage, discharge velocities (scouring during discharge) and maintenance of the two foot water level. Whenever the desired hydraulic capacity cannot be satisfied by one pipe, multiple structures should be utilized. These multiple structures should have their inlets and outlets located respectively to minimize turbulence within the ponds. The necessity to secure piping with anchors to prevent pipe movement should be evaluated.

Locating the shutoff valve on the downstream pipe in a control structure is required to facilitate measuring the depth of the upstream cell in the control structure.

Polyvinyl chloride (PVC) pipe must be anchored to prevent pipe movement.

All pond systems shall be designed with piping flexibilities to permit isolation of any unit without affecting the transfer and discharge capabilities of the influent waste load to a minimum of two units and/or all primary units in the system should be provided.

Refer to Section 5 in locating pipes regarding the seal.

Outlets from control structures discharging to cells within the pond system should be located a minimum of ten feet from the toe of the dike to prevent clogging (30 feet if in a corner). The outlet should be located as far away from the inlet as possible (i.e., on the dike opposite the inlet) to avoid short circuiting.

When interconnecting control structures are designed for flow operation in either direction, the vertical inlet can be considered adequate for erosion control purposes. When the control structure is a one way design, the discharge may be horizontal and near the bottom only if adequate erosion control protection is provided such that the velocity of the influent does not exceed one foot per second at the terminus of the slab (four feet square) at maximum head difference.

For units designed for shallow or variable depth operations, submerged intakes are recommended.

Pipe intakes shall be located a minimum of ten feet from the toe of the dike (30 feet if in a corner); two feet above the top of the finished pond bottom and employ a vertical intake.

7.3 Emergency drawdown intake

All ponds shall have drawdown capability to allow complete draining for emergency repairs. Knockout plugs or some form of removable cap at the end of the riser tee is required.

7.4 Hydraulic capacity

7.4.1 Non-aerated pond system

The hydraulic capacity for controlled discharge systems shall permit transfer or discharge of water at a minimum rate of six inches of pond water depth per day at the minimum head.

For calculation purposes, minimum head over the two foot riser may be assumed to be one foot.

7.4.2 Aerated pond system

The Hydraulic capacity for constant discharge structures and piping shall allow for a minimum of the peak instantaneous wet weather flow of the system.

7.5 Operational flexibility

Operational flexibility includes the ability to transfer and discharge water various ways. The system should be designed so that it is possible to discharge any of the cells while bypassing the remaining cells. For instance, it is desirable to be able to discharge the primary pond(s) without having to transfer the water into the secondary. This allows complete isolation of the cells. The system should also be designed to allow raw influent to be discharged directly to the secondary while bypassing the primary(s). This insures optimal flexibility for pond operation.

7.6 Outlet line and outlet structure design

The outlet (effluent) line requires a shut off valve on the downstream side to prevent unpermitted discharges. The discharge shall include necessary erosion protection to protect the stream bank with a minimum discharge apron size of four square feet. The discharge pipe should include a rodent guard of some type on the discharge end.

8. Aeration equipment

8.1 Electrical controls

Suitable protection from the elements shall be provided for electrical controls. All electrical equipment must be in accordance with the National Electrical Code or NFPA 70.

8.2 Aeration location

Design and location of aeration devices should provide for adequate mixing and aeration of sloped areas of the dike to prevent dead areas.

Aerators that are located along the bottom of the pond must provide sludge storage depth in relation to the location of the aerators.

Consideration shall be given to how aerators will be accessed to allow for maintenance.

8.3 System reliability

Each cell must have the capability of providing aeration that will maintain a minimum of 0.5 MG/L of oxygen within the cell at the increased loading when the preceding cell is out of service. Equipment reliability requirements are listed under the specific aeration type.

8.4 Aeration type

8.4.1 Diffused aeration system

The specified capacity of blowers or air compressors, particularly centrifugal blowers, should consider the possibility that the air intake temperature may reach 115° F (46° C) or higher and also that the pressure may be less than normal.

The specified capacity of the motor drive should also consider that the intake air temperature may be as low as -20° F (-29° C) or lower, which may require over sizing of the motor or a means of reducing the rate of air delivery to prevent overheating and damage to the motor.

Air filters shall be provided in numbers, arrangements, and capacities to always furnish an air supply sufficiently free from dust to prevent clogging of the diffuser system. The location of air filters shall be easily accessible for maintenance purposes.

Blower unit locations shall be carefully chosen to reduce noise levels in adjacent working areas.

The blowers shall be provided in multiple units, so arranged and in such capacity as to meet the peak day design air demand with the single largest unit out of service. The design also shall provide for varying the volume of air delivered in proportion to the demand resulting from differing loads which may require a greater oxygen supply.

The piping and air diffuser system shall be capable of delivering 200 percent of the normal air requirements throughout each pond. The spacing of the diffuser should be in accordance with the oxygenation and mixing requirements throughout each pond.

Individual control valves shall be provided at each junction in the aeration matrix, preferably with each indicator markings for throttling, or for complete shut off. Diffusers in any single assembly shall be designed to have substantially uniform pressure loss.

8.4.2 Bubbler diffuser system

Bubbler tubes shall be constructed of a rodent resistant material. The diffuser lines shall extend across the entire pond and be connected to air headers on both sites. Sufficient slack shall be allowed for raising and cleaning of the bubbler tubes.

Gas ports shall be installed at each connection to the air headers.

Extra bubbler tube lines shall be provided. Ten percent of the total length shall be supplied as spare equipment.

A boat and boat access suitable for maintenance of the bubbler system shall be provided.

If a motor for the boat is provided, water cooled engines are not acceptable.

Calcium build-up in the fine silt bubbler tube system is a major problem and should be addressed.

8.4.3 Diffused aeration with spargers or helixers

Aeration piping should extend across the ponds and up both dikes for accessibility.

Air supply lines shall be properly anchored with non-corrosive anchors capable of withstanding two times the buoyant force of the lines. Positive anti-slip devices shall be incorporated in the design to prevent vertical movement of the air supply lines. Flexible couplings of sufficient length to prevent joint separation shall be used at any connections where movement of displacement may occur.

Air lines should be designed to be easily removable or cleaned without draining of the pond.

Gassing ports should be provided at each connection to the air headers.

The water depth to the top of the sparger or helixer shall not be less than four feet to allow for potential winter freezing problems.

8.4.4 Surface aerators

8.4.4.1 Platform mounted

The raw sewage should be discharged immediately below the aerators.

Consideration shall be given to protecting the mechanisms from freezing.

A minimum of two aerators shall be supplied in each pond, unless otherwise justified. The remaining aerators shall have the capability to supply the average air demand with the largest aerator in each pond out of service.

The designer should consider varying the amount of oxygen transferred in proportion to the demand represented by the load on the pond. (For example: time clock aerator operator or water level flexibility).

Aerator accessibility shall be provided for periodic and major maintenance repairs. Access bridges shall be designed to provide structural support for necessary equipment and maintenance/removal vehicles. Safety railings shall be corrosion resistant. Consideration shall be given to either providing:

1. reinforced safety railings with tripod equipment, or
2. equipment removal vehicles and compatible walkway widths for easy aerator/motor removals.

Platform legs shall be spaced at sufficient distance from the aerator to minimize ice build-up caused by splashing and should conform to the manufacturer’s recommendations for baffling requirements.

Manufacturer's data shall be submitted to verify mixing zone and oxygen dispersion capabilities of the aerators to be used.

8.4.4.2 Floating aerators

Floating surface aerators shall be anchored in three directions.

The flotation device shall be capable of floating two times the weight of the total unit to the one-half depth mark on the float.

The floating aerator shall be designed to prevent tipping problems caused by an ice build-up on one side or on top of the unit. Ninety percent of the total weight of the unit shall be at or below the water level.

The depth of the impeller below the water surface shall be a minimum of 12 inches to prevent freeze-up in case of a winter power switchover is provided.

Heated covers or another method to prevent ice build-up on the aerators should be considered.

An alternate power source shall be required when floating aerators are to be used.

Design considerations should be included for removal of the aerators for maintenance purposes.

8.4.4.3 Brush rotor

Brush rotor aerators may be either the fixed or floating type and shall conform to the applicable requirements for fixed or floating aerators. They shall have the capability of variable brush immersion depths. Additionally, they shall be provided with covers and heating mechanisms to prevent winter freeze-up problems. Baffles on the intake side should be provided to prevent ice from entering the brushes.

9. Miscellaneous

9.1 Fencing

The pond area shall be enclosed with an adequate stock tight fence to preclude livestock and discourage trespassing. The fence shall be located such that travel along the top of the dike by maintenance vehicles and mowing equipment is not obstructed. A vehicle access gate of sufficient width to accommodate mowing equipment shall be provided. All access gates shall be provided with locks.

Do not put the fence line on the inner dike slope or at the toe of the outer dike to avoid interference with mowers and maintenance trucks. Normally hog wire topped with barbed wire is considered adequate protection.

9.2 Road access

An all-weather access road shall be provided to the pond entrance to allow year-round access of the facility.

9.3 Warning signs

Appropriate permanent signs shall be provided along the fence around the pond to designate the nature of the facility and advise against trespassing. At least one sign shall be provided on each side of the site and one for every 500 feet of its perimeter.

9.4 Laboratory equipment

At a minimum, the following equipment shall be provided as part of the project:

- DO meter (w/replacement membrane if membrane type meter)
- pH meter, w/storage and buffer solutions 4, 7, 10
  - Beakers for pH buffers (3 - 50 ml)
- Wash Bottle w/distilled water
- Large sample bottle (2 liter)
- Sample bottles (2 - 1 liter)
- Graduated cylinder (1000 ml)
- Plastic gloves
- A long handled sampling pole/dipper (w/appropriate bottle)
- Thermometer
- Cooler for sample storage

9.5 Pond depth gauges

Portable pond level gauge shall be provided to measure water depths in control structures for each cell in a minimum of ½ inch increments. Permanently mounted measuring devices are not acceptable. One recommendation is a fuel tank measurement staff.

9.6 Inspection

The specifications for construction must clearly indicate the Agency staff must conduct inspections of the pond before placement of synthetic liner on finished sub grade and following completion of construction and prior to pre-filling and prior to liner placement if a synthetic liner is used.

9.7 Control building

If a building is considered necessary at the pond site, it should be large enough to offer protection for equipment used for the operation and maintenance of the ponds. The building may be a “garage type” of metal or wooden construction with slab floors.

For aerated ponds, a building and laboratory space should be considered dependent on the type of equipment needed for operation and maintenance of the pond and the type of wastewater testing that will be required during operation.

9.8 Screening and grit removal

9.8.1 Aerated pond system

For mechanical aerated pond systems, preliminary facilities shall be required to remove rags, sticks or other debris that can cause aerator clogging problems.

Appendix A – Pre-Aeration Pond Design

A-1 Introduction

This appendix will address aeration basins designed to reduce high strength biochemical oxygen demand (BOD) loading being discharged continuously or intermittently to subsequent secondary treatment units. These aerated basins are designed to maintain bio-solids in suspension, thereby supplying complete mixing within the basin for the purpose of BOD reduction.

The design criteria for aerated stabilization ponds will apply to pre-aeration ponds except for the following section. The section numbers noted below will be preceded by the letter A and will correspond to the respective section numbers in the stabilization pond design criteria.

A-2 Aeration and loadings for pre-aeration pond design

Loading rates are to be determined on the strength of waste and frequency of discharge from the high strength contributor.

The pre-aeration pond system design for minimum detention time may be estimated using the following formula, consideration should be given to using loading rates of peak hour, peak day, peak week, etc. dependent upon the source of loading and the detention time to be provided:

$$t = \frac{E}{2.3\, K_T \times (100-E)}$$

t = detention time, days

E = percent of BOD_5 to be removed in

pre-aeration ponds (soluble BOD removal)

K_T = reaction rate coefficient, per day, for complete mix aeration basin, (sludge removal in subsequent treatment units) base ten. The K_T value shall be determined experimentally to arrive at optimum treatment efficiencies for the type and strength of the wastewater characteristics.

The design detention time shall be determined in the above formula using the minimum critical temperature which will be anticipated in the pre-aeration pond. This temperature shall be determined and justified by the design engineer using heat loss calculations, influent temperature, etc. (20 C may be used to determine oxygen requirements of the pond).

The variation of the reaction coefficient to various temperature ranges shall be determined during the experimental studies on the reaction rate coefficient, K_T.

The volume of the basins shall also reflect the detention time needed for hydraulic and organic surges to the system.

A-3 Multiple units

At a minimum, pre-aeration basins shall consist of two units designed to facilitate both parallel and series operations. Exceptions may apply to very small installations. Normal configuration is the parallel information.

All systems shall be designed with piping flexibilities to permit isolation and de-watering of any basin without affecting the transfer and discharge capabilities of the total system.

Recirculation capabilities, from subsequent treatment units, should be considered in the design so as to provide flexibility in operation, and a means of diluting incoming high strength waste with oxygen enriched water.

A-4 Basin shape

Basins shall be designed to minimize solids deposition or floating materials accumulation in areas of low velocity. Earthen basins that are square or rectangular basins should be rounded at corners.

A-5 Maximum slopes – dike

Dike slopes shall not be greater than a 3:1 (rise to run) ratio.

A-6 Additional erosion and seal protection

In addition to the discussion in the aeration stabilization pond design criteria, total seal protection shall be provided since velocities shall be such as to maintain bio-solids in suspension throughout the basin.

Total seal protection should include dike and pond bottom, riprap may be a typical seal protection.

A-7 Dissolved oxygen

Dissolved oxygen (DO) throughout the polishing pond contents shall be maintained, always at an average of 3 mg/1. Where the applicable stream standards dictate a higher DO, some mechanism shall be provided to accomplish this during discharge.

A-8 Aeration equipment

Shall be sized on influent load and maintaining DO levels in the pond.

Appendix – B Polishing pond design

Non-aerated polishing ponds shall be designed in accordance with the stabilization pond design criteria. In addition, the following considerations shall be incorporated in the design of non-aerated polishing ponds.

B-1 Controlled discharge – storage operation

Discharge during spring and fall only

Normally 180 (210 for spray operation and those operating in the Northern regions) days

Minimum number of two units with the capacity of series and parallel operation

Ponds shall be no greater than six feet to maintain acceptable DO levels throughout the pond content. When the pond is used intermittently, a three-foot minimum water depth must be maintained to protect the seal during low water conditions in the pond.

Appendix C

Figure 1: **Three-cell non-aerated stabilization pond**

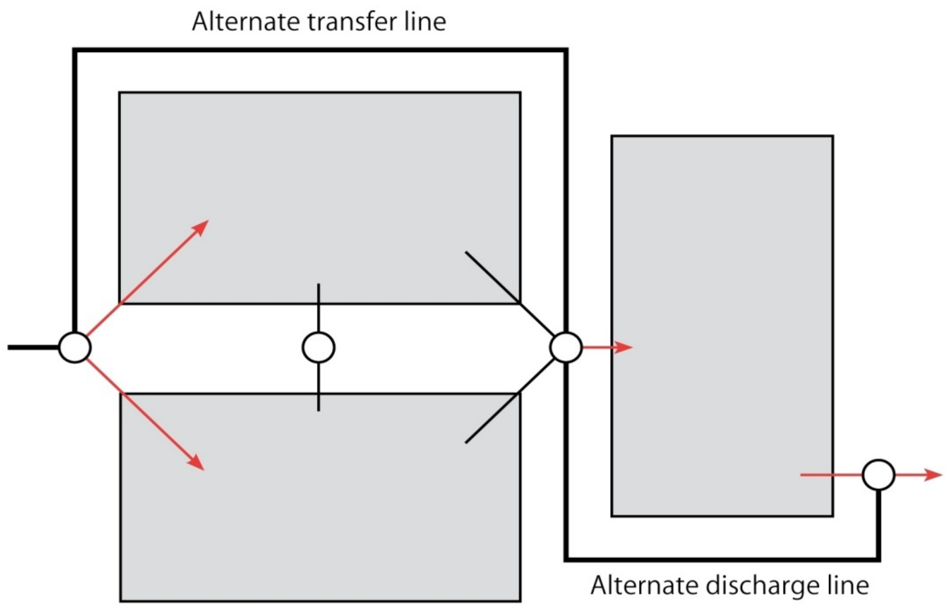


Figure 2: **Two-cell non-aerated stabilization pond**

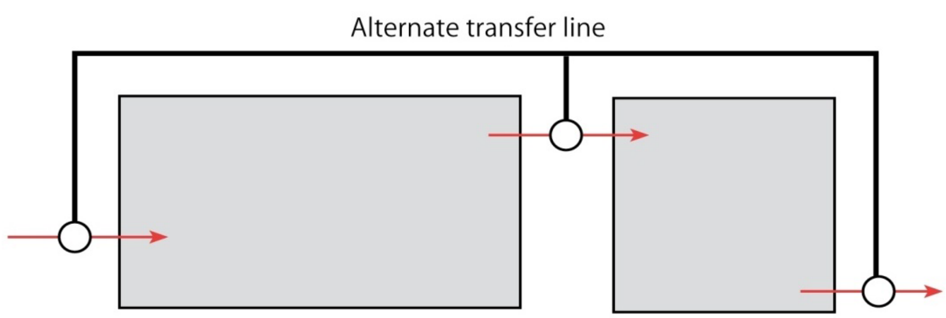


Figure 3: **Aerated pond system**

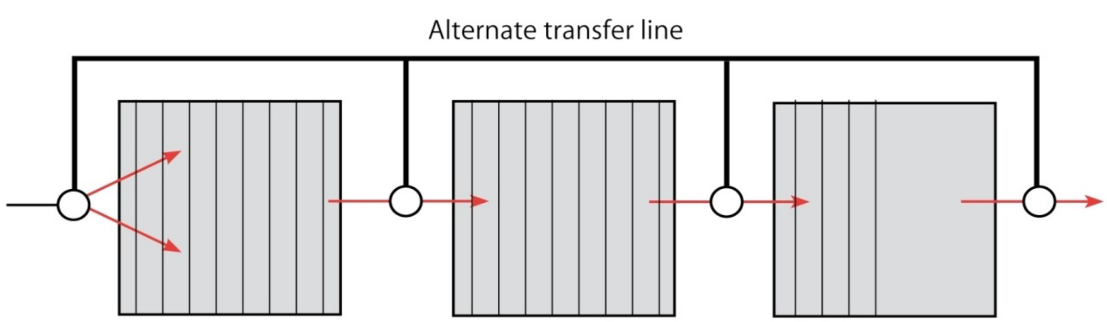
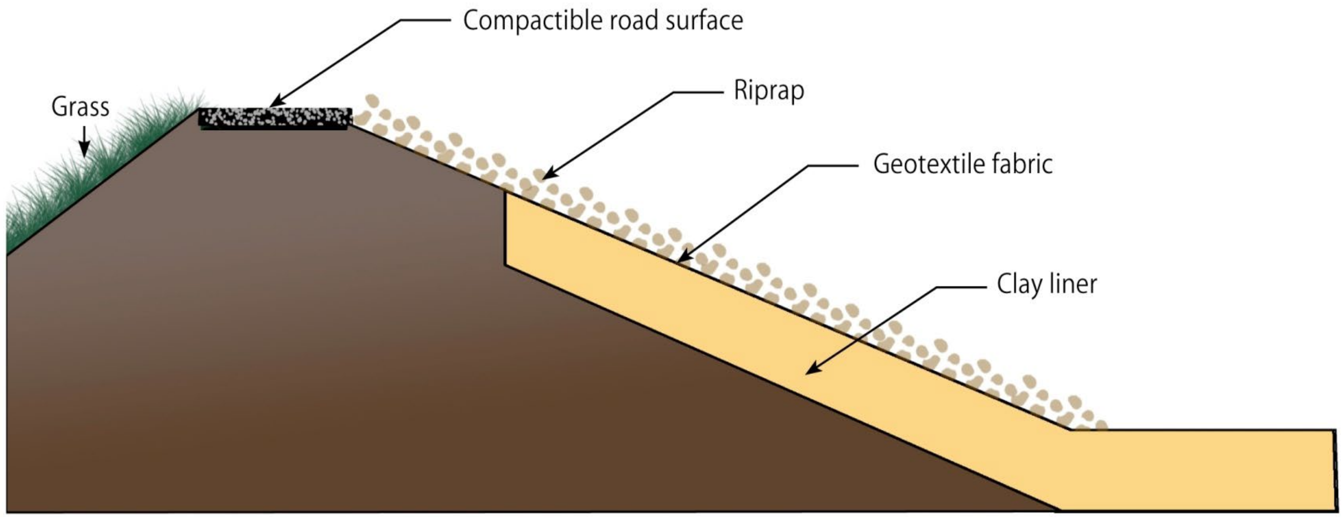


Figure 4: **Clay lined pond**



NOTE: See design criteria for specifications for riprap, clay and synthetic liner.

Figure 5: **Synthetic lined pond**

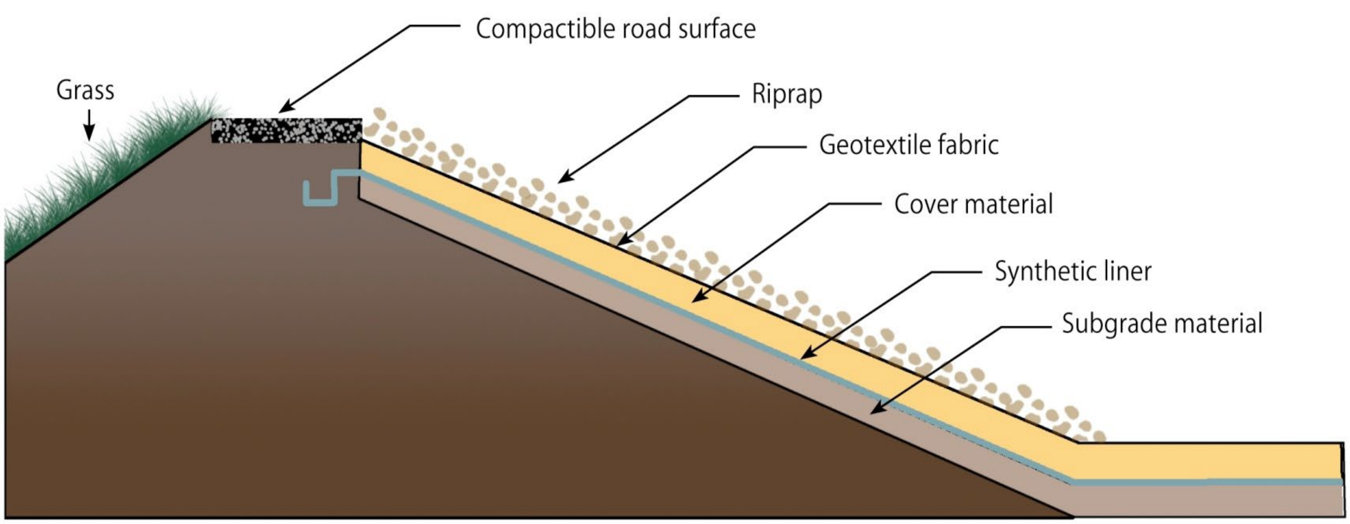
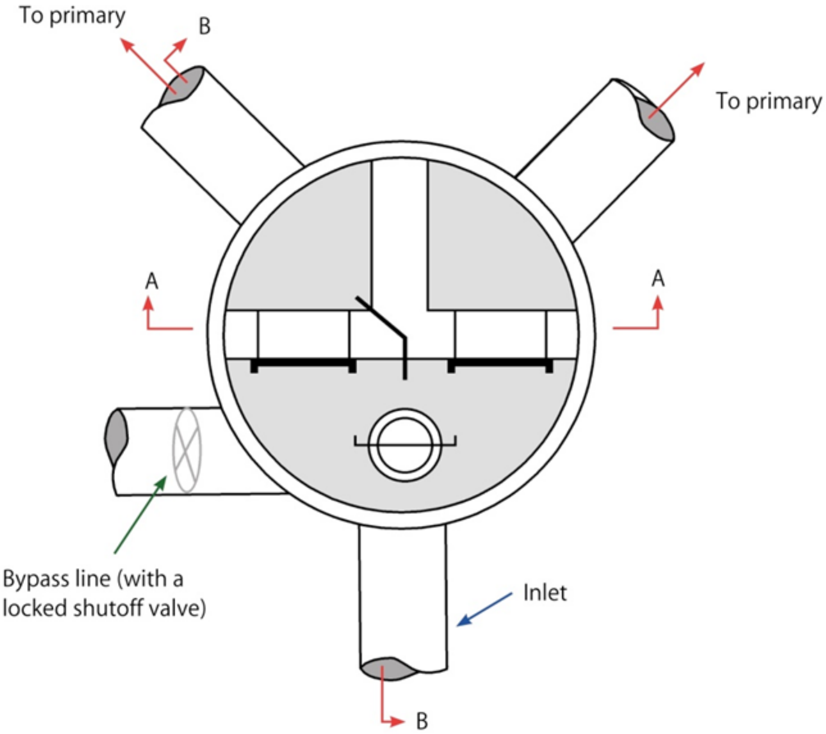
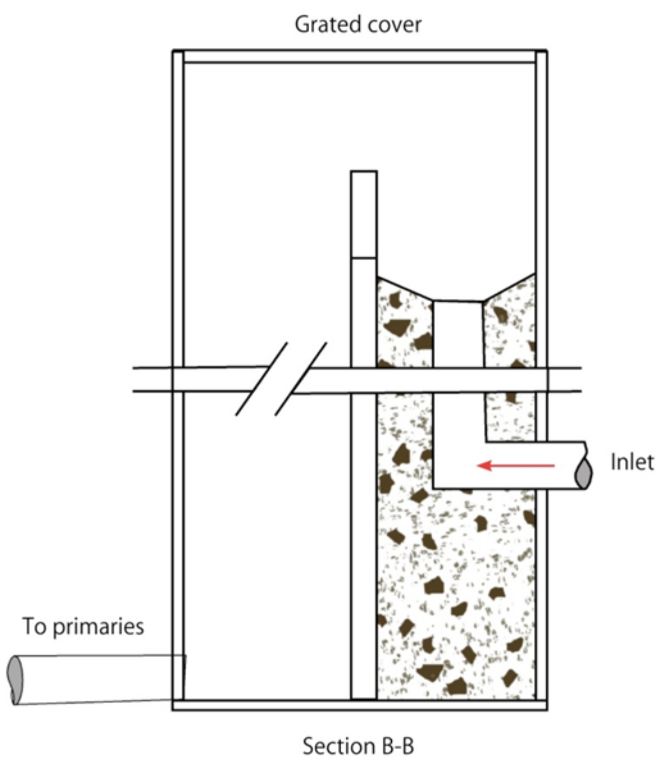


Figure 6: **Upflow inlet splitter structure**





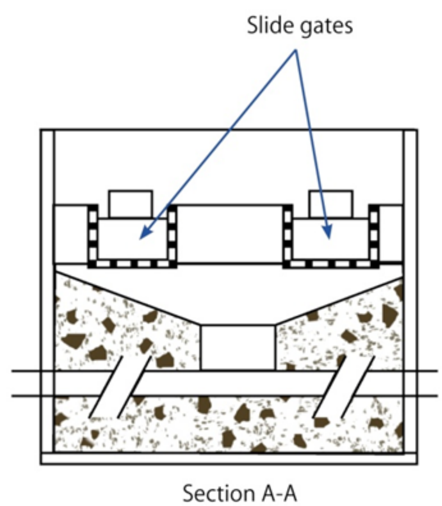


Figure 7A: **Telescoping valve**

Note: For illustration only; actual design may vary by manufacturer.

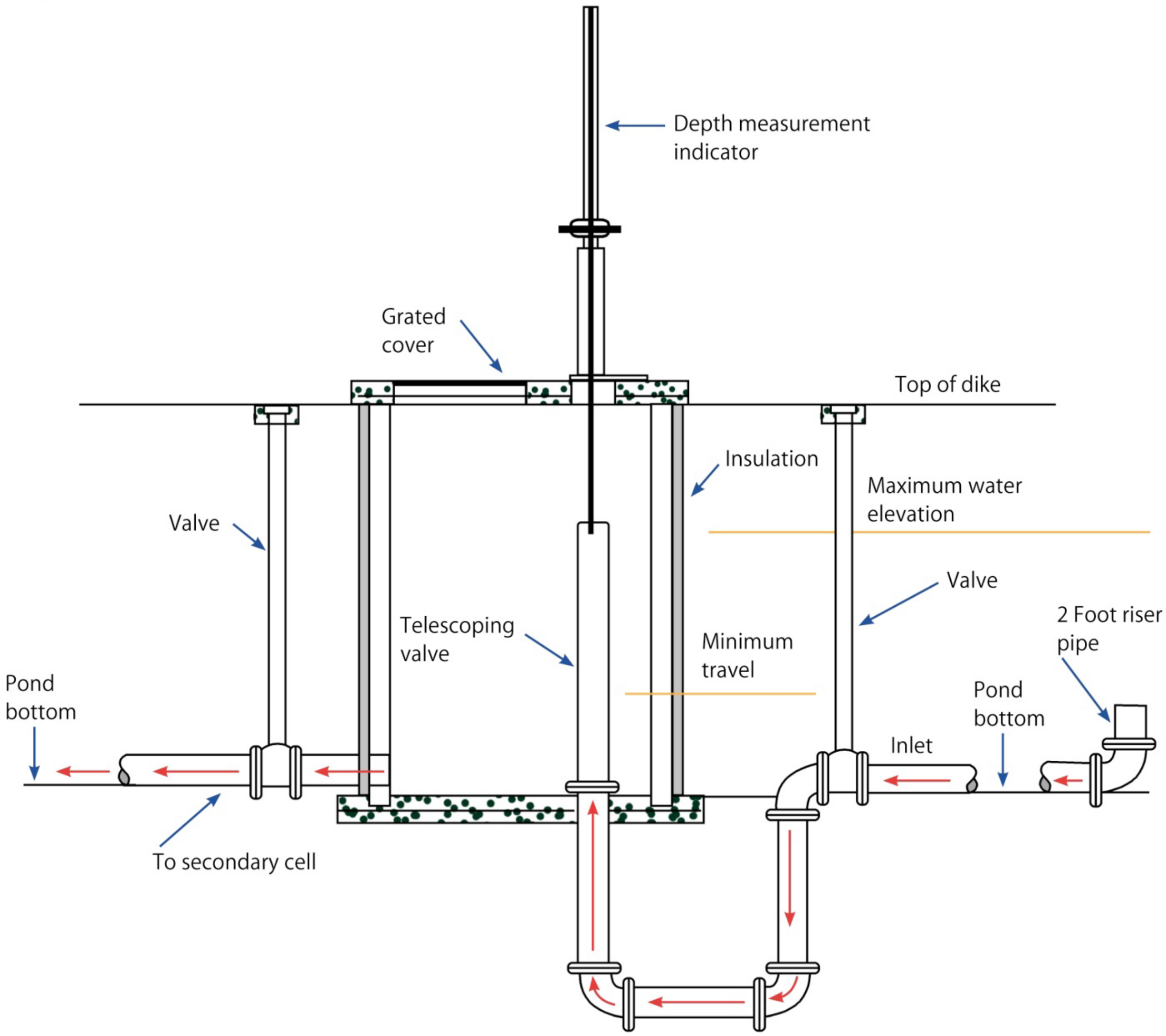


Figure 7B: **Telescoping valve**

Note: For illustration only; actual design may vary by manufacturer.

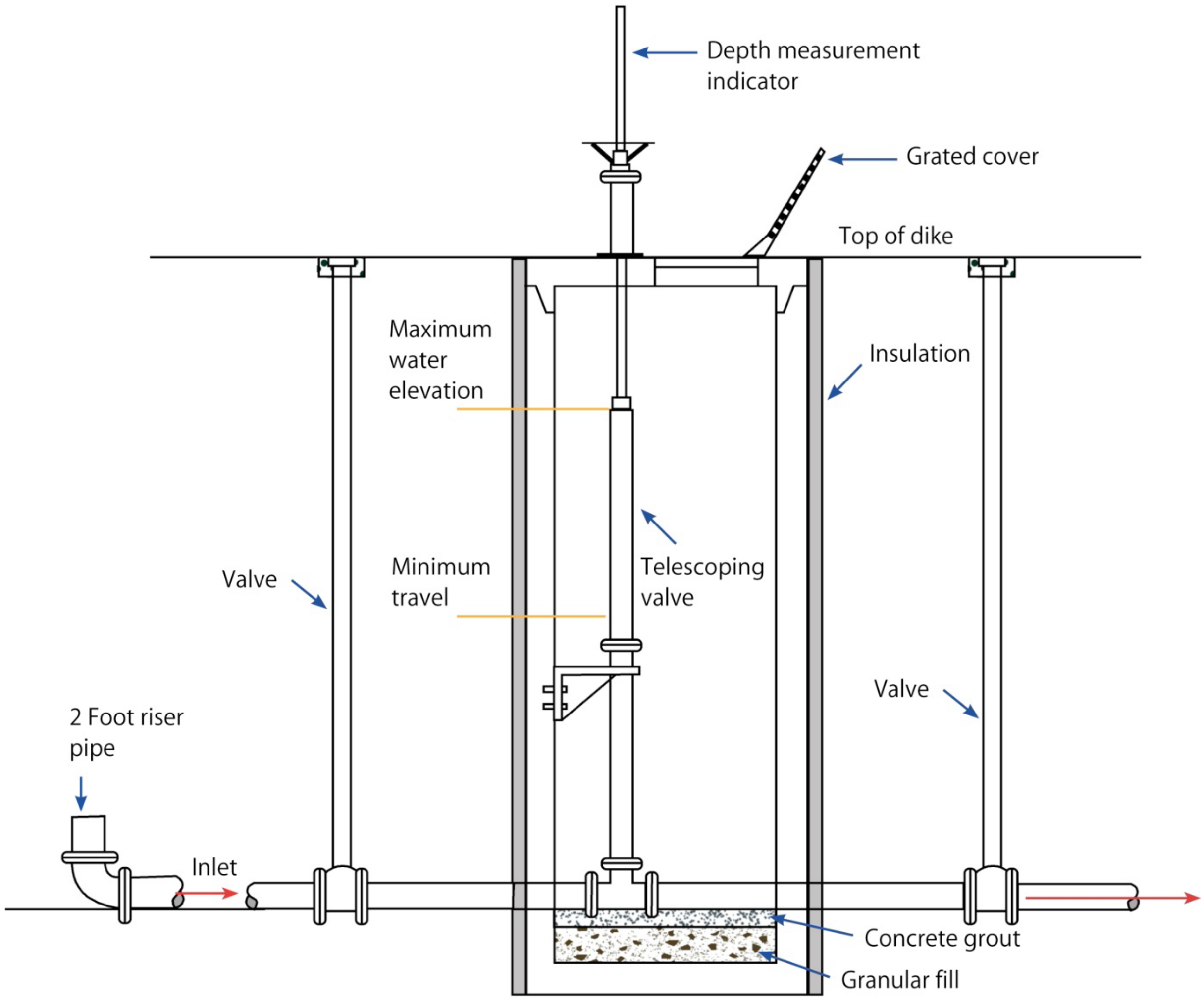


Figure 7C: **Telescoping valve**

Note: For illustration only; actual design may vary by manufacturer.