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Pumped Outlets for Subsurface Drainage

Improved Subsurface Drainage

Generally speaking, surface drainage is not as effective as subsurface drainage for satisfying the drainage needs of many soils. Enhancing surface drainage with subsurface, or tile drainage, has the potential to improve crop productivity and farm efficiency where wet soils persist. In addition, improved tile drainage has been found to reduce (in some cases dramatically) runoff and peak outflow rates, as compared with surface drainage alone. In terms of nutrient and sediment losses, tile drainage provides a mixed bag of impacts. Compared to surface drainage alone, tile drainage decreases the loss of some constituents such as sediment, phosphorus, and organic nitrogen, while increasing the loss of mobile constituents, such as nitrate-nitrogen and some salts. Planning an effective tile drainage system requires consideration of a number of factors. The Minnesota Drainage Guide, local drainage experience and expertise, appropriate agency personnel, soil survey information, site topography surveys, field evaluation, wetland restrictions, and outlet limitations should all be considered in the planning process.

Pumped outlets enable improved drainage at reasonable cost, in areas that lack a natural gravity outlet. A pump drainage system consists of a collection system (tile or surface drainage system), a pumping plant, and a free outlet. A typical pumping plant is shown in Figure 1. For pumped drainage to be feasible, the economic benefits of improved drainage must be weighed against the startup and operating costs associated with the pumping plant. Potential economic benefits must be assessed locally, and will depend on the adequacy of the current drainage system, soil texture, and crop to be grown. Operating costs depend on design of the pumping plant (in particular, size of the pump and lift) and rainfall characteristics over the drainage season.

Area to be Pump Drained

The drainage system of the area served by pumps should be planned to meet both drainage needs of the area and efficient operation of the pump. Runoff from areas outside the drainage area should be diverted to a suitable outlet. The drained area should be protected against backwater or overflow from the outlet by perimeter dikes designed against overtopping.

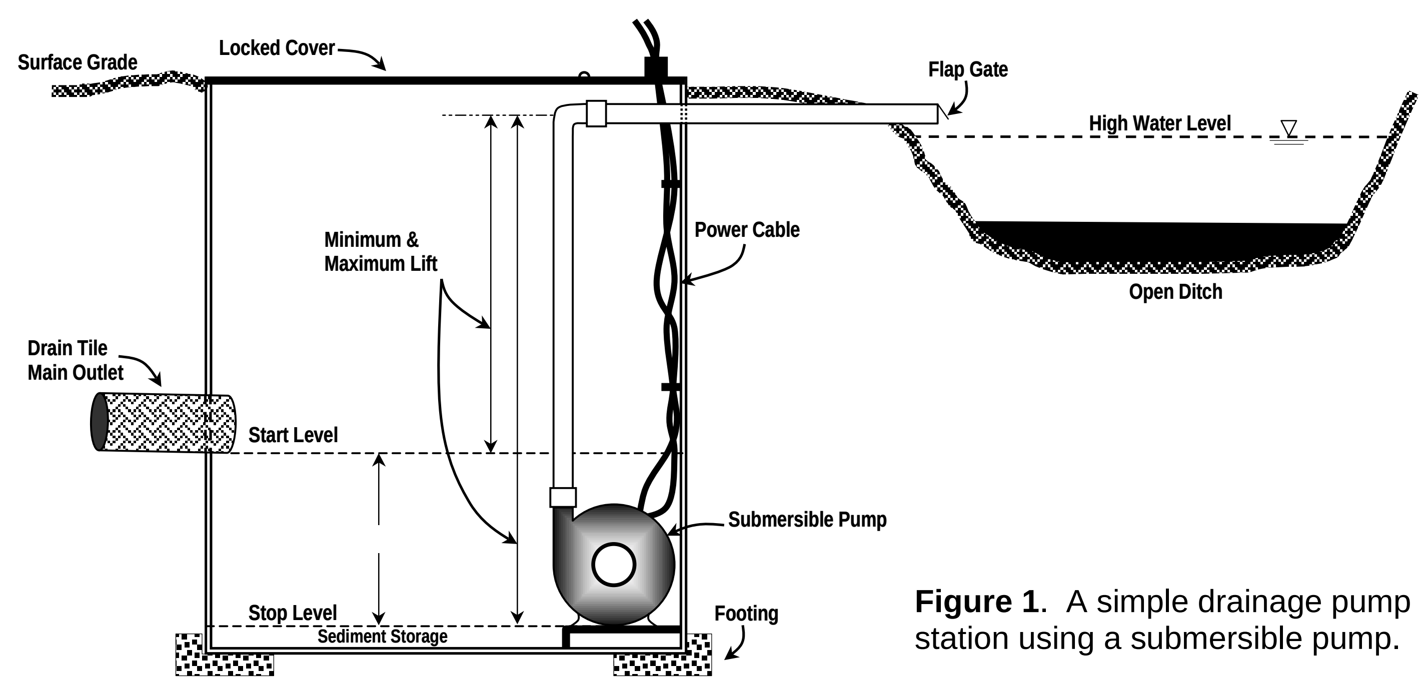

Figure 1. A simple drainage pump station using a submersible pump.

Pumping Lift and Capacity

Pumping lift is one of the most important factors in the initial and operating costs of a pumping plant. The intake of the pump depends on the placement of the tile main. The highest water level in the sump should not exceed the bottom of the tile main, as shown above. Although higher water levels may be possible in some cases, this will usually compromise the effectiveness of the tile system. Discharge level of the pump is determined by the condition of the natural outlet. If water levels in the outlet are relatively stable, the discharge pipe can be set just above the maximum anticipated water level to provide a free discharge. Where outlet water elevation fluctuates considerably, outlet elevation can be made lower, thus reducing operating costs. For this condition, a valve must be installed to prevent backflow during periods when the discharge pipe is submerged.

The required pump capacity must match the capacity of the drainage system such that during peak flow periods the pump can operate continuously while satisfying drainage discharge requirements. (1 acre-inch/day drainage rate = 19 gal/min (gpm); 1 cubic foot/second (cfs) = 448 gpm) As the growing season progresses, drainage requirements will likely decrease and the pump will run intermittently.

Pumps and Power Units

Centrifugal pumps are the most common type of pump used in agricultural drainage. There are three types of centrifugal pumps: radial flow, axial flow, and mixed flow. Required discharge flowrate and head may dictate which type of pump is best suited for the pumping station. Submersible pumps can also be used as illustrated on the following page. Electric drive power units should be used whenever electric power can be brought to the site at reasonable cost. A direct-connected, vertical-shaft motor is best for low-maintenance operation.

Storage Requirements and Design of Sump

The sump storage volume, shape and position are important because together with pump capacity, they determine the intermittent operating characteristics pump. The sump must be large enough so the pump doesn't start/stop excessively. Storage below the minimum water level serves as sediment storage and minimum clearance for the suction pipe. There should be a bottom clearance of $^1/_3$ the diameter of the suction pipe. The sump can be a pit, tank, section of ditch, or a low area that serves as a collection point for the drainage system. Concrete silo staves or corrugated metal make inexpensive sump walls as long as a stable foundation is possible. When a tank is used, anchor it securely so that the tank isn't pushed upward when the watertable is high.

Pumps should be limited to 10 or less cycles of operation per hour for automatic operation. A cycle of operation includes both running and standing time. Running time should not be less than 3 minutes. The minimum storage in cubic feet, S, for automatic operation can be calculated by the following formula, where n equals the desired number of cycles per hour, and Q is the pumping capacity in gpm. The storage area and depth are then chosen so that their product is equal to or greater than S. For an economical operation the sump should be large and shallow, not small and deep. Storage depths of 2 feet are recommended for closed sumps and 1 foot for open sumps.

$$\mathbf{S\,(ft^3) = \frac{2 \times Q(gpm)}{n\,(cycles/hr)}}$$

Example: Sump storage is being designed for a pumping plant designed to serve a 100-acre tile drainage system with a drainage coefficient (water removal rate) of 3/8-inch/day. The pump will run at 8 cycles per hour. The flowrate for the drainage system is 3/8-inch/day $\times$ 18.9 gpm/acre $\times$ 100 acres = **709 gpm**. Required sump storage volume = 2(depth) $\times$ 709(Q) $\div$ 10(n) = **142 cubic feet**. With a storage depth of 2 ft and a circular sump, the sump diameter must be $\sqrt{142 \times 4 / 2 \times 3.14}$ = **9.5 ft**.

References & Resources

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For more information, contact:

Gary R. Sands, Extension Engineer-Water Resources
Biosystems & Agricultural Engineering Department
University of Minnesota
St. Paul, MN 55108
612.625.4756 voice
612.624.3005 fax
email: *grsands@tc.umn.edu*
web: *www.bae.umn.edu*