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Water Control Structures Used in the Restoration and Creation of Wetlands

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Introduction

An estimated 215 million acres of wetlands once existed in the lower 48 states at the time of the United States settlement (Wenzel 1992). Since then extensive losses have occurred due to drainage and conversion of wetlands to other uses such as agriculture. Local estimates indicate that 80 percent of Minnesota's prairie potholes have been drained since settlement (Wenzel 1992). These losses took place because the importance of wetlands was not fully understood. The general attitude during this time was that wetlands were nothing but wastelands. Prior to 1985 some governmental upports existed that encouraged landowners to convert wetland into farmland.Gradually, society's attitude toward wetlands has begun to change and we are now encouraged to protect rather than destroy them. As the country began to understand the importance of wetlands and the negative effects of destroying them, the attitude shifted toward the conservation of these ast resources. Wetlands provide many benefits including: flood control, ground water recharge, erosion control, water quality improvements, habitat and food sources for wildlife, and areas for passive and active recreation (Hammer 1996). Property owners are now more aware of the benefits wetlands provide and the negative effects of destroying them. Financial support is also available to restore/create wetlands from non-profit organizations and governmental programs. Because of this awareness and support landowners are more willing to restore and create wetlands on their own property.

The creation of a wetland requires the engineering of hydrology as opposed to restoration which is the re-establishment of the pre-existing hydrologic regime. Restored wetlands are areas that supported a natural wetland ecosystem but were modified to serve other purposes and then returned to its natural state (Hammer 1996). Ditching, tiling, and pumping were the basic techniques used to drain these wetlands. The restoration process involves reversing the effect of these drainage methods. Created wetlands are non-wetland sites intentionally converted to produce or replace natural habitat (Hammer 1996). The creation of wetlands involves confining water with dikes, dams, by excavating fill.

Design Considerations

Water control structures are used to control, discharge, and maintain water levels. A water control structure may consist of an earthen embankment, a structure manipulating subsurface drainage, a spillway system or any combination of the above (Wenzel 1992). The type of wetland desired and the goals of the project will determine the water control methods used. The selection of the appropriate type and size of water control structure is important because it will determine the success and safety of the project. The feasibility of the design will also have an effect on water control structure selected.

Water Control Structures

Water control structures must be chosen and installed correctly to ensure a successful project. The ideal water control structure will be required to perform many functions: An accurate regulation of the water levels must be maintained while having the ability to release the maximum water capacity at a safe level. Water control structures should be able to completely dewater the wetland and allow for changes to be made easily. No changes should be needed because of an increase or decrease of inflow due to precipitation. The structure should be constructed simply so that it requires little or no maintenance. Vandalism susceptibility should be minimized. Structures should also have low risk from debris or animals. (Hammer 1996).

Earthen Structures

Earthen structures are fabrications of earth or other suitable material that retain water. Dikes, levees, and ditch plugs are examples of earthen structures. The basic purpose of a earthen structure is to raise the water level to a design elevation and/or to prevent the flooding of adjacent lands.

Earthen structures used to raise water levels are usually constructed perpendicular to a drainage system or as a U-shaped slope. Dikes designed to raise water levels should only be considered if the restored basin will receive sufficient water to fill the basin to full design capacity and only if dikes are needed to achieve required water depths (Galatowitsch and van der Valk 1996). Dikes used for the restriction of water levels are often constructed along property lines, roads, and other boundaries. For economic reasons dikes are often constructed with the material obtain on-site. Typically two types of earthen dikes are constructed. They can be constructed with a homogenous fill material or with a impervious clay core (Wenzel 1992). A dike constructed with homogenous fill needs to be impervious to retain water. If the earthen structure is constructed of a semi-impervious fill, an impervious blanket is required on the water side(s) of the dike. Clay cores create an impervious layer. Dikes are typically constructed to be impervious to water. Seepage and water loss is not as critical if there is a sufficient water source and the seepage is not causing erosion or damage (Wenzel 1992).

Organic soils should be avoided for earthen structure construction. If organic soils must be used, an impervious core should be installed. Up to 50 percent shrinkage can be expected when using organic soil (Wenzel 1992). Over construction must take place so that the berm is large enough to maintain the water levels after it settles (Wenzel 1992). The soil materials used in the construction of earthen structures creates sites known as "borrow areas". Borrows should not be excavated from areas to close the earthen structure. Guidelines exist as to how close the borrow areas can be to the dike for structural strength reasons. Borrow excavations should not be so close as to affect the stability of the dike, the hydraulic characteristics of the outlet, or the wetland's ability to retain water (Wenzel 1992).

Side slopes of the dike should be no steeper than 3:1 (Hammer 1996). Any grade increase will decrease the stability of the dike. The top width of an embankment should be six feet for dikes under six feet in height and eight feet for dikes between six feet and ten feet high (Galatowitsch 1986). The height of the dike will be the estimated height of the high water stage, with allowances for settlement. The height is generally one foot above the emergency spillway (Hammer 1996).

Earthen structures must be maintained and checked periodically for damage. Seepage through the dike itself or along the piping of the principal spillway can lead to structure failure. Anti-seep collars are the most common form of seepage prevention used for principal spillways (Wenzel 1992). An anti-seep collars are water tight fitted around the outside of the principal spillway. They prevent seepage by restricting the water flow around the outside of the principal spillway. Seepage control along a pipe may also be provide by a sand of gravel filter (Wenzel 1992). Seepage occurrence through the material of the earthen structure may require additional fill on the side the water is seeping to.

Muskrats can also cause major damage to earthen structures. The borrowing habits of the animals can results in a destruction of earthen structures. Their borrows may cave in and cause leakage or lower the height of the structure. Muskrats also destroy vegetation along the shoreline which helps prevent wave action erosion. To control the problem muskrats can be removed by trapping or other methods during certain parts of the year. A lining of hardware cloth or chicken wire in an earthen structure will deter the animals from burrowing. The liner screens should be laid on the upstream slopes of the dike and covered with at least one foot of fill (Galtowitsch and van der Valk 1994).

Trickle Tubes

Trickle tubes transport water from one elevation to another. They are generally used on smaller wetland projects to keep vegetated spillways dry. The concern being that the spillway is too wet to maintain vegetation. The opening of the intake should be at a lower elevation than the spillway. Under normal conditions the tube will drain the excess water and keep the spillway dry to sustain vegetative growth (Wenzel 1992). Trickle tubes should be 6 to 8 inches in diameter and non-perforated. A variety of conduits types may be used as trickle tubes, with the most common being non-perforated corrugated polyethylene (PE) tubing (drain tile) (Wenzel 1992).

There are two basic types of inlets used for trickle tubes: a horizontal inlet and a vertical drop (Wenzel 1992). The horizontal inlet is simply a straight conduit through the embankment. The vertical drop is a vertical drop into the embankment with a horizontal 90 degree connection to the outlet. In both cases the openings should be located at a minimum of 6 inches from the maximum desired water level or dike crest (Wenzel 1992). Also a 1.5 foot of elevation difference is required between the intake and outlet for a efficient flow of water. If the 1.5 foot elevation difference can not be obtained, a horizontal inlet should be used (Wenzel 1992). The outlet of the trickle tubes can discharge onto the ground surface, into an open ditch or into an existing tile. The major concern is that the slope be very gradual so that erosion is minimized.

Principal and Emergency Spillway

The need to release excess water from a wetland after high rainfall or due snow melt runoff is met by the principal and emergency spillway. In some cases only a principal spillway is required, but with larger projects and under special circumstances an emergency spillway is added to relieve water pressure.

A vegetated spillway is sufficient for impoundments one foot or less in height (Galatowitsch and van der Valk 1994). Larger projects require a principal spillway through the dike and a vegetated emergency spillway. The design limitations and requirements of the principle spillway are similar to that of the trickle tube discussed earlier. The same principles are used at larger capacities to relieve more water pressure. The capacity of the principal spillway should be able to handle the peak flow of runoff expected every ten years over a 24-hour period. The elevation difference between the principal and emergency spillway should be great enough to fill the principal spillway to full capacity before any water is discharged through the emergency spillway (Wenzel 1992).

Drop Structures

Although the drop structure concept is rather simple, many different types and combinations of drop structures are used. The function of a drop structure is to remove excess water from the wetland and transport it through the mbankment to an outlet at a lower elevation. Drop structures are different from a horizontal structure in that the water drops down into a conduit and then flows horizontal to the outlet. Most drop structures are used in conjunction with a vegetated spillway.

One of the main advantages of the drop structure system is that it can be designed or manipulated to control water levels. The appropriate water level control has benefits to wildlife, flood control, and agriculture. The installation of devices to control water can be useful in the management of water regimes to favor certain plant and animal species (Kantrud 1986). Two basic types of drop structures used to control water levels. The oldest and most widely used is the Òflashboard or ÒstoplogÓ type. The stoplog has sleeves that can be removed or stacked upon to regulate the water level. When a sleeve is removed a water is allowed to pour into the drop structure at a lower elevation and thus lowers the water level. The addition of a sleeve allows the water to rise to a higher level in the wetland before it can drain.

A control structure is normally built with reinforced concrete and treated timbers. Polyvinyl chloride (PVC), metal or concrete commonly make up the sleeves. Also culvert type flashboard water control structures have a high availability but are rather cumbersome to transport and assemble in the field.

Recently, at least two manufactures have begun producing small stoplog control structures of fiberglass and PVC that have similar design concepts that eliminate the need for fabricating the structure on site (Hammer 1996). The major benefits the manufactured stoplog control structures have over the field constructed types are that they are light weight, inexpensive, and allow for easy water level adjustments. Agri-Drain Corporation and FOB Adair produce similar models that range from $175 to more than $900 depending on style chosen and diameter and length (Hammer 1996).

The other common type of drop structure is the swiveling pipe structure. The swiveling pipe structure is a relatively simple and inexpensive drop structure, but provides a large capacity for water level regulation (Hammer 1996). The inlet is a swiveling arm placed inside the drop structure. The water level is regulated by simply rotating the swivel arm. At its vertical position, it will provide the greatest depth and at the horizontal position will maintain the lowest level of water.

Beaver activity can cause major problems in a restored wetland. The blockage of the principal spillways by beavers raises the water level and can flood near by lands. This results in constant maintenance of removing debris from inlets. To control the beaver problem than can be removed by the same methods as muskrats. Since this is only a temporary solution the wetland should be made as beaver proof as possible, if the project exists in an area known to be home to beaver. Drop structures are more difficult for beaver to dam than straight structures and should be used in these locations (Wenzel 1992).

Trash guards or grates should be installed at the inlet of principal spillways to restrict debris from flowing into the piping and restricting water flow. Trash guards should be checked periodically for build-up, especially after periods of high runoff. Similar guards should be installed at the outlet of spillways if a restriction of fish species is desired.

Subsurface Drainage Manipulation

Wetlands can sometimes be restored by simply plugging ditch lines or blocking tile that drain wetlands. Both of these techniques are often used when restoring wetlands and can be use in conjunction with water control structures. A tile block is a stopping of the water transported through the tile. The most economically feasible way to perform this is to remove a strategic section of tile. The removal of the section of tile will halt the drainage of the basin and return it to its normal state. To manage water levels, a drop inlet can be modified to fit a tile block and outlet into the existing tile at a lower elevation (Wenzel 1992). The inlet examples discussed earlier can be fitted with non-pervious tile and connected to the existing tile to drain the excess water. The only real limitation is that downstream drainage may be restricted by the carrying capacity of the drop inlet (Wenzel) 1992).

Tile replacement is an option that will not negatively affect subsurface drainage flow. Tile replacement is accomplished by removing tile under the basin and replacing it with non-impervious tile, allowing water to pool over the replacement tile while not hindering the drainage of near by land. The cost can be high depending upon the diameter and length of the new conduit and the amount of excavation required (Wenzel 1992). Costs can vary, but a rough estimate of a replacement conduit 12 inches in diameter is around $8.00 a foot for material and installation.

Cost of Wetland Restoration and Creation

Little information about the total costs of wetland restorations has been compiled. Data from Heiser (1989) estimates that the cost of relatively simple pothole wetland restoration may average between $150 and $250 per acre (for earth moving and installation of tile plugs). Projects requiring installation of sophisticated water-control structures may reach thousands of dollars per acre.

Conclusion

The hydrologic success of a wetland restoration/creation project is determined by correct match of site and water control structures used. Knowing the strengths and limitations of these water control structures allows for a more accurate selection and will help reduce maintenance, future cost, and problems. Budget is almost always a limitation and site selection is important in choosing a site that can be feasibly restored. The goals of most wetland restorations project are to return the site its pre-settlement conditions but because of present day boundry limitations, water control structures are necessary to restore wetland water levels. Water control structures provide the ability to create wetlands where they now can not naturally form.

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