BLOCKING SUBSURFACE DRAINAGE TILE

TECHNICAL GUIDANCE DOCUMENT

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Table of Contents

INTRODUCTION

Restoring wetlands drained by subsurface drainage tile is often considered as the easiest or simplest type of wetland restoration to perform. While for many locations that may be true, it certainly does not apply to every project situation. In fact, the design and construction issues associated with many tile drained wetland landscapes are often quite challenging.

To successfully restore hydrology to tile drained wetlands, it will be necessary to render the subsurface tile drainage system that drains the wetland inoperable. To accomplish this it is usually not necessary to remove or plug the entire length of tile within the wetland. Successful restoration can be achieved by excavating and removing or plugging a designed length of tile at strategically identified locations. This process along with capping or plugging the exposed tile ends is generally referred to as "blocking" the tile.

Figure 1. Removing "Blocking" Subsurface Drainage Tile

APPLICATION

Subsurface tile drainage removes excess water from the soil profile, usually through a network of underground perforated conduits or tubes. These tubes are commonly called "tiles" because they were originally made from short lengths of clay and concrete pipe known as tiles. Water within the soil profile seeps into the small spaces between the tiles and drains away. The predominant type of drainage tile used today is corrugated plastic tubing which has small perforations or slits in it to allow drainage.

Subsurface tile drainage is installed in a number of different configurations and is usually 2 to 5 feet in depth, on average. It can be in the form of a single tile line draining small depressional wetlands to an extensive array of parallel lines or pattern tile draining wetland flats, floodplains, sloped wetlands, and larger depressional wetland basins. In some cases, open intakes at the ground surface are installed to aide in the removal of ponded water and improve overall drainage efficiency.

Restoration complexity including the location, length, and number of tile blocks needed to restore hydrology to tile drained wetlands will be dependent on a number of factors including; geological and topographic conditions of the site; size, elevations, grades, extents, and condition of the existing tile drainage system; former wetland type; and requirements for any associated outlet structures.

DESIGN CONSIDERATIONS

The design of all tile blocks should ensure long-term restoration success of wetland hydrology.

A functional design requires gathering enough site information to determine sizes, locations, and flow directions of existing drainage tile within the vicinity of the planned wetland. The design must consider and address all of the following conditions:

- How to construct the tile blocks
- When to construct the tile blocks relative to other construction or restoration components
- Strategies to protect upstream neighboring lands that share and benefit from the tile system to be blocked
- The length, location, and number of tile blocks needed to effectively restore wetland hydrology

The standard method of blocking a tile line is to excavate and remove a specified length of tile, plug both ends of the exposed, remaining tile, and then backfill and compact the excavated trench. An alternative method is to not remove the tile but instead plug it with a solid fill material for a specified length. Fill materials can include sand slurry mixes, concrete grout, or certain expanding polyurethane foams.

Plugging drainage tile can have certain advantages compared to excavating and removing it. For example, where quality native vegetation has already been established or exists on a site, it may be desired to avoid extensive site disturbances associated with removing tile. Also, when it is necessary to block tile under existing or newly constructed embankment structures, plugging the tile vs. excavating to remove it can avoid extensive excavation and disturbance to those features and in turn potentially reduce construction costs.

For many sites, restoration components may be fairly simple and decisions of when to construct tile blocks and restore site hydrology are fairly easy to make. There may, however, be situations when it will be desired to allow existing tile systems to continue to function and keep the site dewatered until other construction and restoration components are completed. It may be desired to delay the construction of tile blocks for just a few days or perhaps for as long as one year to allow vegetation within the wetland to become fully established prior to restoring hydrology.

The construction and stabilization of embankments, outlet structures, scrapes, etc., in addition to overall vegetation establishment within planned wetland areas can all benefit from delayed or partial restoration of site hydrology. This delayed approach to restoring hydrology does require some planning regarding construction sequence and methods, especially when tile exists under planned embankments, other fill areas, or in areas where good vegetation has been established and disturbance is not desired.

Should any tile lines extend upstream from planned wetlands and out of the project area, considerations for addressing upstream drainage benefits and drainage rights provided by the tile system are needed. This could occur through tile re-routes or through a strategy known as "day-lighting" or "outletting" the upstream tile into restored wetlands or other areas of the restoration site. Additional information on these and other wetland restoration strategies can be found in Technical Guidance Documents as part of Appendix 4-A.

Lengths, locations, and number of tile blocks needed to restore a wetland varies depending on landscape setting and type of wetland that is being restored. The design will also be influenced by specific characteristics of the site including locations of project/property boundaries and of any embankments that may be planned or exist. Design considerations and additional discussion for each of these items follows.

DEPRESSIONAL WETLANDS

Depressional shallow to deep marsh or "pothole" wetlands are commonly drained or altered by subsurface tile. Drainage is typically provided by just a single tile line or tile main. The main tile line will exit the depressional basin as it flows towards an outlet somewhere downstream of the site. One or more laterals or branches of the tile system may also exist and will tie or junction into a tile main, usually somewhere within the wetland basin.

Typically only one tile block on the main tile line that exits the basin is all that will be needed to successfully restore hydrology to the wetland (**Figure 2)**. If more than one tile line exits the basin, a block on each of the exiting lines is needed.

The design should ensure that the location and length of the tile block will prevent the functioning downstream drainage system (tile or ditch) from having continued drainage influences on the restored wetland basin. This requires careful consideration to the location of the tile block with respect to the planned wetland edge and some basic understanding of lateral effect of subsurface drainage tile. Ideally the tile block should begin at the anticipated restored wetland's edge and extend downstream for at least **100** feet (**Figure 3**).

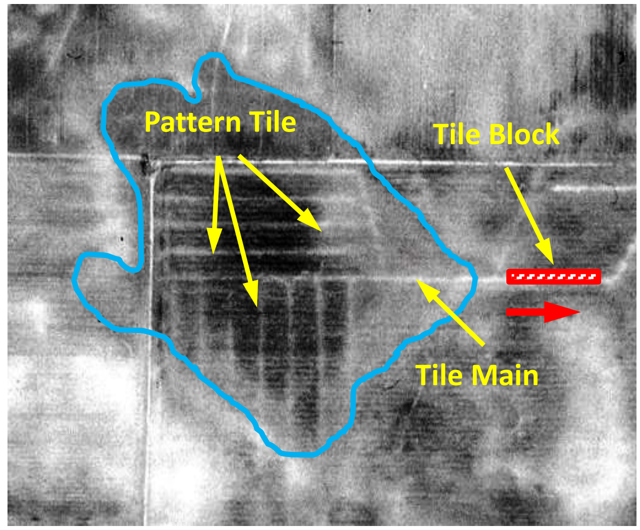

Figure 2. Tile Block Location for Pattern Tiled Depressional Wetland

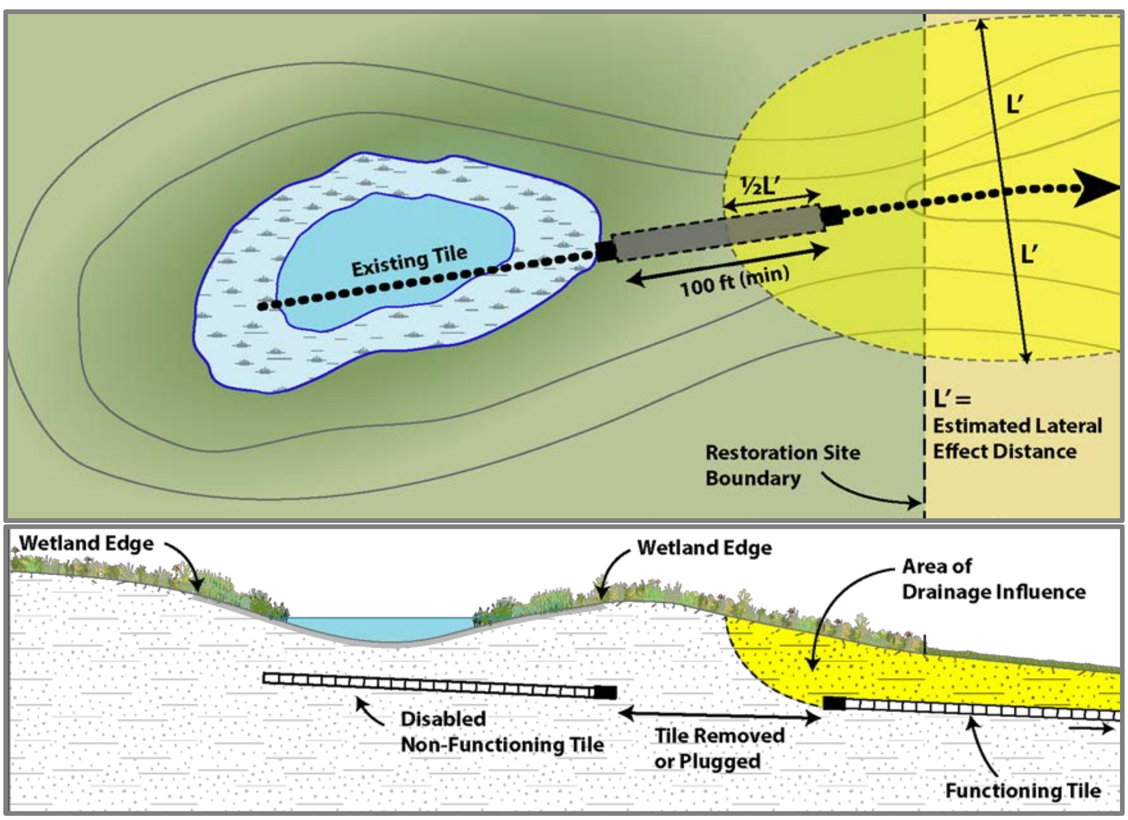

Figure 3. Where to Locate Block on Tile Exiting a Depressional Wetland

Considerations for increasing the length of the block may be warranted in sandy or organic soils where greater lateral drainage effects from the downstream drainage system may exist.

Larger, shallow depressional wetlands may contain pockets or cells with varied water depths "micro-topography". To further improve restoration results, additional tile blocks should be considered at locations within the basin where higher elevations exist between areas or pockets of lower elevation (**Figure 4**).

Sloped Wetlands

Whether drained by a single string of tile or a pattern tile system, the restoration of sloped wetlands can provide a number of design and construction challenges. Because of the moderate to steeply sloping topography associated with these types of wetlands, a single tile block is likely to be ineffective at fully restoring hydrology to the wetland. The restoration of sloped wetlands often requires that for each tile line found, multiple tile blocks be constructed along it. In some situations, this can lead to a large number of tile blocks being needed, depending on the size of the site and extent of existing tile.

Information on the grade or slope of the land along with the locations, depths, sizes, and type of tile material that exists is needed for a functional design. The design objective should be to perform multiple tile blocks on each subsurface tile line running up-slope through the wetland.

For landscapes that have less than a 3 to 4 percent average slope, blocks should be spaced every **one** to **two f**eet of vertical slope relief of the land surface. For more steeply sloped landscapes, blocks can be spaced every **two** to **four** feet of vertical slope relief of the land surface (**Figure 5**). This stepped or segmented approach to performing tile blocks helps to ensure full restoration of hydrology to the drained wetland area. It also helps to reduce excessive hydraulic "head" pressures and the potential for blowouts or surface "seepage" discharges to occur at areas immediately upstream of constructed tile blocks. For these sloped landscape settings, the tighter the spacing of the blocks, the more effective the restoration of wetland hydrology.

> The distance between each tile block is a function of the land slope

This approach to restoration can help limit construction costs as it does not require removal or plugging of the full length of existing tile. Alternatively, the entire length of tile can be removed or plugged, however, that can be expensive and requires extra consideration for backfilling and stabilizing long lengths of any trenches that are excavated.

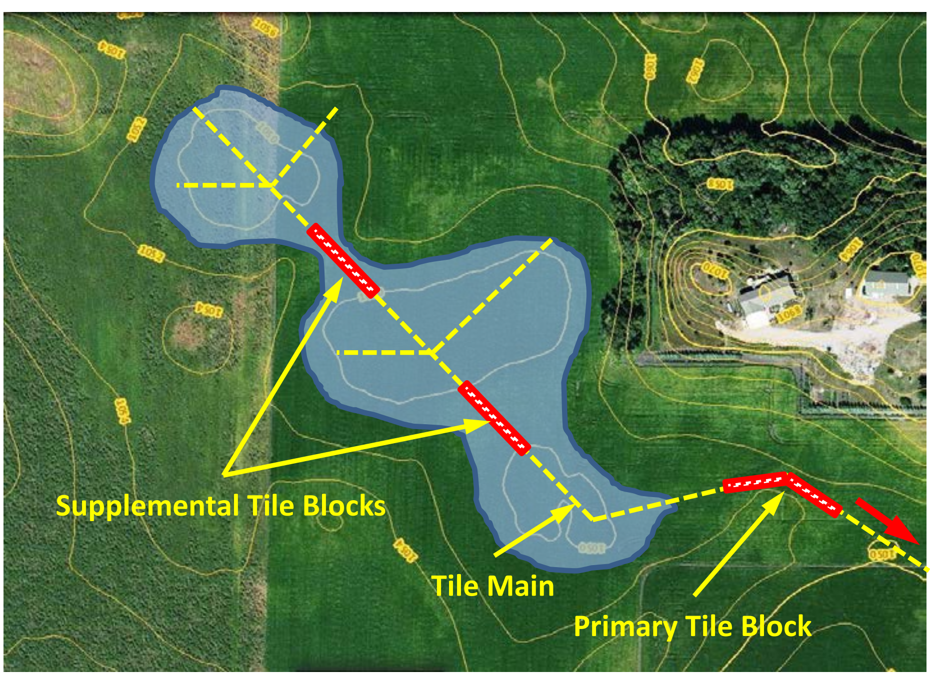

Figure 4. Beneficial Additional "Supplemental" Tile Block Locations Within Restored Depressional Wetland Setting

For sloped landscape settings, it is recommended that a minimum of **30** to **50** feet of tile be removed or plugged at each tile block location. Longer lengths may need to be considered in locations that have steeper topography or in areas that contain more organic or sandy soils. At the bottom of the slope or project boundary (furthest downstream or lowest elevation tile block), it is recommended that a minimum of **100** feet of tile be removed or plugged. Considerations for increasing

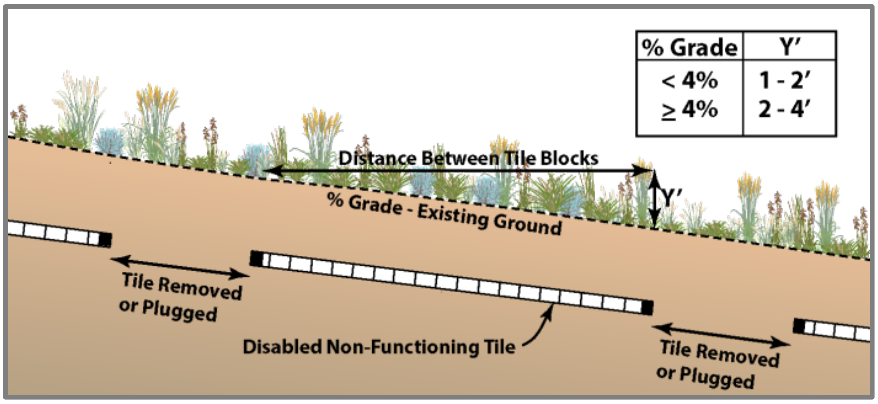

Figure 5. Recommended Tile Block Spacing when Restoring Sloped Wetlands

this length may be warranted in sandy or organic soils.

When restoring larger sloped wetlands that are pattern tiled, additional restoration benefits can be achieved if construction also includes ripping or knifing the site following a trajectory that is perpendicular to the slope and tile. The ripping or knifing should occur to reaches of tile that are between planned or constructed tile blocks. This requires using a blade that reaches the tile depth and cuts the tile as it crosses it (**Figure 6**). This method of tile ripping is most effective where plastic drain tile exists and should only be used to supplement the construction of tile blocks as described above, not replace or change their required lengths or spacing.

Figure 6. Supplemental Trenching to Aid in Destroying Subsurface Tile Within Sloped Wetland Settings

Non-Depressional Wetland Flats

Non-depressional wetland flats typically consist of vast areas of peat or organic soils. Extensive pattern tile systems are often used to drain wetlands in this type of landscape setting. As a result, restoring wetland hydrology to these tiled areas likely requires the construction of multiple tile blocks at the project boundary or furthest downstream area of the planned wetland.

The soils that are often associated with non-depressional wetland flats generally have relatively high permeability rates therefore; it is recommended that at least **150** feet of tile be removed or plugged at each tile block location for effective restoration of wetland hydrology. If less permeable soils exist, the length of the block can be reduced but should not be less than **100** feet.

In addition, when attempting to restore non-depressional wetland flats that are large in size, some grade or elevation drop may exist across the landscape. While this elevation change may be subtle, the effective restoration of wetland hydrology to these landscapes may require that additional tile blocks within the project area be designed and constructed. For this situation, refer to the discussion on sloped wetlands above for applicable design guidance, however, it may be necessary to alter the design criteria with tile blocks instead spaced every **one** to **two** feet of vertical slope relief.

Project Boundaries/Property Lines

Special consideration is needed when planned tile blocks are in close proximity to project or property boundaries. Depending on the downstream land use, it may be necessary or beneficial to incorporate specific design measures to address and prevent potential adverse impacts as result of the restoration to the adjoining, downstream lands.

One method to accomplish this is to offset any planned tile blocks by **25** feet or more from the project/property line. Leaving a short reach of the existing drainage system intact may help prevent negative off-site hydrologic impacts as a result of the restoration (**Figure 7**).

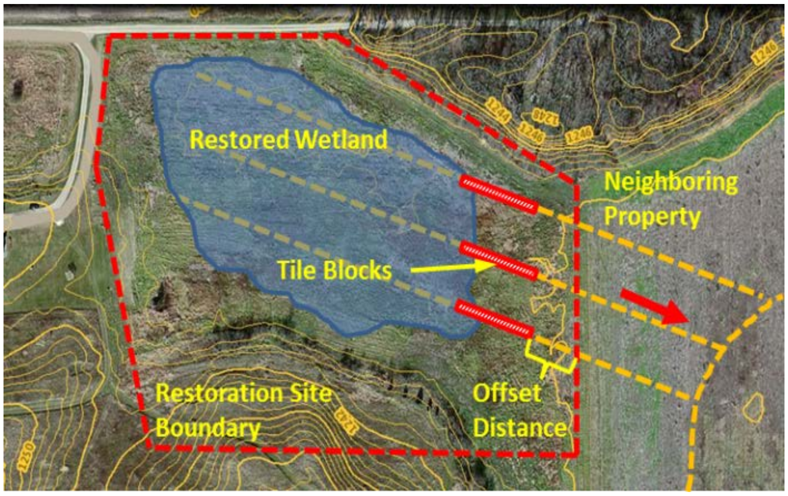

Figure 7. Tile Blocks Offset from Adjoining Property

Another method is to consider installing additional tile on the adjoining property. A single tile line offset and parallel to the project boundary will usually suffice. The length, size and offset distance from the project boundary are design parameters that, in addition to regulatory compliance, need consideration.

Embankments, Ditch Banks, and Roads

When tile blocks are needed under and as part of the construction of earthen embankments it will be important that a long enough length of tile will be removed or plugged under the planned fills.

At minimum, this includes the entire length of tile under the embankment "footprint". It is also recommended to extend the length of the block at least **25** feet upstream and, where possible, at least **50** feet downstream from the embankment (**Figure 8**). Considerations for increasing the length of tile removal for the downstream portion may be warranted in sandy or organic soils where the drainage effect from the downstream functioning drainage system may be greater. Following this design guidance, about **125** total feet of tile needs to be blocked for most embankment situations.

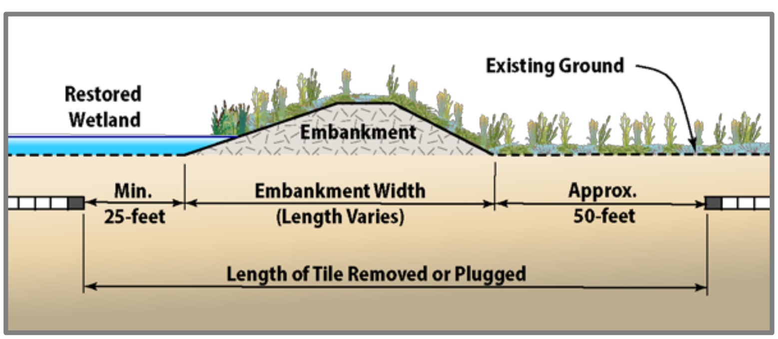

Figure 8. Tile Removal Detail Under Planned Embankment

An important aspect of the design is determining when and how the block will actually be constructed under the embankment. In many situations, it will be beneficial to allow the existing tile system to continue functioning and keep the site dewatered during construction of the embankment and any possible outlets. In such cases, plugging the tile for the desired length of the block under the embankment may be the preferred method to block the tile as it avoids further embankment disturbance.

When tile blocks are needed under existing roads, driveways, and ditch banks, etc., it may not be possible or desired to disturb those existing features as part of constructing a functional tile block. In such cases, it is recommended to plug the entire length of tile under the existing structure (**Figure 9**). Access to one or both sides of the structure is needed to accomplish this.

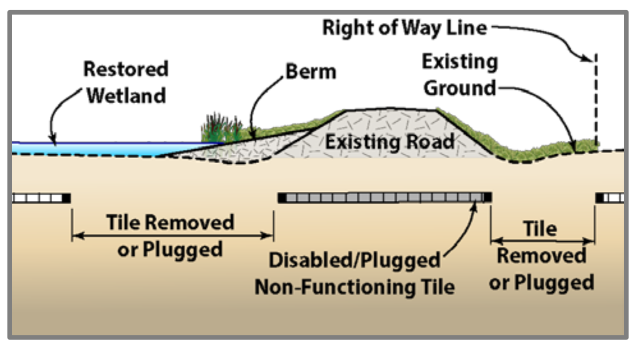

Figure 9. Tile Block Detail Under Existing Road

If the existing earthen structure can be excavated, then the tile can be removed as part of constructing the block. If so, guidance for tile removal should be similar to that for new embankments.

If removing tile via excavation as part of constructing tile blocks under planned or existing embankment features, extra care must be taken during construction to ensure the tile removal trench is properly backfilled and compacted. With consideration of potential excavation depths to remove the tile, total fill heights can easily approach 8 feet or more. Stringent backfill and compaction requirements are needed to avoid undesired differential settlement of the above grade embankment fills. Extra allowances for settlement will also be needed in these locations compared to other areas of the embankment where total fill heights will potentially be much less.

CONSTRUCTION REQUIREMENTS

Tile block locations, lengths, methods used to remove or plug the tile, seal the tile ends, and to backfill and compact excavated areas all need to be clearly defined and stated as part of prepared construction plans and specifications.

When excavating to remove tile it will be necessary to remove all tile fragments along with any envelope or filter materials from the excavated trench. Prior to backfilling the trench, the two exposed ends of the tile system should be sealed or capped to prevent water and soil from entering or exiting the tile. Sealing the tile ends can be achieved through a variety of methods including plugging with one to two feet of concrete or grout or securing a manufactured tile cap to the tile ends (**Figure 10**). A tile end left unplugged or uncapped often leads to failure of the tile block.

Even with the tile removed, the trench can serve as a conduit for flowing water resulting in continued drainage of the wetland if it is not backfilled with appropriate soil material and properly compacted. To ensure conditions are appropriate for proper backfill and compaction, the side slopes of the excavated tile removal trench should not be vertical and instead be excavated to a slope of about 1:1. The trench should normally be backfilled with the same material excavated from the trench or with other similar soils. The backfill should be placed in lifts and compacted to achieve densities equal to the adjacent, undisturbed underlying soils.

> The backfill material should not contain plastic tile and larger broken clay or concrete tile segments

In many cases, outlet spillways or other surface flow areas will occur at locations where tile blocks need to be performed. At these locations, problems can occur due to settling of the backfilled materials in the tile block trench (**Figure 11**). This settling can create an undesired narrow channel or gully at the ground surface which can concentrate or channelize overground flows potentially leading to excessive erosion of surface soils. It is important in these locations to implement stringent construction measures during backfilling and compaction of the tile trench and to "over build" the backfill to allow for settlement in the trench as part of final grading. Where possible, outflows should be diverted from these locations as part of the final site grading.

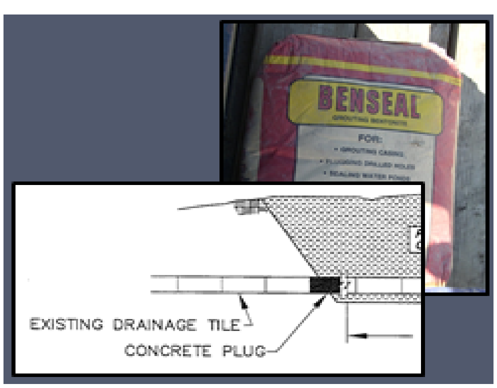

Figure 10. Plugging Exposed Tile Ends

Figure 11. Eroded Channel above Settled Tile Block Trench

Particular attention is needed when backfilling and compacting tile removal trenches located under planned embankments. The same backfilling and compaction requirements used for construction of the embankment should be used for the underlying tile removal trench. Even with proper compaction, additional embankment settling will occur in the area above the tile removal trench. Provisions for extra embankment fill will be needed as part of construction in those areas. Typically, additional fill equaling 10 to 15 percent of the total fill height is needed.

> Settling of backfill materials placed in the tile removal trench should be expected

OTHER CONSIDERATIONS

- Tile intakes may exist within the wetland being restored and consideration for their removal is needed. Larger diameter intakes can pose a potential future safety hazard if not removed. Intakes that remain open can also provide access to overwintering locations for undesirable wetland species such as fathead minnows. This can be counterproductive to management strategies for shallow wetland especially where winter kill is expected to control the presence of these undesirable species.
- Despite the best planning and site assessment efforts, locating existing tile lines can be a challenge for many project sites. Ideally, the construction plan should ensure enough flexibility and extra funding, should it be necessary, to investigate and find tile. When hand-probing to locate tile is not possible or practicable, a backhoe or excavator should be used **(Figure 12)**. Consideration is needed for where to conduct the investigation work. Excavated trenches used to search for tile are typically loosely backfilled and therefore should not occur in the immediate vicinity of existing or planned embankments or near areas where concentrated flow will potentially occur upon restoration, such as a spillway.

Figure 12. Tile Investigation Trench

- When surface drainage ditches, watercourses, wetlands, property boundaries, or other obstacles exist and are immediately adjacent to and downstream of the tile drained wetland, this design guidance for blocking tile may be difficult to implement. In such cases, tile blocks should be designed and constructed to the extent allowed with consideration to their potential effectiveness. Where concerns exist, additional design and construction strategies may also need to be considered.
- When restoring tile drained wetlands it is often necessary to utilize the downstream functioning tile system as the primary outlet for wetland discharges or base flows. This typically occurs through the use of trickle drains or drop inlet structures.
- Consideration is needed to address stabilizing areas of the restoration site that are disturbed during construction. All disturbed areas should be seeded with consideration for additional stabilization on slopes and in other areas where concentrated flow may occur. This can include the use of straw mulch, erosion control blankets, hydro mulching, etc.
- It will be important to understand the legal implications of any planned actions to block and abandon subsurface tile drainage systems. This includes determining whether the tile is part of a public drainage system, is governed by a private drainage agreement, or is just simply a private drainage system shared among several property owners. Regardless, certain legal and administrative functions may need to be addressed as part of the planning and design process. Additional discussion on this topic occurs in Section 4-9 Construction Related Laws, Regulations and Permits.

COST

It is recommended that at least two pay items be established when working with contractors to perform tile blocks. The first, should it be necessary, addresses the costs associated with searching for tile with a backhoe or excavator. Unlike the actual tile block, the trench for such investigation is usually shallower, can incorporate near vertical side walls, and can likely be loosely backfilled. Therefore, the cost to investigate for tile should typically be less than for the actual tile block. This work can be bid and paid for by the hour or per lineal foot of trench dug.

The actual tile block will cost more due to excavation depths, side slope requirements, sealing of tile ends, and backfill and compaction requirements of the excavated trench. While this work can also be bid and paid for by the hour, the different pieces of construction equipment potentially needed along with hand labor makes this difficult. Therefore, bidding and paying for tile blocks by the lineal foot or lump sum basis is recommended. Paying for tile removal by the lineal foot often provides much needed construction flexibility as exact locations or even the number of tile blocks needed is not always known. The sealing of the tile ends should be considered incidental work to the tile block.

MAINTENANCE

Locations where tile blocks are constructed need periodic inspection to identify and correct any identified problems. Problems can occur due to excessive settling of the backfilled materials in the tile block trench. This can result in concentrated or channelized surface water flows potentially leading to erosion of surface soils. Problems can also develop if the remaining functioning subsurface tile just downstream of the tile block continues to provide drainage of wetland hydrology. Inspect for depressions ("sink holes" or "blow outs") at the soil surface in the vicinity of the downstream end of the tile block (beginning of the downstream, functioning tile system). This can be an indication that the downstream tile system is removing both hydrology and soil from the area. This usually becomes a problem when tile blocks are incorrectly located, sized, or incorrectly sealed or blocked at the tile ends. If these areas are identified and left uncorrected, significant amounts of sediment could potentially enter the downstream tile drainage system.

ADDITIONAL REFERENCES

Other Related Technical Guidance Documents can be found in Appendix 4-A of the Minnesota Wetland Restoration Guide.

Standard Engineering Drawings to aide in the design of tile blocks along with other drainage manipulation strategies are provided in Appendix 4-B**.**