MULTI-PURPOSE DRAINAGE MANAGEMENT REPORT FOR:

COUNTY DITCH 10
WRIGHT COUNTY, MINNESOTA

February 2018
Project No. 17-20449

REPORT FOR:
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ARCHITECTURE + ENGINEERING + ENVIRONMENTAL + PLANNING

Signature Sheet

I HEREBY CERTIFY THAT THESE CALCULATIONS WERE PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MINNESOTA.

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County Ditch 10 Repairs
Wright County, Minnesota

Engineer's Project Number: 17-20449

Dated this __22nd___ day of February, 2018

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Scope

The project scope includes preparing an inventory and multi-purpose drainage management analysis for the Wright County Ditch No. 10 (CD 10) public drainage system. The inventory will document specific drainage items linked to sedimentation, erosion, damaged infrastructure, and areas where best management practices (BMPs) can supplement drainage projects utilizing methods aimed at reducing peak flows and erosion, trapping sediment, reducing nutrient loading, and improving water quality throughout the watershed and the receiving waters.

This report begins with an overview of multi-purpose drainage management (MDM) and describes preventative, control, and treatment measures which include best management practices that combine drainage and water quality. The report also includes a detailed inventory of the CD 10 drainage system, potential water quality improvement scenarios, and cost estimates for water quality improvements associated with MDM BMPs along CD 10.

This report was prepared utilizing a topographic survey, drone videos, aerial photos, LiDAR, ESRI ArcMap tools, and site visits. Several calculations were made to analyze the existing drainage capacities throughout the system, potential storage and treatment areas, and potential reductions of nutrients and sediment to improve water quality downstream.

Multi-Purpose Drainage Management

Multi-purpose drainage management incorporates best management practices (BMPs) that can be incorporated into an open ditch system and throughout a watershed. These practices are aimed at improving water quality that will benefit the entire drainage system and the receiving waters. Practices can be incorporated by individual landowners or implemented through the public drainage system. Scenarios include conservation practices and drainage needs, the benefits of each, and practical areas with design criteria to make the practice successful. The BMPs used to supplement multi-purpose drainage management are divided into three sections: preventative measures, control measures, and treatment measures.

Figure 1: Multi-Purpose Drainage Management BMPs

Preventative Measures

Preventative Measures are practices that can be applied to the existing landscape without dramatically changing the current land use or landscape. These practices can be incorporated by any land owner after considering several factors including current farming practices, soil types and soil health, and the surrounding landscape. Such measures will contribute towards improving water quality through erosion control, soil stability and health, and nutrient management. Several references are utilized from the "Fields to Streams-Managing Water in Rural Landscapes" publication by the University of Minnesota Extension.

Cover Crops

Cover crops refer to the use of grasses, forbs, or legumes planted to provide seasonal soil cover on cropland when the soil would otherwise be bare and unseeded. Typical vegetation includes winter rye, oats, barley, and buckwheat planted near the end of a crop cycle or after harvest to utilize the short growing season to provide winter topsoil cover. Other vegetation used when fields are bare when conditions did not allow early planting include alfalfa, hay, oats, turnips or radishes (Figure 2).

Figure 2: Radishes used as a cover crop

Cover crops, especially those that over-winter, affect stream flows in that they transpire (evaporate) in the fall and spring when summer annuals or row crops are not active, increase infiltration, and can maintain or increase soil organic matter if sufficient cover crop growth is allowed. They have less of an effect on runoff than established native or perennial grasses, as they take additional time to establish each year. The living root systems cover crops provide in the fall and/or spring directly prevent soil erosion, increase infiltration, and contribute to less runoff. Additional information regarding cover crops can be found in the NRCS Conservation Practice Standard 340.

Residue Management

Crop residues are materials left from harvest including stems, leaves, stalks, and seed pods. These residues can be properly managed through reduced tillage, strip tillage, and no till farming. The effects of tillage and crop residue management on stream flows are complex and interact closely with crop rotations, soils, and climate. Tillage can impede infiltration both by degradation of soil structure and by compaction below the tilled zone. It increases oxidation of soil organic matter, reducing its content in soils over time. However, corn is sensitive to cold wet soils in the spring found in the flatter and poorly drained glacial till and lacustrine soils of southcentral and southwest Minnesota. Tillage and reduced residue increase surface soil temperature and evaporation in the spring.

Figure 3: Strip Tillage Management

Strip tillage is a conservative tillage practice where rather than tilling the entire field; strips are tilled, exposing a small strip of topsoil for the seed bed while leaving some residue on the surface from the past year's harvest (Figure 3). Strip tillage or full width mulch tillage permit corn to germinate and grow earlier and provide more consistent yields in poorly drained soils. Soybeans respond less to tillage in these areas where higher slopes increase the risk of soil erosion with tillage. Reduced tillage is any method of cultivation that leaves 15 to 30 percent of the previous year's crop residue on fields before and after planting the next crop. No till farming is a practice where crops are planted each year without disturbing the soil from the previous year's harvest. Additional information can be found in the NRCS Conservation Practice Standard 329 and 345.

Nutrient Management

Nutrient Management is a system used by farmers to manage the amount, form, placement, and timing of the application of nutrients to crops. The purpose is to provide crops with enough nutrients for optimum yields while minimizing the nutrient runoff, groundwater contamination, and by sustaining soil health. Nutrient Management consists of proper quantity selection in the fertilizers, the type of fertilizers, and application rate being used. Other practices include the timing and method of manure application where it is less susceptible to runoff, erosion, and leaching. Additional details can be found in the NRCS Conservation Practice Standard 590.

Crop Rotation

Crop rotation is defined as a system for growing several different crops in a planned succession on the same field. At least one soil conserving crop rotation such as perennial hay or other small grain must be included in the rotation. This practice typically consists of a corn-soybean-hay or corn-soybean-small grain rotation. Crop rotation benefits include reduced soil erosion, improved soil quality and fertility, and reduced nutrient leaching. Each crop in a rotation will affect the amount and timing of water reaching a stream through the timing and amount of its transpiration, and its effect on soil organic matter and structure. Winter annuals like winter wheat and winter rye grow quickly in the spring, removing more water in that excess precipitation period than summer row crops. Perennials in the rotation reduce excess water in the spring and fall as described above. Additional benefits include more nitrogen credits to the soil and reducing fertilizer inputs therefore reducing nitrate leaching and nutrient runoff. More information regarding crop rotation can be found in the NRCS Conservation Practice Standard 328.

Control Measures

Control Measures focus on the hydraulics of water as it passes through a drainage tile, open channel, or through any hydraulic structures. They focus on controlling flow after it has exceeded the preventative stage and begins to transport downstream. Overall goals of control measures include conveyance, peak runoff, and water level controls.

Structures for Water Control

A structure for water control in a drainage management system either conveys water, controls flow direction and rate, or maintains a desired water elevation. These structures include a variety of weirs, drop inlets, stop log weirs, culverts, or baffles. They are normally installed in open channels; however they can be used to control water elevations on tiling systems. Water quality benefits associated with structures for water control include sedimentation, reducing flow rates, and providing wildlife habitat. Figure 4 shows a sheet pile weir used in a wetland restoration.

Figure 4: Sheet Pile Weir used in a Wetland Restoration

Two-Stage Ditch

A two-stage ditch is a low-flow channel inside a high-flow channel. The inner (or low flow) channel is smaller and designed to carry water during perennial flows or base flows. The benches of the larger outer channel act as the floodplain to the inner channel. The benches have the capacity for the high flow events while also providing an area for sedimentation, nutrient trapping, and biological treatment to occur. Two-stage ditches are primarily applicable where the majority of the flow is perennial low flows and where the existing side slopes are unstable. A two-stage ditch can minimize and prevent sediment and nutrients from traveling further downstream while the low flow channel can help reduce high flow channel bank erosion. Figure 5 shows a two-stage ditch constructed on in Blue Earth County.

Figure 5: Two-Stage Ditch Constructed in Blue Earth County

Two-stage ditches are designed to mimic the naturally occurring hydrology of streams and rivers. With the inner channel confinement of a two-stage ditch; less meandering occurs and keeps the majority of the conveyance away from the ditch banks, increasing bank stability. The outer channel serves as the floodplain to the inner channel during peak flows and provides controlled conveyance throughout the open channel.

The inner channel is designed to carry baseflow with higher velocities. As a result, less sedimentation occurs in the inner channel which lowers maintenance on the ditch. The outer channel equipped with native grasses provides an area for sediment capture and potentially nutrient uptake depending on the hydrology. Two-stage ditches are generally incorporated in new construction projects, as existing channel and bank conditions make modifying existing channels challenging.

Alternative Intakes

Alternative tile intake structures replace open surface intakes that are level with the existing ground. They include perforated risers, gravel inlets, dense pattern tile within the associated low area, reduced side intake sizes, trash grates, water quality intakes, and any other variation of the above. They are designed to temporarily pond water around the inlet structure to increase the detention time, reduce the peak flow rates of the surface water as well as settle out sediment and sediment-bound phosphorus. Figure 6 shows an alternative intake used on a public ditch system in Nicollet County.

Figure 6: Alternative Intake (Hickenbottom)

The added detention time for alternative intakes allows for sedimentation prior to entering an open channel or buried tile. It also provides additional water storage on the landscape, effectively reducing peak flow rates downstream. Alternative intakes are sized based on a retention time of 20-24 hours to effectively drain water and prevent crop stress, while also providing water quality benefits through sedimentation and peak runoff reduction.

Grassed Waterways

Grassed waterways are vegetative drainage swales planted through agricultural land that provide a means for concentrated flows to drain from the surface while minimizing erosion Figure 7. Grassed waterways are installed throughout a watershed on fields with concentrated flows to prevent gully erosion. They are also used to convey runoff from terraces and diversions to nearby drainage channels. Grassed waterways reduce surface flow rates and act as a filter for nutrients. As with any perennial vegetated area receiving field runoff, a build-up over years of sediment in the receiving edge can prevent runoff from entering the waterway and must be periodically reshaped to restore flow into the waterway or filter. Additional design details can be found in the NRCS Conservation Practice Standard 412.

Figure 7: Grassed Waterway

Controlled Subsurface Drainage

Controlled subsurface drainage is a practice used to manipulate the ground water elevation in an agricultural field with 0-1% slopes. It is similar to a traditional drainage system; however the outflow is intercepted by a water control structure which controls the water table elevation. This structure contains an inlet and outlet tile with stop logs placed between them to effectively control the water table elevation. Figure 8 shows a water control structure effectively managing the water table in a controlled drainage system.

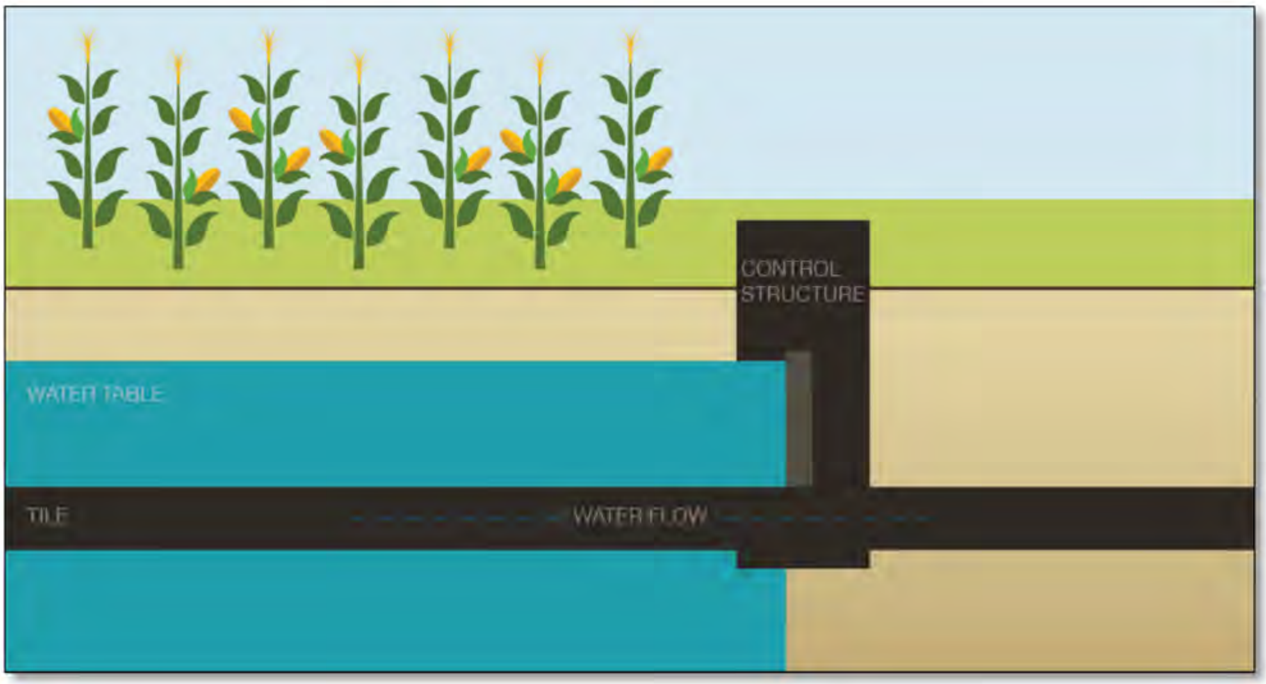


Figure 8: Controlled Drainage Structure

Typically the control structure is adjusted to allow the water to drain during the planting and harvesting months while during the growing season, the water table is held higher in the ground to allow for better crop growth and associated reduced volume of outflow and reduced nutrient transport. In this system, field tile is placed 3-4 feet below the ground surface. The control structures allow water to either remain high in the ground or to be drained when necessary. A control structure can manage the water in the ground for a difference of 1-2 feet of elevation change. For areas where greater elevation changes occur, additional control structures are needed. Adequate areas for controlled subsurface drainage include areas that contain an average of 10 acres over an elevation change of 1-2 feet. Water quality benefits associated with controlled subsurface drainage include overall volume reduction of subsurface drainage, an increase in soil moisture which allows for more plant growth and higher yield potential, and it minimizes the accumulation of nutrients that infiltrate through the soil with the shallower placement of tile laterals. Additional design details can be found in the NRCS Conservation Practice Standard 554 (Drainage Water Management) and 587 (Structure for Water Control).

Treatment Measures

Treatment measures include practices utilized to intercept already flowing water to remove pollutants such as sediment, phosphorous, and nitrogen from the water. These practices include a variety of artificial structures and natural occurrences on the landscape that are utilized to improve water quality.

Vegetative Buffer and Contour Buffer Strips

Vegetative buffer strips are an area of vegetation planted between fields and surface waters to minimize organics, nutrients, and sediment in runoff from entering nearby surface waters. They also effectively reduce runoff velocity and erosion near surface waters by developing sheet flow throughout the strip. They are typically installed on field edges, property lines, or along any waterway at the top of the bank (Figure 9). Vegetation installed along waterways stabilize channel banks, reducing erosion and sedimentation to the channel. Strip widths must be at least 1 rod (16.5 feet) along a public drainage ditch and 50 feet where adjacent to public waters. Suggested plant species in filter strips include stiff, upright stemmed vegetation such as Big Bluestem, Canada Wildrye, Switchgrass, and other native prairie grasses. Additional design details can be found in the NRCS Conservation Practice Standard 393.

Figure 9: Vegetative Buffer Strip along an Open Channel

Contour buffer strips function like filter strips, but are narrow strips alternated with crops planted on the contour within the field (Figure 10). The objective is to slow, filter, and infiltrate surface flows that are moving down the slope through the crop fields. Contour buffer strips reduce sediment and phosphorus delivery to ditches and streams due to filtration, reduced runoff volume (increased infiltration and increased transpiration), and reduced bank sloughing (from reduction of soil water saturation), and increased soil cohesion. Additional design details can be found in the NRCS Conservation Practice Standard 332.

Figure 10: Contour Buffer Strips in a Steep Landscape

Wetland Restoration

A wetland restoration is the re-establishment of natural hydrology and/or native vegetation to a former or degraded wetland that has been drained, farmed or otherwise modified. The goal is to approximate the original pre-settlement wetland as closely as possible. Restored wetland vegetation usually consists of a mix of native hydrophytic (water-loving) vegetation including grasses, sedges, rushes and forbs in the basin or ponded area. Mixtures of native prairie grasses and forbs are also incorporated in the adjacent upland areas. Figure 11 shows a restored wetland in southern Minnesota. There are many benefits to wetland restoration including:

a. Improvement of surface and ground water quality by filtering pollutants such as sediment, pesticides, nutrients, and bacteria
b. Providing nutrient uptake, thereby preventing nutrients from traveling further downstream
c. Reducing soil erosion by slowing the overland flow
d. Increased water storage leading to reduced peak flows, flooding, and channel erosion
e. Filtration/retention of sediment, pesticides, nutrients, and bacteria
f. Nitrate removal by denitrification
g. Restored wildlife habitat

Figure 11: Restored Wetland in Southern Minnesota

Ecological goals of wetland restorations may conflict with goals of re-establishing hydrologic and water quality functions of a wetland, especially in agricultural landscapes. High nutrient levels often lead to reduced biodiversity and dominance by reed canary grass in wet meadows or cattails in the emergent wetland area. Frequent extreme variations in water levels, peak flow rates, and sediment and nutrient loaded water entering the wetland reduce some ecological functions like waterfowl nesting. The goals for each restoration will determine whether or not to include treatment of agricultural runoff or drainage water. Where agricultural runoff contains substantial sediment and nutrients, constructed wetlands may be more appropriate.

In southern and western Minnesota historically there were vast areas of wet prairies with shallow prairie pothole basins and deeper marshes and lakes interspersed, all providing water storage via surface ponding and soil water. Most of the wet prairies were drained for agriculture in these regions leaving only the deeper marshes (3 feet deep or more) and lakes remaining. In the past 30 years, hundreds of small prairie pothole basins restored through various conservation programs have added back some of the lost water storage. Most of the water storage remaining in the agricultural regions of Minnesota today lies in the marshes and lakes and not the shallower wetlands types since the wet prairies have been largely eliminated by drainage.

Wetlands are typically restored in an existing basin where minimal excavation and earthwork is necessary to pond and store water. This may be an old basin, wetland, or lake that was once drained for farming practices. It may also be a low area in relation to the surrounding landscape that consistently has flooding and crop damage due to the natural geometry of the watershed. Wetlands can be restored throughout a watershed, but are suggested in areas where there is a ratio of watershed area to wetland ponded area of 6 to 1 or greater to provide sufficient hydrology to the wetland.

In addition to improved water quality, wetlands are often restored to provide wildlife habitat. Wetland ecosystems are home to numerous species of birds, mammals, and amphibians. Wetlands provide breeding grounds for amphibians such as frogs and salamanders as well as ducks, geese, and migratory waterfowl whose habitat has been reduced. They also provide habitat for small game and other species in the adjacent upland areas. Recently, many wetlands have been restored by private land owners to sell as wetland mitigation credits (wetland banking) as either Standard Wetland Credits (SWC) or Agriculture Wetland Credits (AWC). An individual land owner is responsible for up front design, construction, and monitoring costs, but can sell the credits through the wetland banking program to provide mitigation for wetland losses from other permitted projects. Additional outside funding programs are available for wetland restorations through the Wetland Reserve Easement (WRE) program, RIM-Wetlands, or CREP (Conservation Reserve Enhancement Program) in which purchase easements or long term rental contracts compensate landowners for setting land aside for the restoration.

Water and Sediment Control Basins

Water and sediment control basins (WASCOBs) are an earth embankment placed perpendicular to the water flow direction on a moderate to steep hillside of agricultural area (Figure 12). The primary goal of WASCOBs is improve the ability to farm steep sloped areas of farmland by reducing gully erosion. WASCOBs are placed in areas that experience gully erosion and steep side slopes or can be placed adjacent to ditch banks experiencing gully erosion. They are designed to temporarily pool water on the hillside behind the embankment, thus reducing peak flow rates and soil erosion. Secondary benefits of WASCOBs include sediment and nutrient removal.

Figure 12: Water and Sediment Control Basin

WASOBs range in size and are dependent on several design factors including existing landscape slopes, required fill height, soil types, and severity of the gully. The outlet of a WASOB is typically a vertical drop inlet which is connected to a subsurface drainage tile. WASOBs can be placed either as a single unit or in a series similar to terraces. Additional design details can be found in the NRCS Conservation Practice Standard 638.

Alternative Side Inlet

Alternative side inlet structures replace open surface intakes that are level with the existing ground and convey water through the ditch bank. They are also placed along open ditches where gully erosion is occurring through the ditch bank. The goal of an alternative side inlet is to prevent erosion through the ditch bank and keep sediment and debris from entering the open channel. An alternative side inlet contains a drop pipe behind the ditch bank connected to a 90 degree bend that then enters the open ditch. Various intakes can be place on the drop structure and include Hickenbottom, Slotted Hickenbottom, trash grate, perforated risers, and many others. Alternative side inlets are recommended for areas with existing surface inlets, where gully erosion occurs through the ditch bank, or where large surface flow enters the ditch. Figure 13 shows an alternative side inlet from the top of the ditch bank.

Figure 13: Alternative Side Inlet

ISG has developed an alternative side inlet calculator (Figure 14) which sizes side inlets based on their watershed area, topography, soils, farming practices, and intake type. The calculator properly sizes alternative side inlets to provide a detention time ranging between 20 and 24 hours to make the practice most effective without causing damage to the surrounding crops. Alternative side inlets can effectively reduce sediment entering open channels and other water bodies and can be 50-80% effective in capturing eroded sediment from the surrounding landscape.

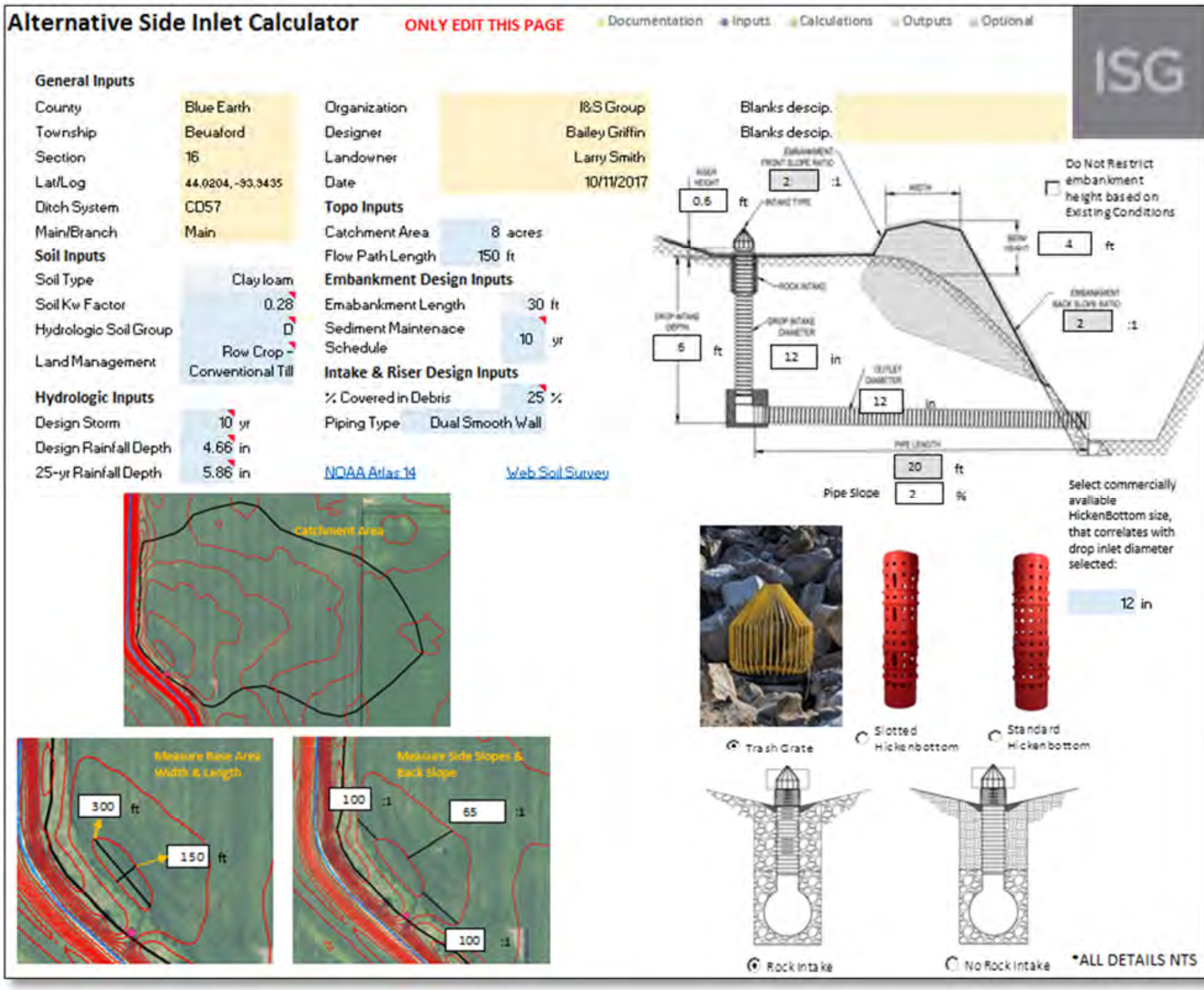


Figure 14: ISG Alternative Side Inlet Calculator

Storage Treatment Basin

A storage treatment basin is an excavated or ponded area with an engineered outlet designed to provide water detention, sediment trapping, and nutrient reduction in a rain event. The basin functions by trapping sediment and associated nutrient laden water for a sufficient time, allowing the particles to drop out of suspension and allow for nutrient uptake and removal in vegetative areas. They may be used in agricultural or urban settings and primary are designed to treat water from disturbed areas. Water quality benefits associated with sediment basins include nitrogen and phosphorous removal, sediment removal, and reduced peak flow rates preventing erosion in downstream waterways. Figure 15 shows a storage treatment basin used for agricultural runoff.

Figure 15: Storage Treatment Basin

Woodchip Bioreactor

The use of a woodchip bioreactor (Figure 16) is a method of removing nitrate from subsurface drainage waters. Carbon from the woodchips is used by bacteria to break down nitrates through the process of denitrification. Construction of a woodchip bioreactor includes excavating a trench in line with the drainage tile system, filling the trench with non-treated chips between ½ and 3 inches in diameter, and installing structures for water control to properly manage the elevation of water entering and leaving the bioreactor. The structure is aligned such that in a large rain event, water can bypass the bioreactor and allow for proper drainage throughout the system. Drainage areas associated with a bioreactor range from 40 to 100 acres on private systems, 100 to 300 acres on public systems, and are generally site specific in design. Life expectancy for a woodchip bioreactor ranges from 10 to 15 years. Additional design details can be found in the NRCS Conservation Practice Standard 605.

Figure 16: Woodchip Bioreactor

Iron-Sand Filter

An iron/sand filter is a treatment device aimed at removing dissolved phosphorous from water. The process is completed through oxidation of iron particles mixed in with a sand media. The dissolved phosphorous through the ion-exchange process binds to the iron particles as they rust. Studies have shown iron/sand filters to have shown reductions between 30 and 80 percent of dissolved phosphorous. There are multiple designs for iron/sand filters which include the following:

- Stormwater Ponds: A ring of sand with iron particles is installed above the maintained water level to treat the water as is rises during rain events
- Underground Trenches: Similar to a woodchip bioreactor, a large underground trench filled with iron/sand media is installed and water is routed into the trench
- Tanks: Iron/sand media is installed in an underground tank (typically similar in size to a septic tank) that intercepts tile water to remove dissolved phosphorous

Each design has a different function and is selected based on the dissolved phosphorous load, watershed size, and available land. Figure 17 shows an iron/sand filter installed in a stormwater pond.

Figure 17: Iron-Sand Filter

Saturated Buffer

A saturated buffer or vegetative subsurface outlet is an alternative drainage tile outlet in which tile drainage water seeps beneath buffer areas of perennial vegetation via a subsurface distribution pipe prior to entering a drainage ditch or other open channels. The purpose of a saturated buffer is to reduce nitrate in tile water via denitrification and plant uptake, and to reduce peak flows associated with typical tile drainage outlets. Construction of a saturated buffer includes installing a structure for water control and subsurface distribution piping capable of diverting drainage system discharge to create an elevated zone of soil saturation near the end of the tile system. The structure diverts water to the vegetative buffer strip via perforated tiling during normal flows while allowing peak flows to travel directly to the system discharge through a non-perforated drain tile. This practice is applicable to agricultural lands with subsurface drainage where the soils and topography are capable of maintaining a raised water table near the outlet of the system without adverse effects to channel banks and adjacent land. Additional design details can be found in the NRCS Conservation Practice Standard 739. Figure 18 shows a completed saturated buffer.

Figure 18: Saturated Buffer

Funding Opportunities

There are many potential funding opportunities for the above mentioned BMPs. Funding or cost share programs include the Environmental Quality Incentives Program (EQIP), Reinvest in Minnesota (RIM-Wetlands), Conservation Reserve Program (CRP), Conservation Reserve Enhancement Program (CREP), or Wetland Reserve Easement (WRE) Program. Some of these programs require a permanent easement where the State purchases vegetative rights to the enrolled area while others provide rental payments from 10 to 15 years.

Funding for all above mentioned BMPs may be available through the Wright County Soil and Water Conservation District (SWCD) or the Natural Resources Conservation Services (NRCS). Contact the SWCD for more cost share opportunities or other funding opportunities.

CD 10 Watershed

Wright County Ditch 10 (CD 10) is an approximately 17,000 acre watershed located southwest of the City of Howard Lake. The watershed lies in Section 1, 2, 10-15, 22-27, 35, 36 of Stockholm Township; Section 31, 32 of Middleville Township; and Sections 4-10, 15-22, 28-31 of Victor Townships in Wright County. The watershed is drained by the CD 10 public open ditch mainline and branches. The open ditch begins in Section 11 of Stockholm Township near Grass Lake and flows east to Lake Ann which serves as the CD 10 outlet. The watershed consists primary of agricultural farmland, open ground pasture, and wetland complexes. The topography throughout the watershed is gently rolling with an elevation difference of approximately 70 feet. Watershed maps are included in Appendix A.

Existing Conditions

ISG performed a topographic survey and a drone video for the public open ditch system. The main line and the laterals consist of approximately 89,000 linear feet of open ditch. The open ditch consists of the mainline and ten other laterals. The mainline includes 30,800 linear feet with an additional 59,000 linear feet of laterals which drain into the mainline.

An inventory of repairs for CD 10 was completed by utilizing the drone videos and topographic survey. Items noted with the inventory include the following things that were present or lacking on the open ditch: field and culvert crossings, existing areas lacking buffers, side intakes, ponds, riprap, sloughing, tree removal, sediment accumulation, and over grown vegetation.

Vegetation

The effects of vegetation in the open ditch vary depending on what type is present. Annual broadleaves and cattails in the open ditch as shown in Figures 19-23 can impede water flow. The impeded flow can back up during storms causing localized flooding. The growth of vegetation also causes the open ditch to start to meander and erode the channel banks.

Figure 19. Vegetation in Open Ditch North of 90th Street in Section 13 of Stockholm Township on Sieg Lateral

Figure 20. Vegetation Growth in Open Ditch (Cattails) Section 5 Victor Township on Tuey Lateral

Figure 21. Vegetation Growth in Section 17 of Victor Township on Eddy Lateral

Figure 22. Vegetation Growth Section 5 Victor Township on Tuey Lateral

Figure 23. Vegetation Growth South of 70th Street in Section 8 of Victor Township on Tuey Lateral

Tree Removal

Excessive tree and shrub growth noticed in the open ditch contributes to erosion, sediment deposition, and flow restrictions. Areas of the open ditch system flow through dense trees along the ditch banks and within the buffer of the open ditch. Areas of tree and shrub growth within the ditch were noticed throughout the system. There is approximately 52,000 linear feet of tree removal necessary for CD 10.

Figures 24-27 show examples of clearing and grubbing, heavy, and light tree removal. Clearing and grubbing consist of wooded areas with dense tree cover, canopy coverage, and large diameter trees. Heavy tree removal consisted of large diameter trees in isolated groups along the banks throughout the ditch system. Light tree removal is comprised of smaller trees and shrubs that are sporadic on the ditch bank. Tree removals will be completed along the ditch bank and through the 1-rod buffer easement area.

Figure 24. Clearing and Grubbing Tree Removal Southeast Quarter of Section 12 of Stockholm Township

Figure 25. Heavy Tree Removal in Section 22 of Victor Township

Figure 26. Light Removal in Section 8 of Victor Township on Tuey Lateral

Figure 27. Southwest Quarter of the Southwest Quarter of Section 15 in Victor Township on the Main Open Ditch

The tree coverage in Figure 28 is shown to be on both sides of the open ditch which is the case for the majority of CD 10. The trees at any time can lose limbs or even fall into the open ditch causing flow restrictions. The trees also provide a canopy across the ditch banks create instabilities more susceptible to erosion. Perennial grasses along the ditch bank and buffer provide dense root growth, creating stable banks less susceptible to erosion.

Figure 28. Clearing and Grubbing Tree Removal Northeast Quarter of the Southwest Quarter of Section 24 in Stockholm Township on Sieg Lateral

Dead and fallen trees can be seen in Figure 29 and Figure 30. The trees that have fallen reduce flow in the open ditch and also redirects the flow direction creating erosion. The trees are also blocking sunlight and not allowing preferred vegetation to grow on the banks.

Figure 29. Heavy Tree Removal Section 13 Stockholm Township, Sieg Lateral

Figure 30. Northeast Quarter of the Northeast Quarter of Section 12 in Stockholm Township on Hass Lateral

The trees in Figure 31 are located in the southeast quarter of Section 12 of Stockholm Township. The trees in this section will be considered light vegetation removal.

Figure 31. Northeast Quarter of Southeast Quarter of Section 8 in Victor Township on Tuey Lateral

Sloughing

Sloughing was identified at various locations along the ditch. Sloughing occurs when the bank of the open ditch shears and collapses into the open ditch. The main causes of sloughing include overland flow overtopping the ditch bank, lack of buffer vegetation, steep side slopes, and meandering alignment of the open ditch. The sloughing deposits sediment into the CD 10 open ditch which restricts flow and requires maintenance. Figures 32 and 33 shows severe sloughing caused by a meandering channel and lack of ditch buffer.

Figure 32. Sloughing along open ditch in the Northeast Quarter of Section 24 in Stockholm Township on Sieg Lateral

Figure 33. Sloughing along open ditch in Northeast Quarter of Section 24 in Stockholm Township on Sieg Lateral

Figures 34-35 shows sloughing caused from bank overtopping and lack of buffer. The locations are all from 95th Street Southwest to 90th Street Southwest.

Figure 34. Northeast Quarter of Section 24 in Stockholm Township on Sieg Lateral

Figure 35. Northeast Quarter of Section 24 in Stockholm Township on Sieg Lateral

In Figure 36 the open ditch has started to meander do to the bank overtopping and sloughing. A factor in the sloughing is the lack of buffer on the field edge.

Figure 36. Southeast Quarter of the Southwest Quarter of Section 5 in Victor Township

Washouts

Gully erosion through the banks of the ditch were identified and are causing substantial deposition of sediment to the open ditch and adjacent landscape. Gully erosion occurs when large surface flow enters a localized area not capable of conveying flow across the bank and appear similar to small ravines through the ditch bank. The gully erosion can be seen in Figure 37-39. Sheet erosion is also present on the open ditch. The sheet erosion is due to the lack of a buffer and the water runs overt the banks and washes the sediment into the open ditch.


Figure 37. Northeast Quarter of Section 24 in Stockholm Township on Sieg Lateral


Figure 38. Gully off of CSAH 5 on the Main Open Ditch


Figure 39. Section 18 of Victor Township Sheet Erosion

Tiles

All tile outlets into the open ditch will be replaced or repaired as part of this project. Some of the tile outlets are in good shape and only require riprap protection on geotextile fabric; however some tiles are bent, broken, covered or completely washed away causing erosion to the ditch banks (Figures 40 and 41). The repair of damaged tiles will consist of replacing the damaged outlets into the ditch with a section of new tile.

Figure 40. Unprotected Tile Draining into the Main Open Ditch

Figure 41. Covered Tile Outlet Draining into Main Open Ditch.

Buffer Seeding

The majority of the CD 10 system does not contain a buffer along the ditch bank. Examples of limited to no buffers are shown below (Figures 42-45) and can also be seen in the other photos presented earlier. Buffer strips help prevent sloughing and sediment from entering into the open ditch.

Figure 42. Northwest Quarter of Section 18 in Victor Township on the Open Ditch Main

Figure 43. Southeast Quarter of Section 5 in Victor Township on the Gilmer Lateral

Figure 44. Border of Section 18 and 17 of Victor Township on the Open Ditch Main

Figure 45. Northeast Quarter of Section 18 in Victor Township on the Main Open Ditch

Multi-Purpose Drainage Management

Multi-purpose drainage management incorporates Best Management Practices (BMPs) which utilize effective measures aimed at reducing sediment and nutrient loading, and improving water quality; all while protecting or improving drainage. These BMPs are divided into three areas: preventative measures, control measures, and treatment measures. Multi-Purpose Drainage Management Maps for CD 10 are included in Appendix B which show specific locations for the BMPs described below.

Preventative Measures

Preventative measures that can be applied throughout the watershed include crop rotation, cover crops, residue management, and nutrient management. These measures are aimed at controlling sediment, minimizing erosion and nutrient loss, and sustaining the soils health, all without dramatically changing the current land use of the landscape.

The soils throughout CD 10 predominately contain loam, sandy loam, and silt loam. These soils possess erodibility characteristics and are susceptible to sheet, rill, and wind erosion. Erosion has been noted throughout the watershed and open ditch system through sediment accumulation, gully erosion, and wind erosion. Preventative measures can be provided throughout the CD 10 watershed to create more organic matter within the soil profile, increase infiltration capacity, and create more sustainable soils all in an effort to reduce erosion. These practices should be reviewed on a field by field basis by individual landowners and the Wright SWCD.

Control Measures

Grassed Waterways

Grassed waterways are installed to reduce the risk of concentrated flow (gully) erosion. This practice is effective in preventing gully erosion as the growing grasses can reduce mean velocity of runoff, which discourages soil detachment. Grass vegetation also provides a physical barrier to prevent gully formation and the fibrous root systems of grasses lead to increased soil strength, which can limit detachment of soil particles.

Several areas throughout the CD 10 watershed have been identified where a grassed waterway may be a good practice. These areas were identified based on the topography and land slopes, soil properties, and current land use. These areas are generally away from the open ditch segments of CD 10 and are in the steep upland areas.

Controlled Drainage
A controlled drainage system is a water table management practice that raises the in-field water table during year, thereby reducing overall tile drainage volume. There are several locations within the CD 10 watershed where controlled subsurface drainage is feasible and would have beneficial impacts towards water quality and crop production. These locations are generally in the low basin areas of the watershed or in the upper limits where slopes are flat.

The identified locations have ideal characteristics such as an elevation variation of 1 to 2 feet over an average of 10 acres. Controlled subsurface drainage areas would contain tiling placed between 3 and 4 feet below the ground surface. The tiling would be placed parallel with the contours rather than perpendicular like traditional tiling. A water control structure would be placed on the field tile mainline and would be spaced at every 1 to 2 foot elevation difference. The structures would contain adjustable stop logs which hold water in the tile during the growing season while allowing drainage during the spring plant and fall harvest.

Water and Sediment Control Basins (WASCOBs)
Water and sediment control basins (WASCOBs) are an earth embankment placed perpendicular to the water flow direction on a moderate to steep hillside of an agricultural area. The primary goal of a WASCOB is to improve the ability to farm steep sloped areas of farmland by reducing gully erosion. They are placed in areas that experience gully erosion and steep side slopes. They are designed to temporarily pool water on the hillside behind the embankment, thus reducing peak surface flow, reduce erosion, and provide an area for sedimentation. Figure 46 below shows an example of a WASCOB.

There are several areas throughout the CD 10 watershed where a WASCOB can be incorporated to limit soil erosion. Most of the selected areas are located away from the open ditch where gulley erosion can be seen throughout the hillsides. However, there are severe erosion areas along the ditch bank throughout the mainline CD 10 open ditch where a WASCOB/ alternative side inlet combination could be incorporated.

Alternative Side Inlet

Alternative side inlet structures replace open surface intakes that are level with the existing ground and convey water through the ditch bank or along open ditches where gully erosion is occurring through the ditch bank. Alternative side inlets are recommended for areas with existing surface inlets, where gully erosion occurs through the ditch bank, or where large surface flow enters the ditch.to protect the bank from large events and water flow additional riprap may be added to provide extra stabilization. Alternative side inlets are recommended and have been included with the repair project.

Areas were identified throughout the CD 10 watershed that would benefit from alternative side inlet. These locations were selected based on the soils, slopes, and erosion characteristics of the landscape. Examples of these areas are where ditch bank or gulley erosion is occurring, where sloughing has been identified, where a buffer is recommended due to surface flow over the ditch bank, or where existing surface inlets are located.

When implemented in the correct locations, alternative side inlets can effectively reduce sediment entering open channels and other water bodies. Alternative side inlets can be 50-80% effective in capturing eroded sediment. An analysis of CD 10 watershed shows a potential for the implementation of 32 alternative side intakes with sediment capture potential of approximately 0.7-4 tons per acre per year of soil reduction within each alternative side inlet respective catchment area. Figure 47 shows a constructed alternative side inlet while Figures 48 and 49 show a standard detail of side inlets.

Figure 46. Typical Constructed WASCOB

Figure 47. Typical Constructed Side Intake

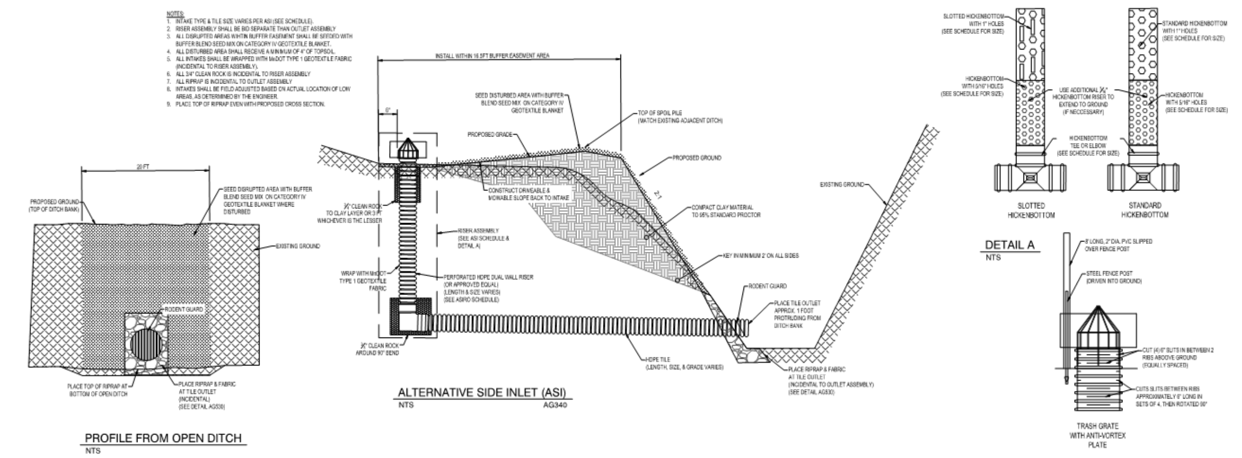


Figure 48. Detail of Alternative Side Inlet

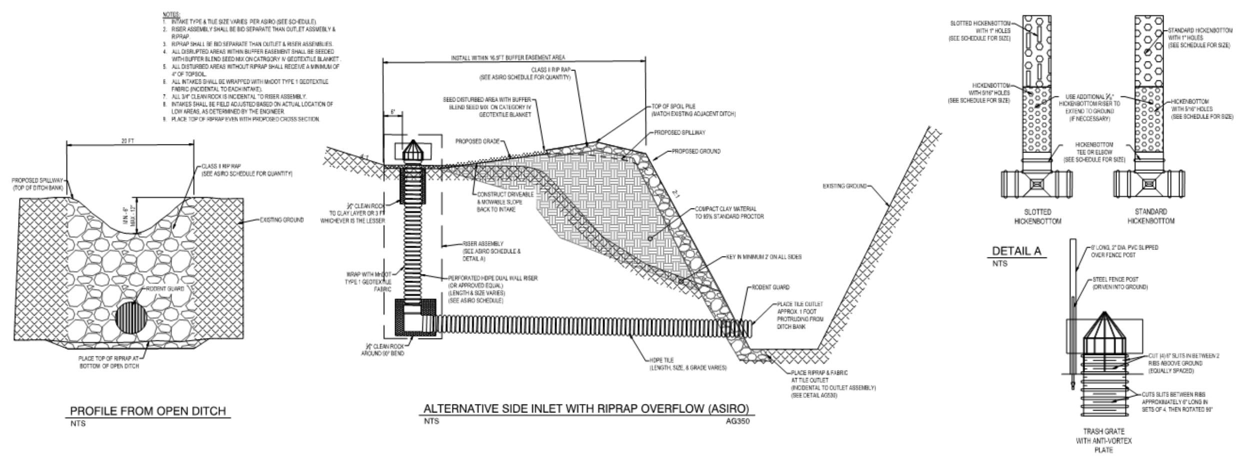


Figure 49. Detail of Alternative Side Inlet with Riprap Overflow

Treatment Measures

A depressional analysis was performed on the entire CD 10 watershed to identify basins or low lying areas with a large contributing watershed to each basin. The basins were then observed to determine the potential for wetland restorations, enhancements, or storage and treatment basins.

Wetland Restoration

Wetland restorations were identified in the analysis where isolated basins exist and are not directly along the open ditch. The basins were prehistoric wetlands that were drained for agricultural production. The wetland restorations identified range in size from 10 to 50 acres and are located throughout the CD 10 watershed. Benefits of a wetland restoration include reduced peak flow rates, sedimentation, nutrient reductions, wildlife enhancement, and overall improved water quality. There are many programs available for wetland restorations and include wetland banking, RIM-WRP, CREP, and through various NRCS programs.

Wetland Enhancement
Several areas were identified by the depressional analysis that are currently wetland complex systems the wetland hydrology and vegetation. These areas were located directly along the CD 10 open ditch. A review of the hydrology, topographic survey, and watershed area draining to the wetland showed the potential to gain storage volume and peak flow reduction within the wetland by installing a rate control structure. The rate control structure would allow more live storage pooling within the existing wetland and would reduce peak flow rates existing the wetland. This would also prevent downstream flooding and improve water quality. 1 below summarizes the locations of wetland enhancement areas.

Table 1. Wetland Enhancement Area Summary

Wetland Enhancement										
Site	Location	Main/Branch	Watershed Area (acre)	Area (acre)	Storage Volume (acre-ft)	Peak Flow Reduction	Potential Sediment Capture (tons/year)	Potential Nutrient reduction	Cost	Priority
1	Section 20,29 Victor Township	Hempel	1,766	45.9	47	23%	593	30%	$ 50,400.00	4
2	Section 8,17 Victor Township	Eddy	184	54.6	14	26%	82	20%	$ 52,800.00	2
3	Section 8, 17 Victor Township	Tuey	1,940	91.0	63	20%	543	35%	$ 62,400.00	5
4	Section 1 Stockholm Township	Hess	465	57	59	13%	158	25%	$ 61,200.00	3
5	Section 11,12,12,14 Stockholm Township	Main	8054	425	213	20%	2694	35%	$ 152,400.00	1

Figure 50. Wetland Enhancement Created by Weir Addition

Storage-Treatment Basins
Storage-treatment basins include low areas adjacent to the open ditch that are currently in agricultural use, but are susceptible to routine flooding. These areas provide an opportunity to excavate a large basins designed as a storage and treatment basin to improve water quality. Water from the existing ditch would be routed through the storage-treatment basin to reduce peak flow rates, provided additional detention time for sedimentation, and would be exposed to vegetation to absorb nutrients. Storage-treatment basins are also beneficial to the CD 10 drainage system, as overall peak flow rates and reduced to open ditch, less frequent flooding and high water levels in the ditch, and less maintenance with less sediment deposits and erosion.

Table 2 below summarizes the locations for storage-treatment basins while Figures 51-55 show a picture of the identified storage treatment location.

Table 2. Storage Treatment Area Summary

Storage Treatment										
Site	Location	Main/Branch	Watershed Area (acre)	Area (acre)	Storage Volume (acre-ft)	Peak Flow Reduction	Potential Sediment Capture (tons/year)	Potential Nutrient Reduction	Cost	Priority
1	Section 7, 18 Victor Township	Main	8,915	8	31	5-15%	1805	10-20%	$ 236,000.00	3
2	Section 17, 18 Victor Township	Main	9,850	16	64	20-25%	2110	5-20%	$ 168,000.00	2
3	Section 15 Victor Township	Main	14,130	19	56	15-20%	3205	20-30%	$ 400,000.00	1
4	Section 20 Victor Township	Hempel	1,768	7	29	10-20%	579	15-30%	$ 200,000.00	4
5	Section 5 Victor Township	Gilmer	325	3	9	20-30%	160	20-40%	$ 90,000.00	5

Figure 51. Southeast Quarter of Section 5 in Victor Township on Tuey Lateral

Figure 52. Southeast Quarter of Section 7 in Victor Township. Near Mainline

Figure 53. Northwest Quarter of Section 20 in Victor Township on Hempel Lateral

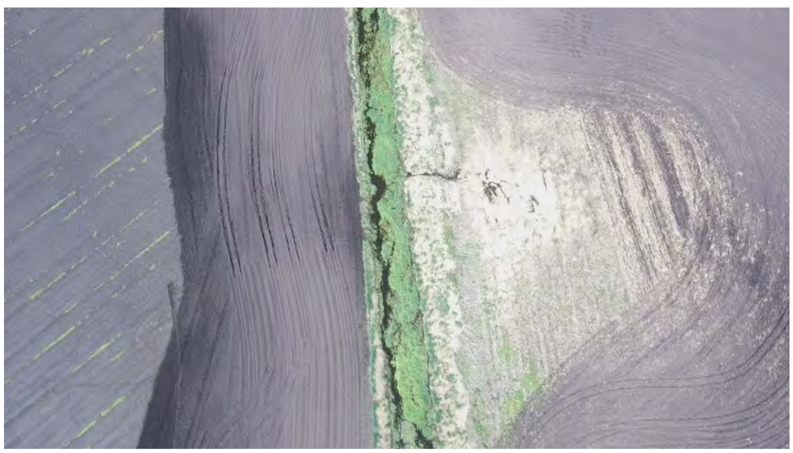


Figure 54. Northeast Quarter of Section 8 in Victor Township on Tuey Lateral

Figure 55. Southeast Quarter of Section 18 in Victor Township on Mainline

Woodchip Bioreactor

The use of a woodchip bioreactor is method of removing nitrates from a subsurface drainage waters. Carbon from the woodchip is used by bacteria to break down nitrates through the process of denitrification. Construction of a woodchip bioreactor includes excavating a trench in line with the drainage tile system, filling the trench with woodchips, and installing water control structures to manage water levels in the trench. Woodchip bioreactors typically reduce nitrate loading by 30-60 percent and can reduce up to 90 percent under base flow conditions.

Specific locations of woodchip bioreactors were not selected for the CD 10 watershed as limited tile information was provided. Recommended locations include areas near field edges that contain tile drainage with watershed sizes between 50 and 150 acres. Larger watershed sizes are possible for treatment if space and funding is available.

Buffer Strips

The majority of the CD 10 system lacks perennial buffer strips. Buffer strips aide in ditch bank stability and reduce erosion along open channels. Under MN Statute 103.E for CD 10, a 16.5 foot buffer is required for the mainline open ditch and all laterals. Other areas were identified recommended buffer do to the large surface flow over the ditch banks and severe erosions currently occurring.

Several areas were also identified to have substantial tree growth along the ditch banks. Trees and non-grassed vegetation along ditch banks pose a significant risk to channel bank erosion. Tree roots do no stabilize channel banks as effectively as perennial vegetation and the canopy of trees prevent permanent growth of dense rooted grasses which are the most effective at bank stability. Tree clearing areas are recommended throughout the CD 10 open ditches and shall be replaced with a grassed buffer.

Cost Estimates

Table 3 below summarizes the cost estimates for each of the outlined MDM Best Management Practices that can be incorporated into the CD 10 watershed. These cost estimates can be used for grant application purposes for cost share opportunities. Items included in the cost estimate focus on channel stability, soil erosion, water storage, and water quality. These items will benefit the integrity of the CD 10 open ditch system, but are outside standard ditch cleaning and maintenance. Other BMPs mentioned in this report such as preventative measures or controlled drainage were not included in this cost estimate as they fall outside the CD 10 ditch system easement.

Table 3. Cost Estimates for Multi-purpose Drainage Management

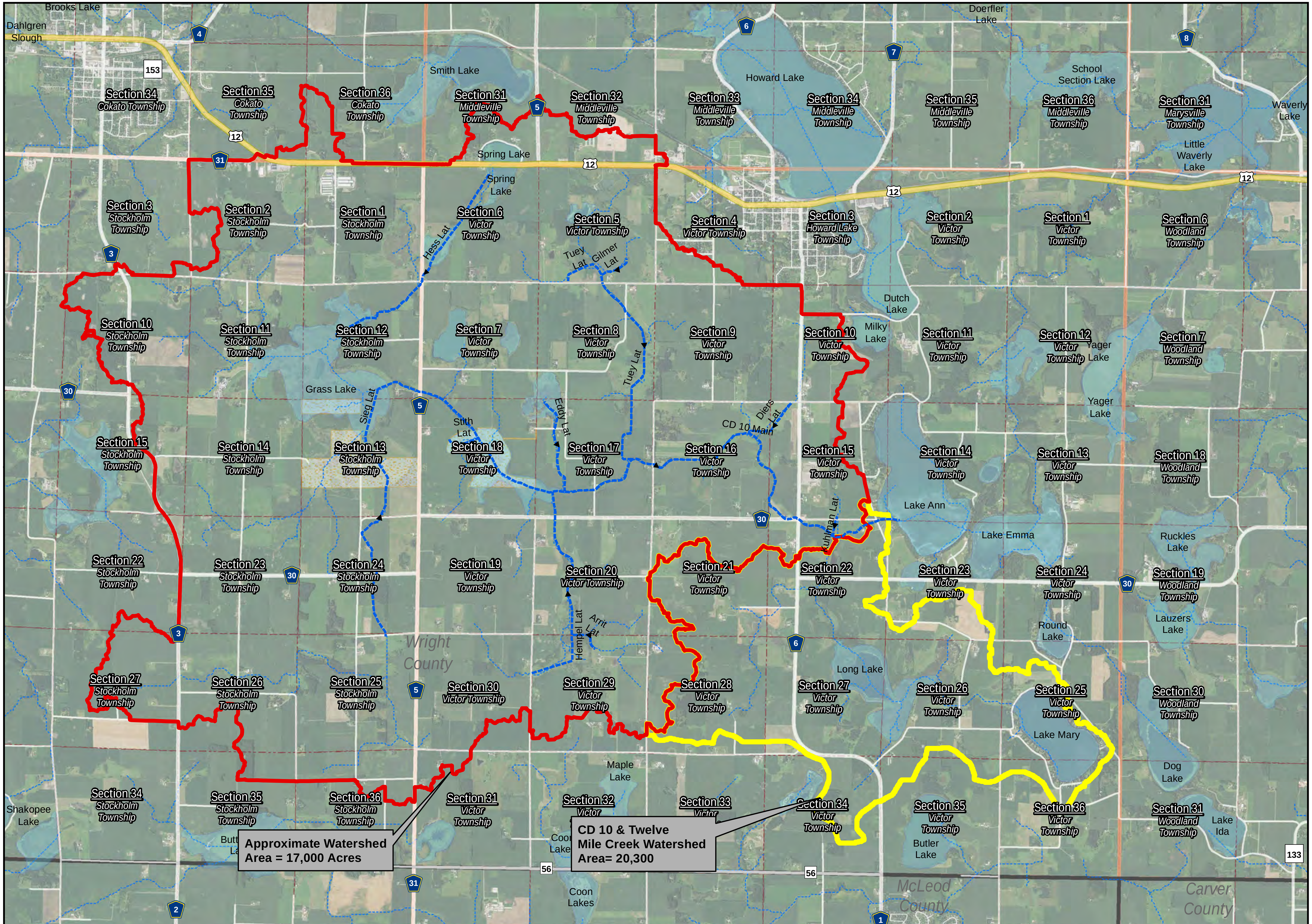
MDM BMP Item	Estimated Cost
Alternative Side Intakes	$75,000-$100,000
WASCOBS	$35,000-$85,000
Bank Stabilization/Slough Repair	$20000-$25,000
Tree Removals	$175000-$250,000
Buffer Seeding and Maintenance	$75000-$100,000
Storage Treatment Basins	$90,000-$240,000
Wetland Enhancement Projects	$50,000-$155,000

Funding options are available to land owners through the NRCS Environmental Quality Incentives Program (EQIP). EQIP is a voluntary program that provides financial assistance to individual land owners for various conservative practices as identified above. Interested landowners shall contact the Wright County SWCD with any questions.

Conclusions & Recommendations

This report provided an inventory of the existing conditions and issues related to erosion, flooding, and water quality throughout the CD 10 system. Also included in this report is a full Multi-Purpose Drainage Management Plan which outlines where water quality best management practices can be incorporated to improve soil health, erosion, flooding, and water quality. This report can be used for targeting areas for water quality improvements and can be utilized for grant funding opportunities.

APPENDIX A:
Watershed Maps



Full Watershed Map

County Ditch No. 10

Wright County, Minnesota

Tuesday, January 09, 2018

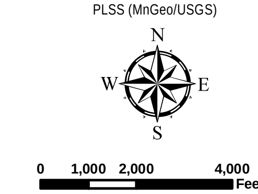
Legend

- Watershed Boundary
- 12 Mile Creek Watershed
- CD 10 OPEN DITCH
- PWI Basins
- DNR State Easement
- Township, Range
- USGS Streams

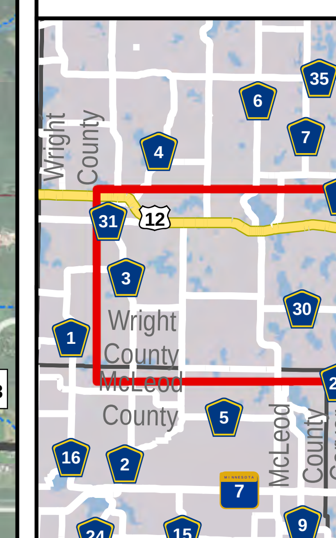
PN: 17-20449

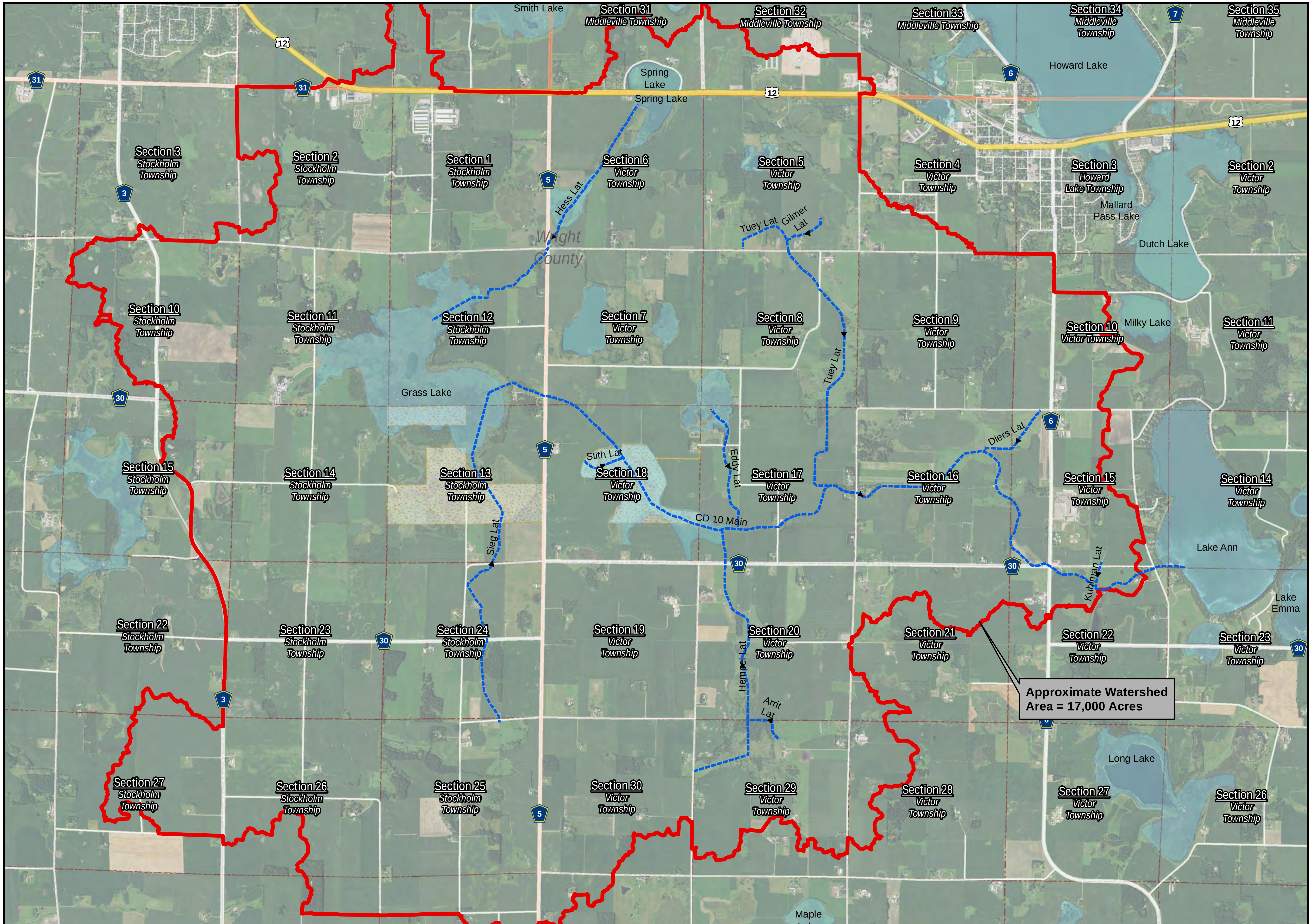
Source:

Orthophotograph (Wright County, 2016)
Tile/Ditch (Wright County, 11/21/2016)
Parcels (Wright County, 2/4/2016)
Lakes (MN DNR, July, 2008)
Major Stream (MN DNR, July 2008)
Counties (MN DNR, July 2013)
PLSS (MnGeo/USGS)



1 inch = 4,000 feet





ISG

Watershed Map

County Ditch No. 10

Wright County, Minnesota

Tuesday, January 09, 2018

Legend

- Watershed Boundary
- CD 10 OPEN DITCH
- PWI Basins
- DNR State Easement
- Township, Range

PN: 17-20449

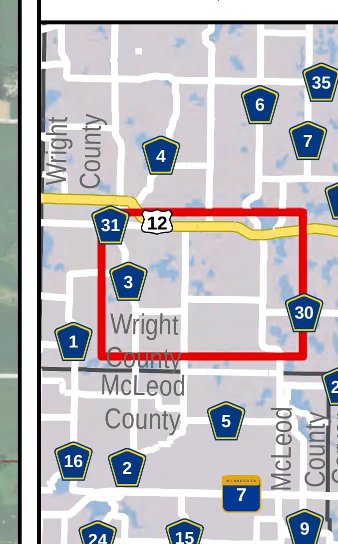
Source:

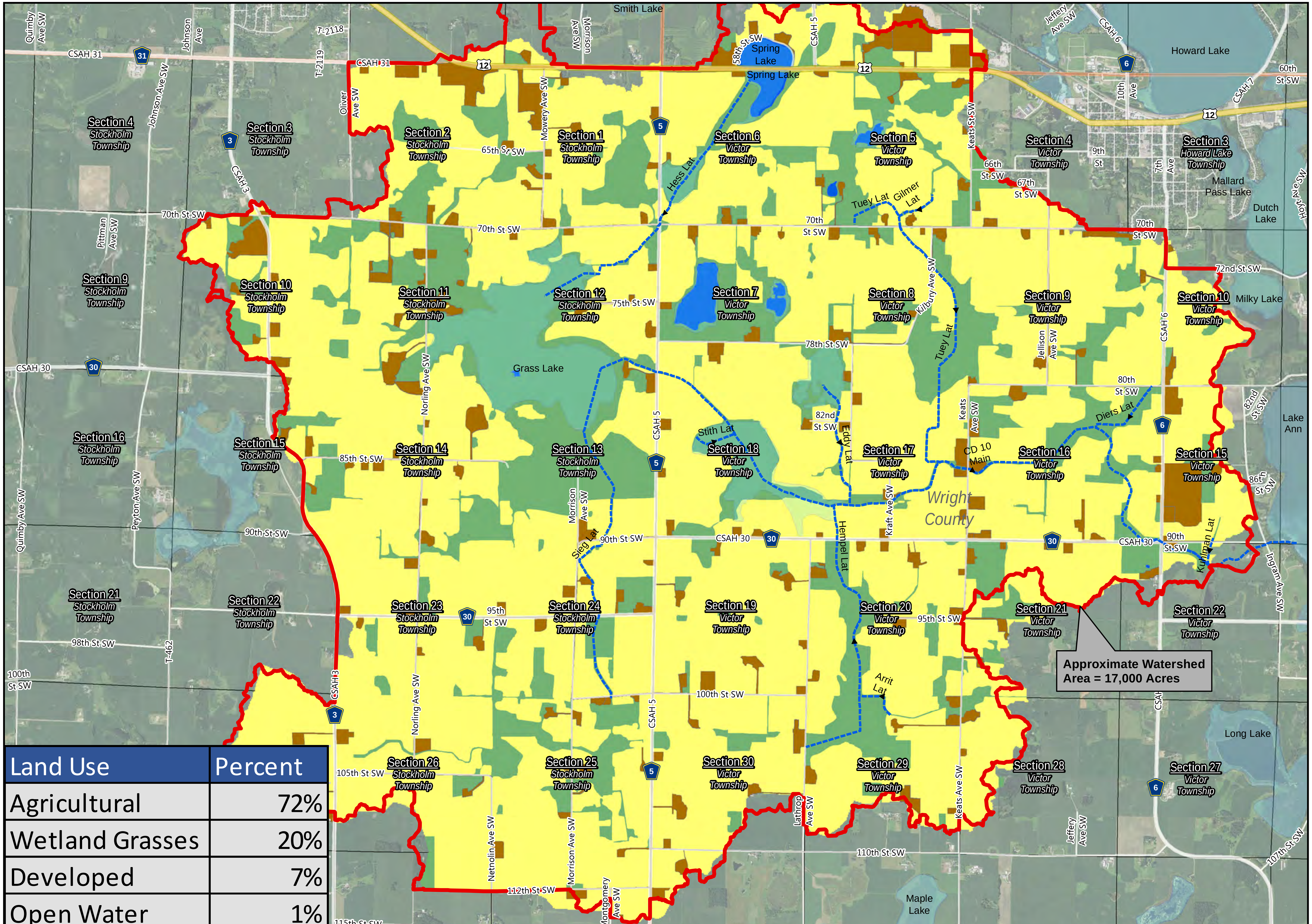
Orthophotograph (Wright County, 2016)
Tile/Ditch (Wright County, 11/21/2016)
Parcels (Wright County, 2/4/2016)
Lakes (MN DNR, July, 2008)
Major Stream (MN DNR, July 2008)
Counties (MN DNR, July 2013)
PLSS (MnGeo/USGS)

N W E S

0 750 1,500 3,000 Feet

1 inch = 3,000 feet





Land Use	Percent
Agricultural	72%
Wetland Grasses	20%
Developed	7%
Open Water	1%

ISG

Land Use Map

County Ditch No. 10

Wright County, Minnesota

Tuesday, January 09, 2018

Legend

- Watershed Boundary
- CD 10 OPEN DITCH

LandUSe

Landuse

- Agricultural Land
- Wetland and Grass
- Developed Land
- Open Water

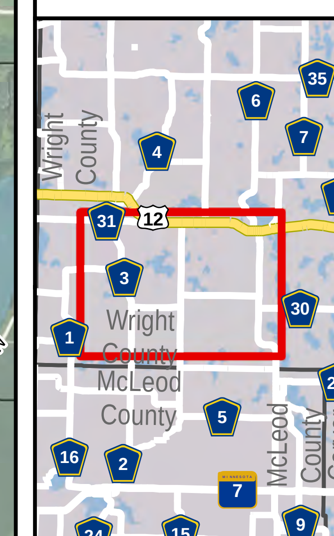
PN: 17-20449

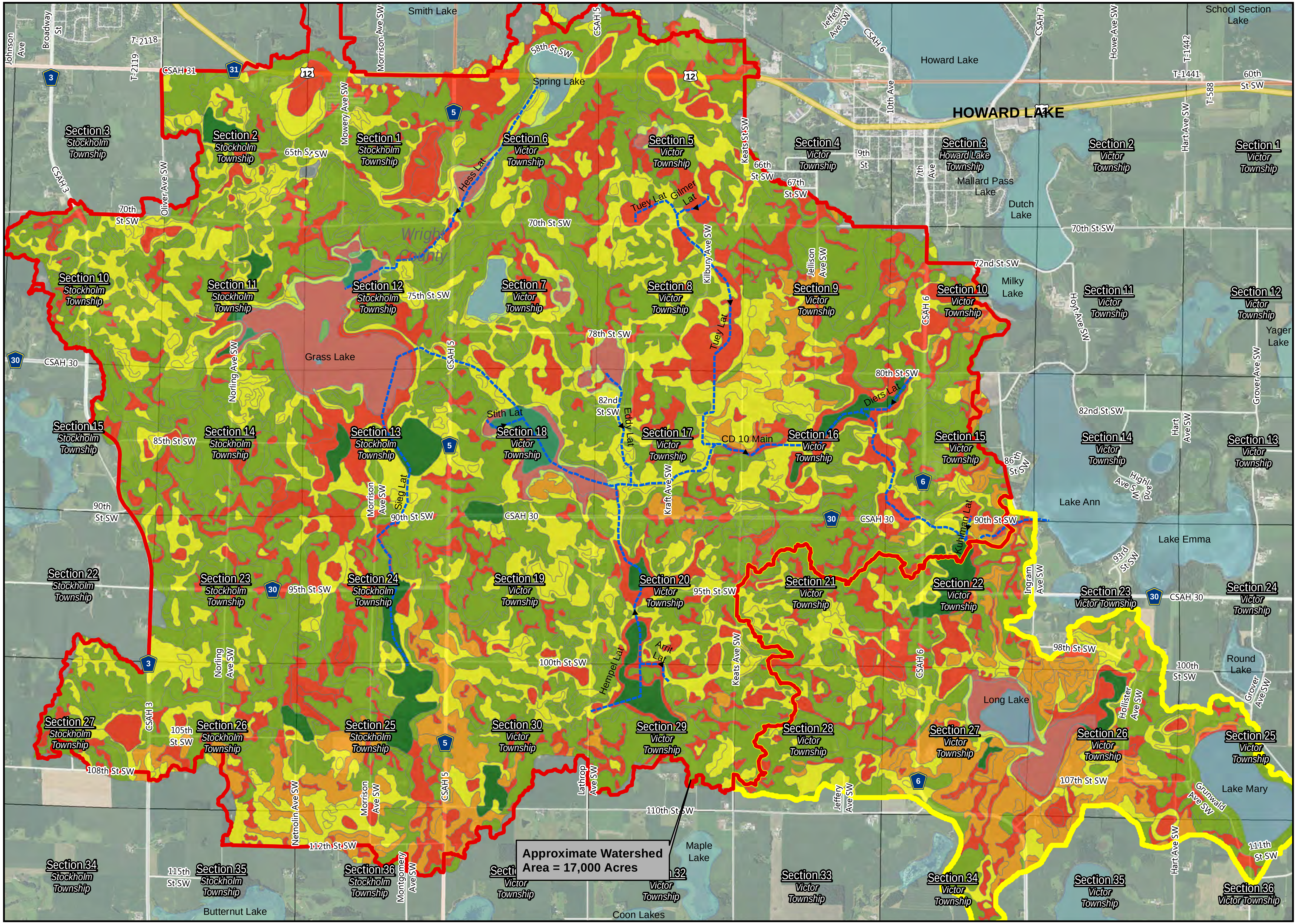
Source:

Orthophotograph (Wright County, 2016)
Tile/Ditch (Wright County, 11/21/2016)
Parcels (Wright County, 2/4/2016)
Lakes (MN DNR, July, 2008)
Major Stream (MN DNR, July 2008)
Counties (MN DNR, July 2013)
PLSS (MnGeo/USGS)

0 750 1,500 3,000 Feet

1 inch = 3,000 feet





ISG

Soils Map

County Ditch No. 10

Wright County, Minnesota

Tuesday, January 09, 2018

Legend

- Watershed Boundary
- 12 Mile Creek Watershed
- CD 10 OPEN DITCH
- PWI Basins

HSG

- A/D
- B
- B/D
- C
- C/D
- Township, Range
- Sections

PN: 17-20449

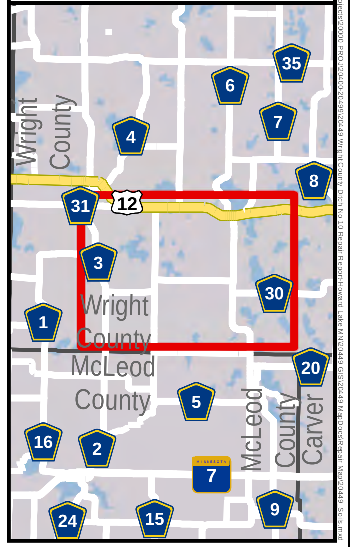
Source:

Orthophotograph (Wright County, 2016)
Tile/Ditch (Wright County, 11/21/2016)
Parcels (Wright County, 2/4/2016)
Lakes (MN DNR, July, 2008)
Major Stream (MN DNR, July 2008)
Counties (MN DNR, July 2013)
PLSS (MnGeo/USGS)

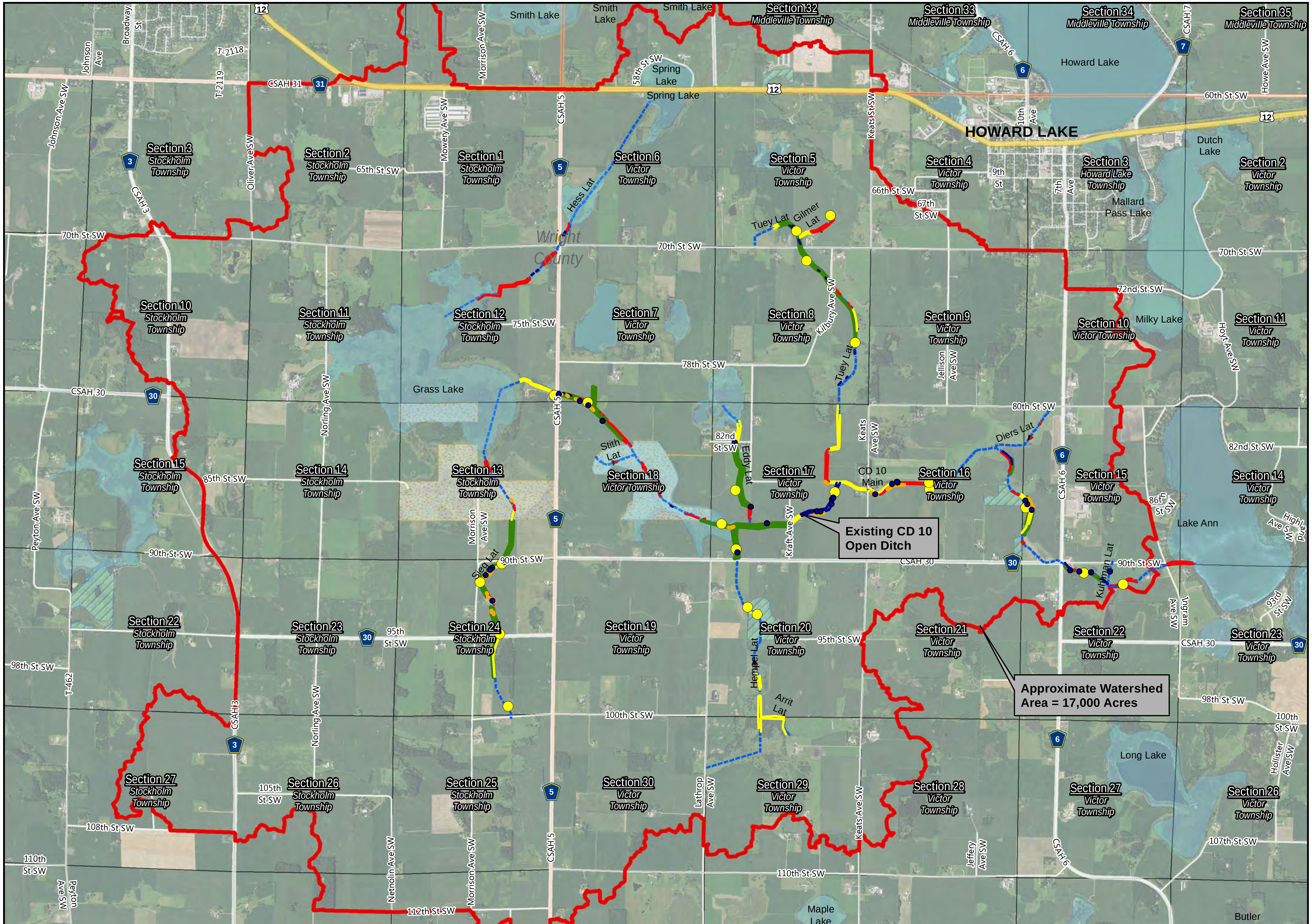
N W E S

0 800 1,600 3,200 Feet

1 inch = 3,167 feet



APPENDIX B:
Multi-Purpose Drainage Management Plan Maps



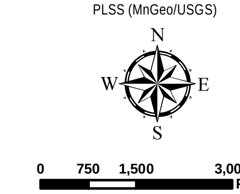
MDM Repairs Map
County Ditch No. 10
Wright County, Minnesota
Tuesday, January 09, 2018

Legend

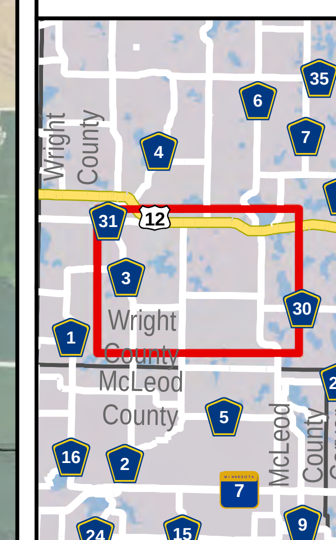
- Watershed Boundary
- CD 10 OPEN DITCH
- Bank Washouts
- Alternative Side Intake
- Sloughing
- Light Tree Clearing
- Heavy Tree Clearing
- Tree Clearing & Grubbing
- Recommended Buffer
- PWI Basins
- DNR State Easement
- NWI
- Township, Range
- Sections

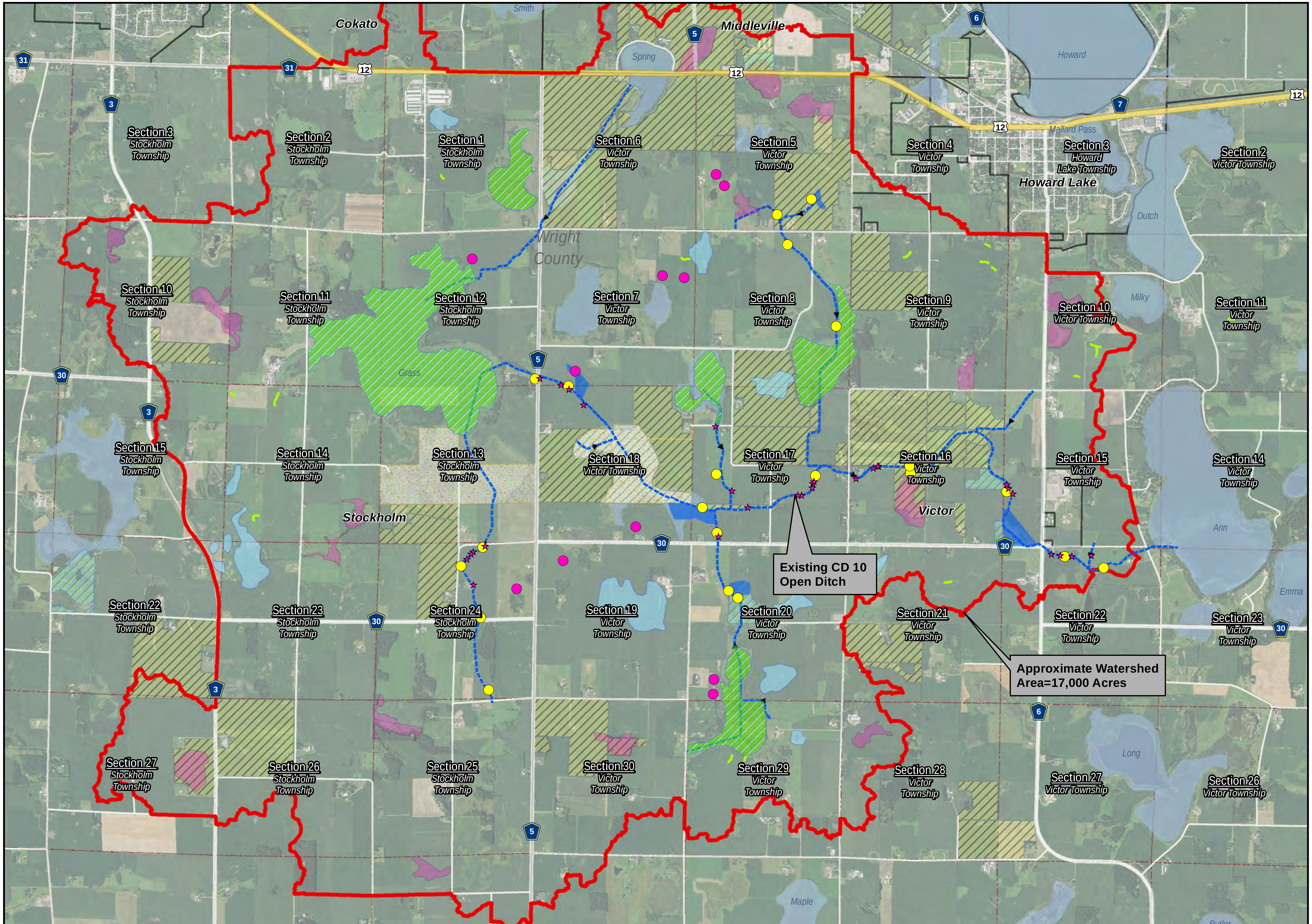
PN: 17-20449

Source:
Orthophotograph (Wright County, 2016)
Tile/Ditch (Wright County, 11/21/2016)
Parcels (Wright County, 2/4/2016)
Lakes (MN DNR, July, 2008)
Major Stream (MN DNR, July 2008)
Counties (MN DNR, July 2013)
PLSS (MnGeo/USGS)



1 inch = 3,000 feet





MDM Map

County Ditch No. 10

Wright County, Minnesota

Tuesday, January 09, 2018

Legend

- Watershed Boundary
- CD 10 OPEN DITCH
- Bank Stabilization
- Wetland Restorations SWCD
- Alternative Side Inlets
- Potential WASCOBs
- Wetland Enhancement
- Storage Treatment
- Grass Water Way
- Wetland Restoration
- Controlled Drainage
- DNR State Easement
- NWI
- Lakes

PN: 17-20449

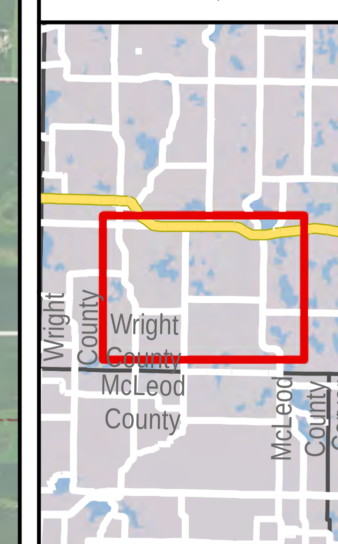
Source:

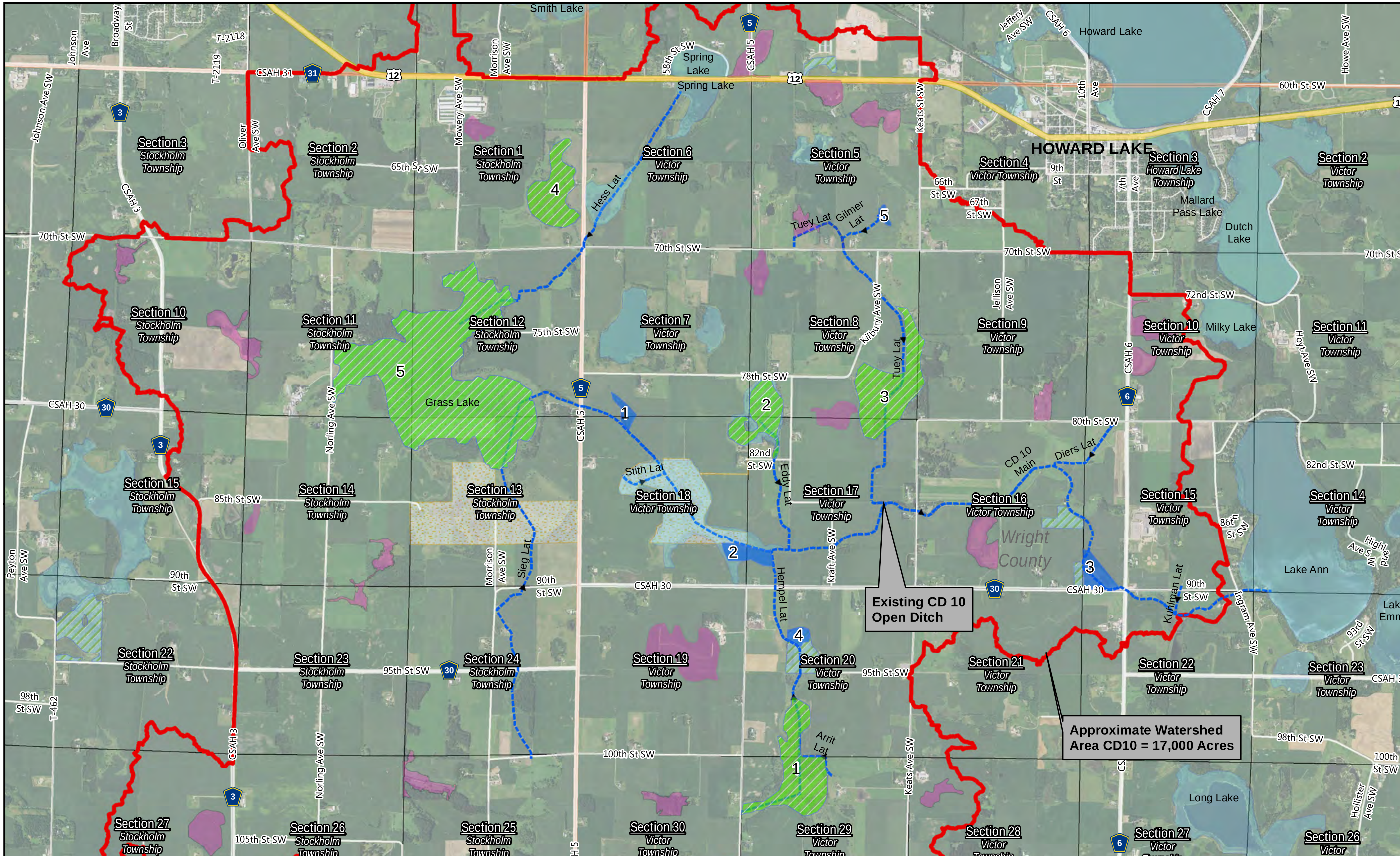
Orthophotograph (Wright County, 2016)
Tile/Ditch (Wright County, 11/21/2016)
Parcels (Wright County, 2/4/2016)
Lakes (MN DNR, July, 2008)
Major Stream (MN DNR, July 2008)
Counties (MN DNR, July 2013)
PLSS (MnGeo/USGS)

N W E S

0 750 1,500 3,000 Feet

1 inch = 3,000 feet





Storage Map

County Ditch No. 10

Wright County, Minnesota

Tuesday, January 09, 2018

Legend

- Watershed Boundary
- CD 10 OPEN DITCH
- Wetland Restoration
- Wetland Enhancement
- Storage Treatment
- PWI Basins
- DNR State Easement
- NWI
- Township, Range
- Sections

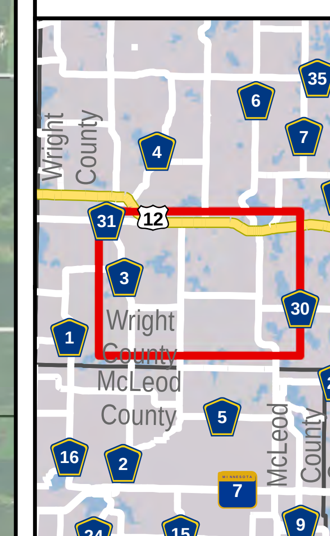
PN: 17-20449

Source:

Orthophotograph (Wright County, 2016)
Tile/Ditch (Wright County, 11/21/2016)
Parcels (Wright County, 2/4/2016)
Lakes (MN DNR, July, 2008)
Major Stream (MN DNR, July 2008)
Counties (MN DNR, July 2013)
PLSS (MnGeo/USGS)

0 750 1,500 3,000 Feet

1 inch = 3,000 feet



Wetland Enhancement

Site	Location	Main/Branch	Watershed Area (acre)	Area (acre)	Storage Volume (acre-ft)	Peak Flow Reduction	Potential Sediment Capture (tons/year)	Potential Nutrient reduction	Cost	Priority
1	Section 20,29 Victor Township	Hempel	1,766	45.9	47	23%	593	30%	$ 50,400.00	4
2	Section 8,17 Victor Township	Eddy	184	54.6	14	26%	82	20%	$ 52,800.00	2
3	Section 8, 17 Victor Township	Tuey	1,940	91.0	63	20%	543	35%	$ 62,400.00	5
4	Section 1 Stockholm Township	Hess	465	57	59	13%	158	25%	$ 61,200.00	3
5	Section 11,12,12,14 Stockholm Township	Main	8054	425	213	20%	2694	35%	$ 152,400.00	1

Storage Treatment

Site	Location	Main/Branch	Watershed Area (acre)	Area (acre)	Storage Volume (acre-ft)	Peak Flow Reduction	Potential Sediment Capture (tons/year)	Potential Nutrient Reduction	Cost	Priority
1	Section 7, 18 Victor Township	Main	8,915	8	31	20-25%	1805	10-20%	$ 236,000.00	2
2	Section 17, 18 Victor Township	Main	9,850	16	64	5-15%	2110	5-20%	$ 168,000.00	3
3	Section 15 Victor Township	Main	14,130	19	56	15-20%	3205	20-30%	$ 400,000.00	1
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5	Section 5 Victor Township	Gilmer	325	3	9	20-30%	160	20-40%	$ 90,000.00	5