Innovative Wastewater Treatment Concept Report



Prepared for

Door County
Soil and Water Conservation Department
Government Center-3rd Floor
421 Nebraska Street
Sturgeon Bay, WI 54235

Prepared by

TRC Environmental Corporation
150 Patrick Boulevard, Suite 150
Brookfield, WI 53045

in cooperation with

Natural Water Solutions LLC
PO BOX 65
Cedarburg, WI 53012

Innovative Wastewater Treatment Concept Plan

Door County Soil and Water Conservation Department

Government Center – 3rd Floor
421 Nebraska Street
Sturgeon Bay, WI 54235

December 2014

John B. Ferris, PE, PH
Senior Water Resource Engineer

David Flowers, PE, BCEE
Professional Engineer

Ginny Plumeau, REM
Senior Ecologist

Ron A. Londré, PWS
Senior Ecologist

150 NORTH PATRICK BLVD, SUITE 180, BROOKFIELD, WI 53045, • 262.212.7013 PHONE • 262.879.1220 FAX
• WWW.TRCSOLUTIONS.COM

Contents

APPENDICES

1.0 PROJECT BACKGROUND

The Door County Soil and Water Conservation Department (SWCD) retained TRC Environmental Corporation (TRC) and its teaming partner Natural Water Solutions, LLC (NWS) to conceptualize a plan for a passive treatment system to help reduce phosphorous in the discharge waters from the Sevastopol Sanitary District's Secondary treatment pond. Stakeholders included the Sevastopol Sanitary District and the Sevastopol School District.

The TRC project team comprised of Ginny Plumeau, REM, senior ecologist; Ron Londré, PWS, wetland ecologist; John Ferris, P.E., P.H., stormwater engineer; and Dave Flowers, P.E., a professional wastewater engineer from NWS.

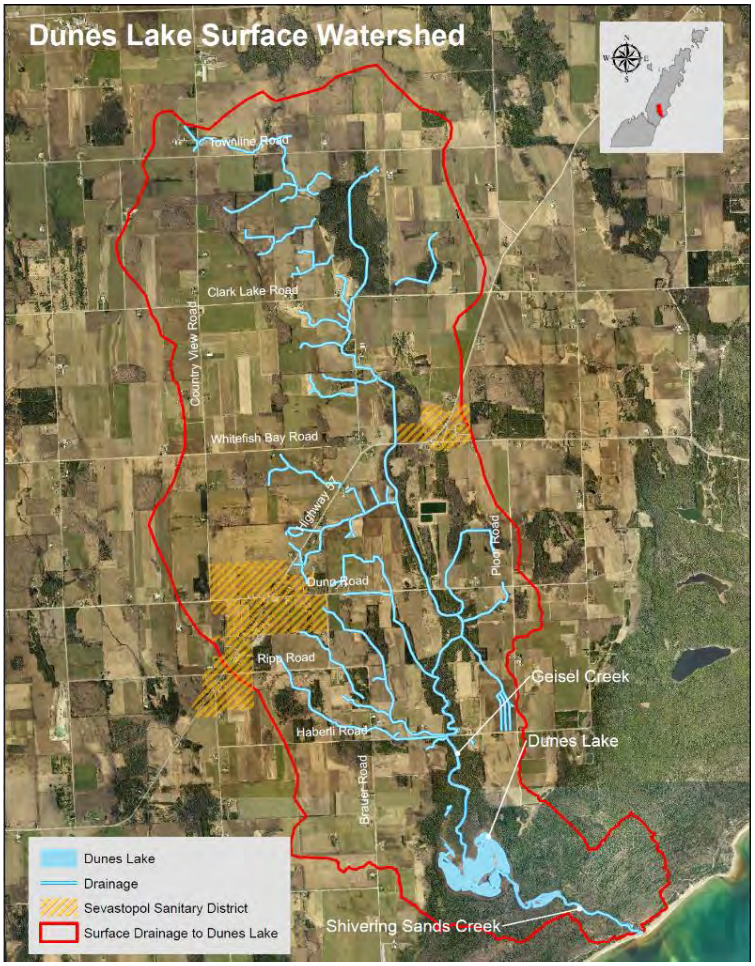
Figure 1
Sevastopol Sanitary District's Secondary Treatment Pond

The objective of the plan was to identify potential passive treatment technologies that could help reduce the nutrient loads that are discharged from the Sevastopol Sanitary District lagoons (Figure 1) to Giesel Creek and Dunes Lake. The report of Water Quality Evaluation and Planning for the Dunes Lake Watershed (2012) provided important background regarding the setting for the project. In the report, it is estimated that the lagoons contribute approximately one (1) percent of the annual water entering Dunes Lake and approximately 23 percent of the annual phosphorus load into Dunes Lake.

In order to identify potential passive treatment technologies that could help reduce the nutrient loads that are discharged from the lagoons, treatment options that were to be evaluated included filtration and/or infiltration, phytoremediation, nutrient recycling and other innovative, low maintenance technologies.

The site available for the placement of a prospective passive treatment system is located on two parcels (parcels 022 0318282731A and 022 0318282734A) totaling 71.46 acres southwest of the Sevastopol lagoons (Figure 2). The parcels are owned by the Sevastopol School District. The site is within the Dunes Lake Surface Watershed, as shown in the Figure below.

Figure 2
Sevastopol Sanitary District Service Area within the Dunes Lake Surface Watershed



Source: Water Quality Evaluation and Planning for the Dunes Lake Watershed, Door County Wisconsin 2008-2012

Key features of the treatment system concept planning process included:

1. Developing an approach that would reduce phosphorus loads to Geisel Creek and Dunes Lake utilizing three potential treatment system options: a single enclosed treatment system for the pond discharge waters; the use of a system that disperses the discharge waters through existing surface; and a hybrid (combination) system.
2. Extending the timeframe for seasonal discharge from the lagoon system to a longer period of time to help reduce leakage from the lagoon and to increase the treatment capacity of the total system.
3. Evaluating ways to minimize the operations and maintenance (O&M) requirements of the system.

The concept plan was developed to provide the Sevastopol Sanitary District and Door County with technical support and documentation. The plan may be utilized to help secure grant funding to design and/or implement the system. Additionally, since the land available for the treatment system is located on Sevastopol School District property, implementing the system could potentially provide educational opportunities on watershed protection, water budgets, nutrient cycles and the role of native vegetation in treating wastewater.

2.0 PROJECT APPROACH

The TRC team conducted an initial evaluation of the proposed setting, as well as a review of available resources that described area soils, drainage, sensitive resources, and topography.

Key baseline factors considered in developing the preliminary concepts included:

1. Identification of the available area for the treatment cell(s).
2. Review of the chemistry of the effluent discharged from the lagoon system for establishing additional treatment that could be achieved by use of an adjunct passive treatment system.
3. Estimation of the potential size of the passive treatment system based on the hydrologic effluent loading.

Based on the findings, three preliminary concepts were developed and presented to Door County, the Sevastopol Sanitary District, and the Wisconsin Department of Natural Resources (WDNR). Selecting the best concept plan for this application was developed with input from stakeholders (Door County Soil and Water Conservation Department (SWCD), Sevastopol Sanitary District and the WDNR).

The TRC Team conducted a concept plan meeting October 20, 2014. The meeting explained the concepts/alternatives and obtained feedback from the project stakeholders. In attendance were the Door County SWCD, the Sevastopol Sanitary District, and the Wisconsin Department of Natural Resources. Appendix C contains copies of the prepared presentation slides.

Other factors evaluated with the Team and discussed with stakeholders included:

- Dosing option or continuous input to the treatment system;
- Seasonality of the discharge to the treatment cell;

- Assessment as to whether there is sufficient carbon to drive nutrient breakdown;
- Surface or groundwater discharge from the treatment cell(s);
- Nutrient harvesting of biomass or adsorbent media;
- Permitting opportunities and hurdles of the alternatives;
- Operations and maintenance considerations; and,
- Cost of construction and maintenance.

Consideration was given to both groundwater and surface water discharge options. Based on evaluation and discussion, a phyto-trench treatment system was selected for further concept planning.

The following sections provide additional project background regarding the current operation of the lagoon system, findings during a field review, and discussion of the concept plan alternatives and assumptions.

3.0 SEVASTOPOL WASTEWATER LAGOONS

SEVASTOPOL SANITARY DISTRICT

The Sevastopol Sanitary District serves the communities of Valmy and Institute as well as Sevastopol High School. The sanitary district is located in the upper end of the Dunes Lake watershed (Figure 1). The district's treatment system is composed of two open ponds (facultative lagoons) connected in series by a pipe with a control valve. The pond system achieves secondary treatment through physical settling and natural bioremediation.

Treated wastewater in the south lagoon is discharged to Geisel Creek through a 10-inch pipe two to three times each year, normally in May, June, and November. A November discharge is avoided, if possible, at the request of Door County.

3.1 CURRENT OPERATIONS

A summary of the wastewater facility operation is summarized here and was taken from information reported in a Memorandum from the Wisconsin Department of Natural Resources, dated May 7, 2008, *Water Quality-Based Effluent Limitations for the Sevastopol SD #1 WPDES Permit No. WI-0026654*.

The Sevastopol Sanitary District's wastewater lagoon was designed for an average daily inflow of 0.078 million gallons per day (MGD). Between 2005 and 2007, the average inflow into the treatment facility was 0.0225 MGD, which was less than 30 percent of its design capacity. The district only discharges a few weeks in the spring and fall. Effluent discharge rates range from 0.195 MGD to 0.365 MGD. The district's current permit limits the effluent discharge rate to a maximum of 0.468 MGD.

Table 1 compiles the volume of the annual influent and effluent for the facility and sourced from the Compliance Maintenance Annual Reports covering years 2005 through 2013.

Table 1 Reported Annual Effluent Discharge Compliance Maintenance Annual Report		
Year	Inflow (MG/yr)	Discharge (MG/yr)
2005 (max)	NM	9.172
2006	7.982	7.1551
2007	8.1431	6.93
2008	NM	7.009
2009	8.208	5.816
2010	8.021	6.7475
2011	8.0	6.6186
2012 (min)	7.7	2.205
2013	7.749	4.918
NM: Influent not metered max: year with highest reported discharge min: year with lowest reported discharge		

3.2 EFFLUENT WATER QUALITY STANDARDS

The water quality limits of the Sevastopol Sanitary District discharge permit are summarized in Table 2 below. Discharges of less than 150 lbs/month of phosphorus from municipal wastewater treatment facilities (Wisconsin Administrative Code, ch. NR 217) are currently not regulated. Therefore, there are no limits set on the amount of phosphorus that can now be discharged from the Sevastopol Sanitary District lagoons.

Table 2 Permit Discharge Limits for the Sevastopol Sanitary District					
Parameter	Daily Maximum	Daily Minimum	Weekly Average (mg/L)	Monthly Average (mg/L)	Monitoring Only
Flow Rate	0.468 MGD				
BOD_5			30	20	
TSS			30	20	
pH	9.0	6.0			
Dissolved Oxygen		4.0 mg/L			
Ammonia Nitrogen					X
Chloride					X

However, the State of Wisconsin phosphorus standard, recently adopted by the Wisconsin DNR, sets the limit for phosphorus discharges to streams, such as Geisel Creek, at 0.075 mg/L (NR 102.06(3)(b), NR 102.06(4)(c)) and 0.040 mg/L for discharges to lakes, such as Dunes Lake (NR 102.06(4)(b)(3), NR 102.06(4)(b)(5)) and 0.007 mg/L (NR 102.06(5)(b)) for Lake Michigan.

It should be noted that adding additional treatment system components could require new or amended permits which could update phosphorus discharge limits, therefore, the TRC team evaluated the reported phosphorus concentration from effluent samples of the existing system (summarized below).

3.3 PHOSPHORUS DISCHARGE CONCENTRATION

Effluent samples from the wastewater lagoon listed in WPDES permit reports between 2008 and 2010 ranged from 0.75 and 1.8 mg/L for an average of 1.23 mg/L (Table 3).

Table 3
Lagoon Effluent Samples - WPDES Permit Reports

Date	Phosphorus (mg/L)
5/2008	1.80
5/2009	0.75
11/2009	1.11
4/2010	1.26

Source: Water Quality Evaluation and Planning for the Dunes Lake Watershed, Door County Wisconsin 2008-2012

In a 2011 report prepared by Scott K. Johnson, the phosphorus concentration from an effluent sample in April 2010 was 1.6 mg/L (Table 4).

Table 4
Lagoons Effluent Samples

Date	Phosphorus (mg/L)
4/2010	1.6

Source: Scott K. Johnson, 2011, January, Groundwater Nutrient Contribution To Dunes Lake, Door County, Wisconsin

Effluent water quality samples collected by Earth Tech in May 2008 averaged 1.8 mg/L (Table 5, below). In an email from Jeffery Hack (WDNR) dated May 18, 2008 to Richard Sachs and Kincaid, both from the WDNR, Hack implied that the 2002 phosphorus data estimated the phosphorus concentration to be 2.2 mg/L.

Table 5 Lagoons Effluent Samples WPDES Permit Reports	
Date	**Phosphorus (mg/L)**
5/11/2008	1.75
5/14/2008	1.86
5/16/2008	1.79
Source: Hack, Jeffery, 2008, May 18 email to Richard Sachs, re: Sevastopol SD Phosphorus Effluent Data	

4.0 FIELD REVIEW

To assess the potential feasibility of placement of a treatment system, the TRC team conducted an initial evaluation of the proposed setting, as well as a review of available resources that described area soils, drainage, sensitive resources, and topography. A background review of available map resources and a brief site visit to evaluate the potential presence of regulated natural resources, including wetlands, floodplains, and groundwater was conducted to identify potential site constraints. Findings are summarized below.

The topography of the site was taken from the Door County GIS digital terrain model (DTM). From the County's DTM, a 0.5 ft. contour map was developed (Appendix A). Soils to the east and west of the old farm field are characterized as hydric soils. Soils in the old farm field are Emmet sandy loam, with a hydrologic soils classification with a moderate infiltration rate. Soil characteristics for the project area were obtained from the NRCS Web Soil Survey (reference Appendix B; http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm).

The TRC Team conducted a brief field reconnaissance of the proposed project area. Historical aerial photographs (source: Google Earth) indicated that agriculture operations on the property had occurred, but ceased between 1992 and 2005. The site is currently comprised of a blend of planted white cedar groves, small isolated sedge meadows and pockets of prairie plant communities, characteristic of "old field" conditions. The previously farmed field gradually slopes from the north to the south and more steeply east to a forested wetland, and west to a forested wetland and Geisel Creek.

A man-made, shallow ephemeral ditch was observed to run the length of the field from north to south. Standing water and moist soils were noted in portions of the ditch, ATV trail ruts, and shallow depressions. Sedges and other hydrophytic vegetation were noted in areas of standing water or moist soils.

Findings indicated that wetlands and a potentially high ground water table are likely present in portions of the site. For purposes of developing a final design of a treatment system in the future, a wetland delineation, conducted in accordance with current regulatory methods, should be performed to delineate the location and extent of wetlands within the project area. The depth to ground water should be evaluated in the proposed location of the treatment system. To evaluate the potential presence of local endangered resources, if any, a review request should be submitted to the Wisconsin Department of Natural Resources.

5.0 CONCEPT PLANNING - ASSUMPTIONS

The TRC team, in commencing the planning process, identified some baseline assumptions, as set forth below.

5.1 ASSUMED AVAILABLE AREA

Based on available mapping and the site reconnaissance, the maximum land area that is potentially be available for a passive system was estimated to be approximately three (3) acres (Figure 3).

Figure 3

Approximate Area Available for Construction of a Passive Treatment System

5.2 ASSUMED DAILY DISCHARGE ALTERNATIVES

Annual effluent discharge reported in the Compliance Maintenance Annual Reports between 2005 through 2013 indicated that the volume of effluent discharged annually is typically in the range of six (6) to seven (7) million gallons (MG) per year. The wettest year was 2005 (9.2 MG) and the driest year 2012 (2.2 MG).

Effluent discharge records were used to size the passive system to take into account the total water budget of the system that includes rainfall, evaporation and seepage. For planning purposes, the design flow was assumed to be based on the reported wettest year from 2005, plus 25%. This brought the design annual effluent discharge from 9.2 MG to 11.5 MG.

The time duration over which effluent is discharged determines the area over which the passive system would be constructed (its size). Three discharge scenarios were considered. A 30 day discharge approximates the current discharge rate to Geisel Creek. Discharging the total annual volume of effluent over a 90 day period represents the peak growing period. Finally, it was assumed that maximum duration over which effluent could be discharged was 180 days.

The design flows through each of these scenarios is summarized in Table 6.

Table 6
Approximate Sizing for the Subsurface Gravel Wetland Alternative

Discharge Scenario	Average Daily Effluent Discharge	Depth of Equivalent Water Application
30 Day Discharge (current operation)	382,200 gpd	4.7 in
90 Day Discharge (peak growing season)	127,400 gpd	1.6 in
180 Day Discharge (max growing season)	63,700 gpd	0.8 in

A passive treatment system is similar to that of an irrigation system. Plants have limited ability to take up and metabolize water and nutrients. Therefore, the average daily effluent discharge was viewed as an average daily application of a depth of water over the assumed area available for constructing the passive treatment system (3 ac). The average depth of water applied over the approximate area available on a daily based ranged from 4.7 inches to 0.8 inches (Table 6)

5.3 Assumed Effluent Water Quality

The various sources of phosphorus data for the Sevastopol Sanitary District lagoon effluent discharge is summarized in section 4.4 of this report and ranges from 1.23 mg/L to 2.2 mg/L. For planning and sizing of the passive treatment system the phosphorus concentration of the effluent was assumed to be 2 mg/L.

6.0 USE OF PLANTS IN PASSIVE TREATMENT SYSTEMS

6.1 Vegetation Phosphorous Uptake

Research has demonstrated that vegetated systems are more effective at phosphorous removal than unvegetated systems (Fraser et al. 2003). In an experiment conducted by Adegbidi et al. (2000) on nutrient removal by willow (*Salix spp.*) trees showed that 1.7 to 12.6 kg/ha (0.017 to 0.126 mg/cm^2) of phosphorus was removed annually by willows, depending on levels of phosphorous and density of plantings.

Monitoring of treatment wetlands planted with herbaceous plants, used to treat dairy wastewater, demonstrated that plant uptake was variable, with phosphorous removal ranging from 3 to 60 percent (Tanner et al., 1995). Experiments on full scale wetlands measured an uptake of phosphorus by plants of 8 percent (Tanner, 2001a).

Table 7 (below) summarizes research completed on the phosphorus uptake for a selection of agricultural crops and trees. The highest phosphorus concentration was reported for the Tame Hay and Wild Hay (0.17 mg/cm^2). The average of the remaining herbaceous crops was approximately 0.03 mg/cm^2. The average phosphorus concentration of the woody plants (trees) in Table 7 was estimated to be 0.03 mg/cm^2.

Herbaceous crops in Table 7 have similar plant structure as the native plants that would be part of the passive treatment systems. Therefore, the phosphorus yield from the passive treatment system was assumed to be 0.03 mg/cm^2, similar to the remaining herbaceous crops and woody plants in Table 7.

Assuming the plants of the passive treatment take up 0.03 mg/cm^2 annually, and this is the only method of removing phosphorus, the treatment system would require approximately 70 acres of vegetation. In successful passive treatment systems, vegetation uptake of phosphorus represents approximately 6 to 10 percent of the total phosphorus removal by harvesting biomass.

Other phosphorus uptake mechanisms by passive treatment systems include uptake in the root system of the vegetation, the sorption of phosphorus by the aggregate and soil of the system, the absorption of phosphorus by a microbiotic film that will grow on the aggregate, and the chemical precipitation of phosphorus.

Table 7

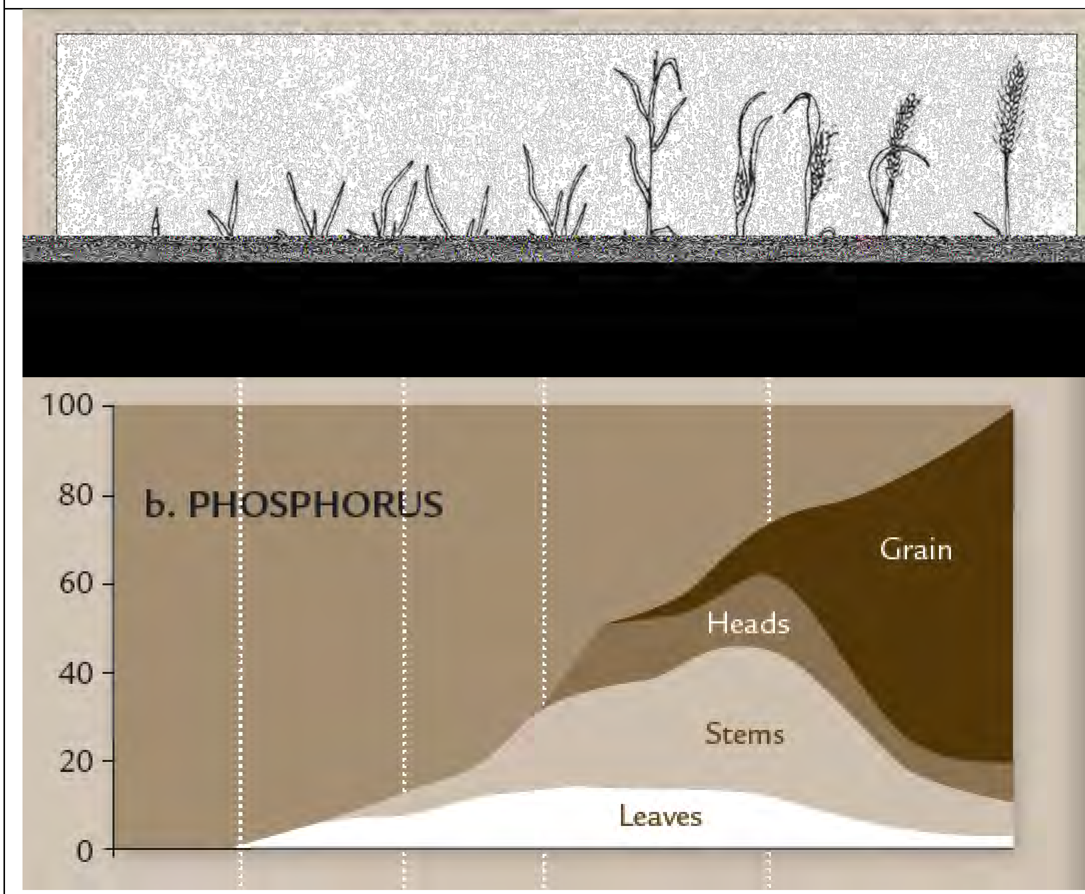
Phosphorus Concentration in Harvested Biomass

Herbaceous		**Trees**	
Crop	**Phosphorus Yield (mg/cm^2)**	**Crop**	**Phosphorus Yield (mg/cm^2)**
Field Corn for Silage	0.01	Birch spp.	0.006
Sorghums for Silage	0.03	Douglas fir	0.053
Alfalfa Hay	0.05	European beech	0.022
Small Grain Hay	0.05	Maple spp	0.059
Other Tame Hay	0.17	Oak spp	0.026
Wild Hay	0.17	Pine spp.	0.008
Grass Silage	0.02	Red Alder	0.101
Salt Hay	0.02	Spruce spp.	0.011
Sorghum Hay	0.01	Yellow poplar	0.009
Charles H. Lander, David Moffitt and Klaus Alt (retired). February 1998. Appendix I, Nutrients Available from Livestock Manure Relative to Crop Growth Requirements U.S. Department of Agriculture, Natural Resources Conservation Service Resource Assessment and Strategic Planning Working Paper 98-1.		Ducnuigeen, J., Williard, K., and Steiner, R.C.. September 1997. Relative Nutrient Requirements of Plants Suitable for Riparian Vegetated Buffer Strips. Virginia Department of Environmental Quality. ICPRB Report Number 97 – 4.	

6.2 TIMING OF PHOSPHORUS UPTAKE

Data compiled by Olson-Rutz and Dinkins (2011) showed the shift in the uptake of phosphorus in various parts of cereal grains throughout the growing season (Figure 4 and Appendix C, Slide 4). Phosphorus in plant biomass typically peaks right as the seed head begins to develop. Phosphorus shifts to the seed heads as the grain matures.

Figure 4
Phosphorus Uptake by Plants Over a Typical Growing Season



Jones, C., Olson-Rutz, K., Dinkins,. C. June 2011. Nutrient Uptake Timing by Crops to assist with fertilizing decisions. Montana State University Extension.

In a passive treatment system, it is expected that the plants will be harvested on a semi-regular basis to optimize phosphorous removal. Recent studies suggest that, depending on the type of vegetation used, as much as a six (6) percent improvement in phosphorous removal can be obtained by harvesting plants (Stottmeister et al. 2013, Toet et al. 2005). The results of a study by Adegbidi et al. (2000) showed that harvesting willows on a 1-year cycle resulted in the highest annual removal of nutrients. In contrast, harvesting on a 3-year rotation resulted in lower rates of nutrient removal.

6.3 Native Plant Use and Selection

The use of native plants, shrubs and trees to facilitate phyto treatment and nutrient handling of discharge waters was evaluated by TRC for the development of a potential treatment system. Based on locally available native plants sources, professional experience with similar systems, and on empirical evidence from a variety of studies (Adegbidi et al. 2001, Brisson and Chazarenc 2009, Fraser et al. 2004, Picard et al. 2005, Kadlec et al. 2008, Tanner 2001, Tanner 1996), TRC developed a list of native plants that could potentially be used in the treatment system.

Native plants selected were identified as those that could optimize the uptake of nutrients. Plant selection was also based on a consideration of minimizing long-term operating and maintenance needs. In addition, the stakeholders expressed an interest in having a selection of plants that could have potential beneficial reuses, therefore, specific woody shrubs were included in the lists. The woody shrubs included in Table 8 below have beneficial reuse potential. It should be noted that harvestable grasses were evaluated but the use of tractor harvesting is not feasible with the proposed system.

Red osier dogwood (*Cornus alba*) and Silky dogwood (*Cornus obliqua*) have showy red bark and are commonly used for winter holiday decorative arrangements. These dogwoods can be harvested in the late fall by cutting just above the lowest branch or a few inches above the soil surface, making sure to leave some stems for regrowth of the plant. Pussy willow (*Salix discolor*) is commonly used in floral arrangements. The shoots of the pussy willow shrub can be harvested in spring after the fuzzy buds have developed. The shoots can be harvested by cutting just above an existing branch to allow for regrowth.

All of the woody shrubs can be used for ecological restoration projects, particularly sandbar willow (*Salix discolor*) due to its hearty and aggressive growth habits. These shrubs can serve as a source for what are called “live stakes”. Live stakes are commonly used in wetland and shoreline restoration projects. Live stakes can be cut from readily-sprouting shrubs while they are dormant in the early spring. Typically the branch cuttings are 2 to 3 feet long with a diameter of about ½-inch to 1-inch. The top of the cutting would be cut flat and the bottom would be cut at a diagonal to make for easier installation.

Lists of recommended species for the phyto-trench system is provided below.

- Table 8 presents recommended native woody shrubs that would be located in the trenches and wherever there could be saturated soils resulting from discharge waters.
- Table 9 lists recommended native herbaceous plants that could be located within the trenches and zones where saturation reaches near the soil surface and remains near the soil surface for approximately 75% of the growing season.
- Table 10 provides a list of recommended native herbaceous plants that would be located in areas saturated 25 to 75 percent of the growing season.

Table 8 Woody Shrubs	
Scientific Name	**Common Name**
Cornus alba	red osier dogwood
Cornus obliqua	silky dogwood
Salix interior	sandbar willow
Salix discolor	pussy willow

Table 9 Recommended Native Herbaceous Plants Within The Saturated Trenches	
Scientific Name	**Common Name**
Aster puniceus	swamp aster
Calamagrostis canadensis	blue joint grass
Carex bebbii	Bebb's oval sedge
Carex bicknellii	copper-shouldered oval sedge
Carex comosa	bristly sedge
Carex crinita	fringed sedge
Carex hystericina	porcupine sedge
Carex lacustris	lake sedge
Carex sprengelii	long-beaked sedge
Carex stipata	common fox sedge
Carex stricta	tussock sedge
Carex vulpinoidea	brown fox sedge
Elymus virginicus	Virginia wild rye
Juncus dudleyi	Dudley's rush
Juncus tenuis	path rush
Juncus torreyi	Torrey's rush
Liatris spicata	marsh blazing star
Mimulus ringens	monkey flower
Leersia oryzoides	rice cut grass
Scirpus acutus	hard-stem bulrush
Scirpus atrovirens	dark-green bulrush
Scirpus validus	great bulrush
Spartina pectinata	prairie cordgrass
Acorus calamus	sweet flag
Iris virginiana	blue flag iris
Asclepias incarnata	marsh milkweed

Table 10 Recommended Native Herbaceous Plants In Zones Saturated 25 To 75 Percent Of The Growing Season	
Scientific Name	**Common Name**
Anemone canadensis	Meadow anemone
Asclepias incarnata	Marsh milkweed
Aster novae-angliae	New England aster
Aster puniceus	swamp aster
Calamagrostis Canadensis	blue joint grass
Carex bebbii	Bebb's oval sedge
Carex bicknellii	copper-shouldered oval sedge
Carex comosa	bristly sedge
Carex crinita	fringed sedge
Carex hystericina	porcupine sedge
Carex lacustris	lake sedge
Carex sprengelii	Long-beaked sedge
Carex stipata	common fox sedge
Carex stricta	tussock sedge
Carex vulpinoidea	brown fox sedge
Elymus virginicus	Virginia wild rye
Helenium autumnale	sneezeweed
Heliopsis helianthoides	early sunflower
Juncus dudleyi	Dudley's rush
Juncus tenuis	path rush
Juncus torreyi	Torrey's rush
Liatris spicata	marsh blazing star
Mimulus ringens	monkey flower
Panicum virgatum	switchgrass
Thalictrum dasycarpum	purple meadow rue
Verbena hastata	blue vervain
Vernonia faxciculata	ironweed

7.0 ALTERNATIVE PASSIVE DESIGN CONCEPTS

The TRC team evaluated the pros and cons of three potential alternative concepts for a treatment system. These systems included a subsurface flow gravel wetland, a phyto-treatment trench, and a hybrid of the two concepts that integrated the subsurface flow gravel wetland and phyto-treatment trench components.

7.1 SUBSURFACE GRAVEL WETLAND ALTERNATIVE

The cross section of a subsurface gravel wetland consists of an excavation lined with a geotextile covered by one to two feet of open graded gravel. Covering the gravel is typically 10 or more inches of soil within which select vegetation can thrive in the unique hydrologic loading of the treatment system.

As water passes horizontally through the gravel layer (reference Appendix C, Slides 6 and 10), the treatment system consumes carbon, measured by the concentration of BOD_5, to reduce nitrogen concentrations through the processes of nitrification (the oxidation of ammonia) and denitrification (reducing nitrates or nitrites to nitrogen-containing gases). Based on the TRC team experience, gravel wetlands reduce nitrogen. Based on monitoring of systems built by David Flowers, Natural Water Solutions, the gravel wetlands typically reduced nitrogen levels by 50 to 85 percent. At the same time, microbes are converting organic phosphorus to soluble orthophosphate (PO_4^{3-}). For a period of one or two years after a subsurface gravel wetland comes on line, wetland plants and microbes grow rapidly and consume most of the orthophosphate. In addition, the orthophosphate will adsorb onto the gravel and soil particles. In treatment systems of raw wastewater the almost total adsorption of phosphorus typically lasts two to three years. After that time, the system becomes saturated and experiences what is called "breakthrough". Once "breakthrough" occurs, orthophosphate begins to appear in the effluent of the system. The time that "breakthrough" occurs for a system treating "cleaned" effluent should be longer than that of a wastewater system.

Sizing the subsurface gravel wetland utilized the design equations that have been successfully used to engineer subsurface flow (gravel wetlands) treatment systems that are designed for the treatment of wastewater. The equations are based on the kinetics of the reactions to reduce the level of BOD_5 to acceptable standards. The spreadsheet that was used to estimate the size of the treatment system was developed by David Flowers of Natural Water Solutions of the TRC Team. The spreadsheet is a slightly modified approach recommended by the US EPA in their manual titled "Constructed Wetlands Treatment of Municipal Wastewaters," EPA/625/R-99/010, dated September 2000.

Sizing of the treatment facility is a function of 1) the hydrologic load, 2) the pollutant load and 3) the pollutant reduction target. Utilizing the results of the spreadsheet sizing model a subsurface gravel wetland for the three effluent discharge scenarios are summarized in Table 11. Slides 7, 8 and 9 (Appendix C) delineate the conceptual footprint of the treatment system.

Table 11 Estimated Size of Subsurface Gravel Wetland for 3 Flow Scenarios		
Discharge Scenario	**Average Daily Effluent Discharge**	**Estimated Size of Subsurface Grave Wetland**
30 Day Discharge	382,200 gpd	3.0 ac
90 Day Discharge	127,400 gpd	1.0 ac
180 Day Discharge	63,700 gpd	0.5 ac

There are a number of products on the market that could be used to target the adsorption of phosphorus and extend the treatment capability of the gravel wetland after "breakthrough" occurs. Three products often considered are shown in Table 12. Other materials that have been evaluated and have shown some success include dolomite and crushed concrete.

The TRC team recommends that a design of a subsurface gravel wetland accommodate a portion of the system that would contain materials that can absorb phosphorus and can be periodically replaced with fresh adsorptive material, either at the time of construction or at a time when the treatment system is starting to experience "breakthrough."

Table 12 Product Characteristics of Phosphorus Adsorptive Material	
Product	**Manufacture**
Sorbtive™ Media	Imbrium, MD
ACT MX®	ESFILTER™ , UT
Expanded Clay (Haydite)	Hydraulic Press Brick Company, IN

Though Slides 7, 8 and 9 indicate a single cell of increasing dimensions, the treatment system could be one (1), two (2) cells or more to allow construction over multiple years or to avoid impacts to protected wetlands (Slide 19). Advantages and disadvantages of the subsurface grave wetland alternative are summarized in Table 13 (Slide 12).

Table 13 Advantages and Disadvantages of a Subsurface Gravel Wetland	
Pros	**Cons**
• Reduced Discharge Rate	• Highest Potential for Unfavorable Wetland Impacts
• Reduction of P Loads	– Permitting & Mitigation ($70,000/ac)
• SGW Equalize Lagoon Upsets	• Requires Secondary P Uptake Practice
• Enclosed Treatment System	• Cost of Annual Harvesting
• Expanded Clay or Other Sorption Media for Polishing	• Requires Discharge Pipe
• Reduced Discharge Rate	• Water/Sediment Trapped in Existing 10” Pipe
	• Highest Cost Option

Its greatest advantage is that a subsurface gravel wetland could augment the treatment of the lagoon effluent should adverse conditions cause a disruption in the normally high level of treatment. This would result in a greater confidence that the system would meet the performance requirements of the permit and the phosphorus reduction goals for Dunes Lake. The greatest disadvantage of this alternative would be a construction cost which would most likely be increased by wetland permitting/mitigation costs.

7.2 PHYTO-TREATMENT TRENCH ALTERNATIVE

A phyto-treatment trench system distributes water similarly to an irrigation system. It relies more on existing vegetation than on a planted vegetated treatment cover, in contrast to the subsurface gravel wetland. There is a main transmission trench which feeds smaller distribution trenches, utilizing existing native vegetation within the project area.

Slide 13 (Appendix C) depicts a conceptual plan view of a phyto-treatment trench system where the transmission and distribution trenches are straight. In practice there may be more than one transmission trench and the trenches will likely be curved to avoid/minimize impacting wetlands.

Slide 15 illustrates the conceptual cross section of the transmission and distribution trenches. The water resistant geotextile lining of the transmission trench extends partially up the sides of the trench to prevent infiltration and enable planted vegetation above and native vegetation adjacent to the trench to take up the remaining nutrients in the effluent. Distribution trenches are smaller and shallower. The liner covers the bottom of the trench to serve as a separation barrier to the groundwater and to prevent infiltration. Harvesting native and planted biomass is often part of this strategy to enhance phosphorus removal.

Advantages and disadvantages of the phyto-treatment trench alternative are summarized in Table 14 (Appendix C, Slide 16).

Table 14 Advantages and Disadvantages of a Phyto-Treatment Trench	
Pros	**Cons**
• Lowest Cost Option	• Wetland Impacts • Permitting & Mitigation ($70,000/ac)
• Reduced Discharge Rate	• Performance Monitoring Difficult
• Reduction of P Discharge to Dunes Lake	• Cost of Annual Harvesting (O&M)
Multi-P Uptake Mechanisms – Vegetation – Soil – Microbial Film (benthos) – Adsorption on Aggregate	• Treatment Rate limited by Vegetation Uptake, thus the lower the pond discharge rate, the better.
• More Flexible Footprint than SGW to Avoid Wetland Impacts	• Potential Impact to Adjacent Habitats

This alternative makes use of the adsorptive and uptake ability of the native soils and vegetation respectively. It results in the lowest likely cost to construct and maintain of the three alternative systems. The greatest disadvantage of this alternative is that the additional effluent loading might result in a shift in the existing vegetated communities toward conditions that favor competition by invasive species.

7.3 HYBRID ALTERNATIVE

The hybrid alternative combines smaller portions of the previous two alternatives. The hybrid alternative (subsurface gravel wetland / phyto-treatment trench) would be designed to provide partial treatment of the effluent to compensate for possible variation in the water quality of the effluent from the lagoon. As a result, only a portion of the linear feet of phyto-treatment trenches would be required. Advantages and disadvantages of the hybrid alternative are summarized in Table 15 (Appendix C, Slide 18).

The greatest advantage of this alternative is its ability to minimize wetland impacts, since the subsurface gravel wetland cell would be smaller and constructed in a portion of the site that contains the fewest isolated wetlands and the excavation for the phyto-trench would not need to extend as far into the project area.

The greatest disadvantage of this alternative is that of life-cycle costs which would be expected to be less than the subsurface gravel wetland, but more than the phyto-trench alternatives.

Table 15 Advantages and Disadvantages of a Hybrid Subsurface Gravel Wetland / Phyto-Treatment Trench	
Pros	**Cons**
• Reduced Discharge Rate	• Less Reliance on Biological Phosphorous Uptake
• Reduction of P Discharge	• Operation/Maintenance
• SGW Equalize Lagoon Upsets	• Middle Cost Option
• Good Initial Filter Treatment Bed	
• Potentially Best Option to Avoid Wetland Impacts	
• Less Permitting	

8.0 PRELIMINARY DESIGN CRITERIA WITH COST ESTIMATES

Based on input from Door County and the stakeholders, the phyto-trench alternative was selected as the innovative wastewater, passive treatment system for the intended application.

8.1 CONCEPT DESIGN

Sizing the phyto-treatment trench system utilized the design equations that have been successfully used to engineer subsurface flow (gravel wetlands) treatment systems that are designed for the treatment of wastewater. The equations are based on the kinetics of the reactions to reduce the level of BOD_5 to acceptable standards and to determine the hydraulic conveyance of water through the gravel media. As stated above, BOD_5 is the "food" needed to drive the processes that will reduce nitrogen concentrations and convert phosphorus to its soluble form. The methods used are a slightly modified approach recommended by the US EPA in their manual titled "Constructed Wetlands Treatment of Municipal Wastewaters," EPA/625/R-99/010, dated September 2000.

Slide 13 of the October 20, 2014 presentation depicts a close approximation of the size of the phyto-trench that will be required to achieve the maximum reduction in phosphorus, nitrogen, TSS, and BOD_5. Based on preliminary engineering calculations, we estimate that the phyto-trench system would comprise approximately 1,220 linear feet of a main transmission trench and an additional 900 linear feet of smaller distribution trenches, for a total of 2,120 linear feet of trenches (Appendix C, Slide 15). The transmission trench is estimated to be ten to fifteen feet wide (depending on location as it will be wider at the start and narrower at the end, and approximately 2.0 to 2.5 feet deep. The distribution trenches would be four feet wide and one foot deep. Internal weirs would be constructed periodically along the length of the trenches to maintain water levels and velocities throughout the system.

A diversion weir would be constructed in the existing manhole that is located midway along the existing 10-inch discharge pipe from the lagoons. The diversion weir would cause water levels in the discharge pipe to rise nearly to the ground surface, at which point the effluent from the lagoon system would overflow into the transmission trench.

Contractors would access the site from Pond Road. A temporary construction access road would be needed to allow excavating equipment and materials to access the site.

8.2 NUTRIENT REDUCTION

Nitrogen

Subsurface flow treatment systems, such as the recommended phyto-treatment trench system, are designed to consume nitrogen through the processes of nitrification (the oxidation of ammonium) and denitrification (reducing nitrates or nitrites to nitrogen-containing gases). As the treated effluent enters the trench, the remaining organic nutrients would be broken down by aerobic nitrifying microbes. Organic nitrogen is first converted to ammonium (NH_4^+) or ammonia (NH_3) by a process called hydrolysis. Ammonium is then quickly converted to nitrite nitrogen by nitrosomonas bacteria through the process of nitrification. Nitrite is then converted to nitrate nitrogen by nitrobacter bacteria.

Denitrification of nitrate (NO_3) to nitrogen gas (N_2) is accomplished by heterotrophic bacteria. These bacteria feed on carbon utilizing oxygen from the nitrate molecules. Denitrification requires anoxic (<0.3 mg/L O_2) conditions for the bacteria to break apart nitrate (NO_{3-}) to gain the oxygen (O_2) and nitrous oxide (N_2O) which in turn is converted to nitrogen gas (N_2).

Plants would also aid in nitrogen reduction via assimilation. Plants absorb nitrate or nitrite from the soil via their root hairs. If nitrate is absorbed, it is first reduced to nitrite ions and then ammonium ions for incorporation into amino acids, nucleic acids, and chlorophyll. In plants that have a symbiotic relationship with rhizobia, some nitrogen is assimilated in the form of ammonium ions directly in the root nodules. However, when the plants die, the organic form of nitrogen from the dead plant material is released and bacteria or fungi then convert the organic nitrogen back into ammonium, a process called mineralization. Therefore, harvesting the above ground biomass of plants will help to maximize the benefits plants could provide in nitrogen reduction.

Kadlec and Wallace (2008) reported average nitrogen concentration reductions for constructed subsurface flow wetlands to be approximately 54 percent. It is the experience of the gravel wetlands built and monitored by NWS that nitrogen levels are typically reduced by 50 to 85 percent.

The trench system will be comprised of aerobic, anoxic, and anaerobic zones, however it would have fewer zones of anoxic and anaerobic environments, relative to a treatment wetland receiving full strength wastewater. Under these circumstances, results will be less efficient denitrification. We would expect lower levels of BOD_5 that would be discharged to the trench system that would serve as a source of food (carbon) for the denitrifiers. This could decrease the efficiency of the system relative to the systems reported in the scientific literature and experienced by our team.

Finally, according to the Final Dunes Lake study, SSD discharge of Total Nitrogen is 6 mg/L. This is incredibly good N reduction for a two-cell facultative lagoon. This means that there is little nitrogen available to be treated. Therefore, we anticipate a lower percent reduction in nitrogen than what we report above from other project experiences and literature.

Based on the relatively low levels of Total N that would be discharged from the lagoons into the phyto-treatment trench system, the information set forth by available literature, assumption of some vegetation harvesting, and professional experience, we anticipate that the trench system could reduce the Total N by 1 to 2 mg/L for a total of 4 to 5 mg/L (16 – 33% reduction).

Phosphorous

The phyto-trench system is estimated to be able to remove up to approximately 23 percent of the phosphorous in the effluent discharged from the lagoons in the harvestable biomass alone. The phosphorous would be further reduced by the native soils and plants adjacent to the trench system to attain levels below 1.0 mg/L.

The process of phosphorus treatment is as follows: At the same time that nitrification and denitrification is occurring, microbes convert organic phosphorus to soluble orthophosphate (PO_4^{3-}). The orthophosphate is taken up in the roots, stems and leaves by the planted vegetation and growing adjacent to treatment trench. Microbes that break down the nitrogen will also consume phosphorus into their biomass. For a period of one to three years after a gravel wetland comes on line, orthophosphate will adsorb onto the gravel. Eventually the system reaches equilibrium and the concentration of orthophosphate in the effluent of the gravel wetland will increase. Clay in the native soils has almost an unlimited capacity to adsorb orthophosphate. That is why the treatment trench is designed to bring the water in the trench into contact with the native soils during the final polishing phase of the treatment process. This system should be able to polish the remaining soluble phosphorus to below 1.0 mg/L. It should be noted that , based on experience and the available literature on existing natural systems, we are not aware of empirical evidence that demonstrates that a reduction of phosphorous to below 0.04 mg/L can be achieved.

We are anticipating that phosphorous will reach levels below 1 mg/L based on experience and literature. NWS has subsurface flow wetlands where shallow down gradient wells have achieved 0.3 mg/L (Avoca, Michigan) and 0.5 mg/L (Oak Center, Wisconsin) total phosphorous. There are many variations of soil horizons and vegetation, all of which influence the level of P reduction. Harvesting plant matter will also influence these results, notwithstanding seasonal variations as well. The phyto-trench system maximizes the conditions and processes used to remove nitrogen and phosphorus in a passive treatment system. The phyto-trench system provides the greatest flexibility to be able to produce a consistently high quality effluent (low N and P concentration) despite possible fluctuation in the water quality of the discharge coming from the existing facultative lagoons. Due to the many potential variables, we do not anticipate that we can provide a high degree of certainty that a passive, natural system will be able to achieve a reduction of phosphorous to below 0.04 mg/L.

We believe it to be helpful to explain the current "state of the art" with respect to how publically owned treatment works (POTWs) would meet a 0.04 mg/L total P standard. These systems are challenging to operate and costly to build. Initial treatment could be an advanced biological process in combination with tertiary metal salt addition with excellent filtration. One example could be an A^2/O process with methanol addition, possibly with an upstream fermentation tank, followed by iron salt addition with multimedia filtration. This system has been used in plants as small as 50,000 gpd and higher. The above described system has achieved discharges of 3 to 6 mg/L total nitrogen and total Phosphorous of 0.03 to

1 mg/L. Cost of construction and O&M are very high in comparison to the facultative lagoon system followed by the kind of natural system being considering for treatment of the discharge from the SSD lagoons.

BOD_5, TSS, and Chlorides

The BOD_5 and TSS is quite low at the lagoon discharge. We anticipate that we may see a reduction in the BOD_5 value; however, depending on the seasonal background concentration from natural systems, this value will fluctuate. We expect no appreciable change in concentration.

With respect to TSS, the system should help achieve more consistency in levels. The phyto-treatment trench system will filter out excessive algae releases that will inevitably occur with a 24/7 continuous lagoon discharge during the 180 day period.

Chlorides will go unchanged. This is true with all current conventional POTWs.

8.3 OPERATIONS AND MAINTENANCE

A detailed operations and maintenance plan would be developed during the engineering design of the system. An overview of the typical elements of an operations and maintenance plan is provided herein.

The phyto-trench system design concept is based on a 180 day dosing cycle. Therefore, at the start of the 180 days, in spring, the valve diverting water to the trench system will need to be turned on; it will need to be turned off again after approximately 180 days in the fall. During the time the valve is turned on, we recommend inspecting the diversion valve on a semi-weekly basis to ensure it is kept free from debris. At the same time these inspections occur, we recommend checking the level of water in the SSD pond to check water level and flow rates. If water levels are substantially decreased, the diversion valve may need to be turned off for a period of time until the water levels in the pond return to normal.

We estimate that the trench gravel will likely have a life span of 50 or more years. The gravel in the trenches will not likely need to be replaced for the 50+ year period.

Monitoring, maintenance, and harvesting of vegetation will need to be conducted on a regular basis. Semi-monthly site visits for the first three to five years should be performed to monitor and manage establishment of native vegetation and control invasive vegetation. Tasks should include manual, mechanical, and chemical control of invasive vegetation and possible reseeding or planting of native plants in areas with limited establishment.   Vegetation harvesting for nutrient reduction should occur annually in the fall as the plants go dormant for areas that do not have woody vegetation. The woody vegetation should be allowed to establish for three to five years before regular harvesting occurs.

Once fully established, we recommend harvesting woody vegetation on a biannual basis for optimal nutrient reduction. The time of the year for harvesting woody vegetation will be dependent on the reuse purpose. If being done for a source of live stakes or purely for nutrient reduction, harvesting should occur in the early spring after the catkins have developed.   Harvesting should either be done in rotation or selectively. If done on a rotational basis, select areas would be harvested in their entirety and others left non-harvested. These areas would be rotated so that harvesting occurs annually but no one area is harvested more than once every two years. If done selectively, the entire area would be selectively harvested or "thinned" so that some woody vegetation remains non-harvested. We also recommend monitoring and an adaptive approach to harvesting. If the woody vegetation is not re-growing quickly enough to make harvesting on a biannual basis practical or if it is resulting in mortality of the woody vegetation, then the frequency of harvests should be decreased.

8.4 PRELIMINARY COST ESTIMATE

A preliminary design cost was estimated by the TRC team, outline below. The engineering design costs are estimated to be $110,400 (Table 16).

Table 16
Professional Services – Design Costs (Estimated)
Phyto-Trench Innovative Wastewater Treatment System

Project Elements	**Estimated Cost**
Survey & Subsurface Investigation	$10,500
Threatened & Endangered Species Evaluation	$2,500
Floodplain Evaluation	$4,000
Wetland Delineation	$5,000
Design Development - Prepare Plans & Specifications	$50,000
Permitting (DNR, USACE, County)	$10,000
QAPP (*if needed*, *GLRI)*	$3,500
Bidding Services during Construction (monitoring, etc.)	$6,500
O&M / Maintenance Plan	$4,000
Total	$96,000
15% contingency	$14,400
Total Estimated Design Costs	**$110,400**

Implementation (construction, O&M) costs can only be estimated at this point, since it will be based on specification requirements and quantities. The estimated cost range to construct the phyto-trench alternative is approximately $500,000 to $700,000 (Table 17).

Table 17 Estimated Construction Cost Range Implementation of the Phyto-Trench Innovative Wastewater Treatment System		
Item	**Cost**	
Mobilization	$20,000	$30,000
Diversion Weir	$10,000	$20,000
Excavation & Grading	$20,000	$45,000
GeoTextile & Installation	$90,000	$110,000
Aggregate and Soil Placement	$120,000	$160,000
Native Vegetation Planting	$140,000	$200,000
Erosion Control	$5,000	$15,000
Total	$405,000	$580,000
Contingency 15%	$60,750	$87,000
Estimated Construction Total	**$465,750**	**$667,000**

9.0 FUNDING OPTIONS

Funding options for design and implementation of the treatment system will likely include grant sources. State and other grants may provide good funding opportunities since the potential project has many benefits and opportunities for community outreach, improved water quality, and use of innovative approaches to protect resources that are located within the Lake Michigan basin.

TRC compiled a summarized list of potential grant programs that could be considered for funding the design and implementation of the passive polishing cell. It is included in Appendix D.

REFERENCES

Adegbidi, Hector G., et al. "Biomass and nutrient removal by willow clones in experimental bioenergy plantations in New York State." *Biomass and Bioenergy* 20.6 (2001): 399-411.

Brisson, J., and F. Chazarenc. "Maximizing pollutant removal in constructed wetlands: should we pay more attention to macrophyte species selection?." *Science of the Total Environment* 407.13 (2009): 3923-3930.

Fraser, Lauchlan H., Spring M. Carty, and David Steer. "A test of four plant species to reduce total nitrogen and total phosphorus from soil leachate in subsurface wetland microcosms." *Bioresource technology* 94.2 (2004): 185-192.

Kadlec, Robert H., and Scott Wallace. *Treatment wetlands*. CRC press, 2008.

Picard, Christian R., Lauchlan H. Fraser, and David Steer. "The interacting effects of temperature and plant community type on nutrient removal in wetland microcosms." *Bioresource technology* 96.9 (2005): 1039-1047.

Stottmeister, U., et al. "Effects of plants and microorganisms in constructed wetlands for wastewater treatment." *Biotechnology Advances* 22.1 (2003): 93-117.

Tanner, C. C. "Growth and nutrient dynamics of soft-stem bulrush in constructed wetlands treating nutrient-rich wastewaters." *Wetlands Ecology and Management* 9.1 (2001a): 49-73.

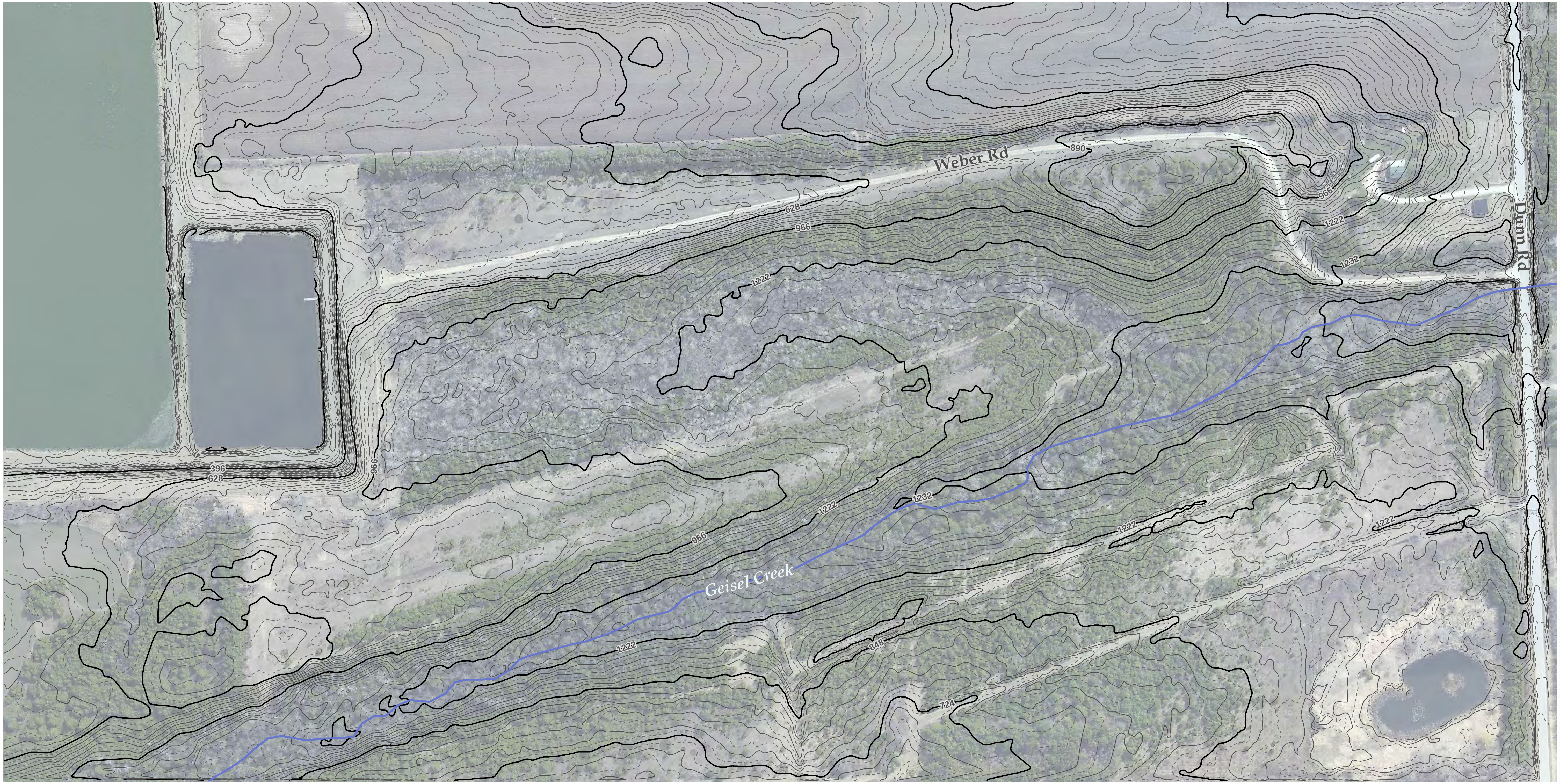
Tanner, C. "Plants as ecosystem engineers in subsurface-flow treatment wetlands." *Water Science & Technology* 44.11-12 (2001b): 11-12.

Tanner, Chris C. "Plants for constructed wetland treatment systems—a comparison of the growth and nutrient uptake of eight emergent species." *Ecological engineering* 7.1 (1996): 59-83.

Toet, Sylvia, et al. "Nutrient removal through autumn harvest of *Phragmites australis* and *Thypha latifolia* shoots in relation to nutrient loading in a wetland system used for polishing sewage treatment plant effluent." *Journal of Environmental Science and Health* 40.6-7 (2005): 1133-1156.

Water Quality Evaluation and Planning for the Dunes Lake Watershed, Door County, Wisconsin 2008-2012 (Draft Final Report).

APPENDIX A
SITE TOPOGRAPHY



LEGEND

- STREAM FLOWLINE
- 0.5' CONTOUR
- 1' CONTOUR
- 5' CONTOUR

NOTES

1. MAP INFORMATION PROVIDED BY DOOR COUNTY LAND INFORMATION OFFICE.

N

0 200 400 Feet

1 " = 200 '

1:2,400

PROJECT: DOOR COUNTY SOIL AND WATER CONSERVATION INNOVATIVE WASTE WATER TREATMENT SYSTEM			
SHEET TITLE: EXHIBIT A: SITE TOPOGRAPHY			
DRAWN BY: PAPEZ J	SCALE: 1: 2,400	PROJ. NO.	223803
CHECKED BY:		FILE NO.	223803-002.mxd
APPROVED BY:	DATE PRINTED:		
DATE: SEPTEMBER 2014			

TRC

708 Heartland Trail, Suite 3000
Madison, WI 53717
Phone: 608.826.3600
www.trcsolutions.com

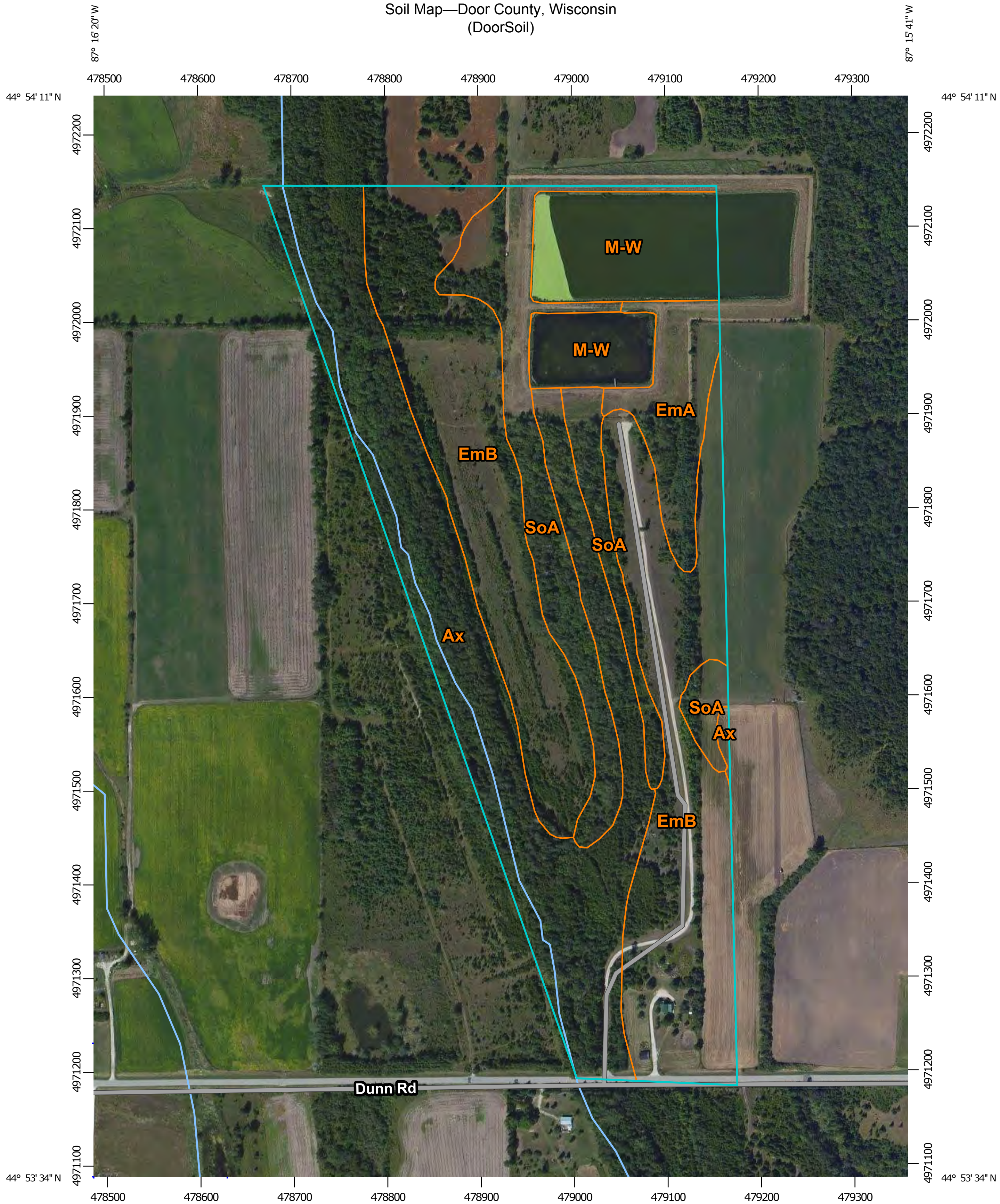
TRC - GIS

Coordinate System: NAD 1983 StatePlane Wisconsin Central FIPS 4802 Feet (Foot US)
Map Rotation: 90

Saved By: JPAPEZ on 9/16/2014, 14:29:59 PM
Path: E:\DoorCoWI\IWWTS_ValmyWI\2014_223803\223803-002.mxd

APPENDIX B
SOIL REPORTS

Soil Map—Door County, Wisconsin
(DoorSoil)



Map Scale: 1:5,620 if printed on A portrait (8.5" x 11") sheet.

Meters: 0, 50, 100, 200, 300

Feet: 0, 250, 500, 1000, 1500

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 16N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Door County, Wisconsin
Survey Area Data: Version 8, Dec 26, 2013

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

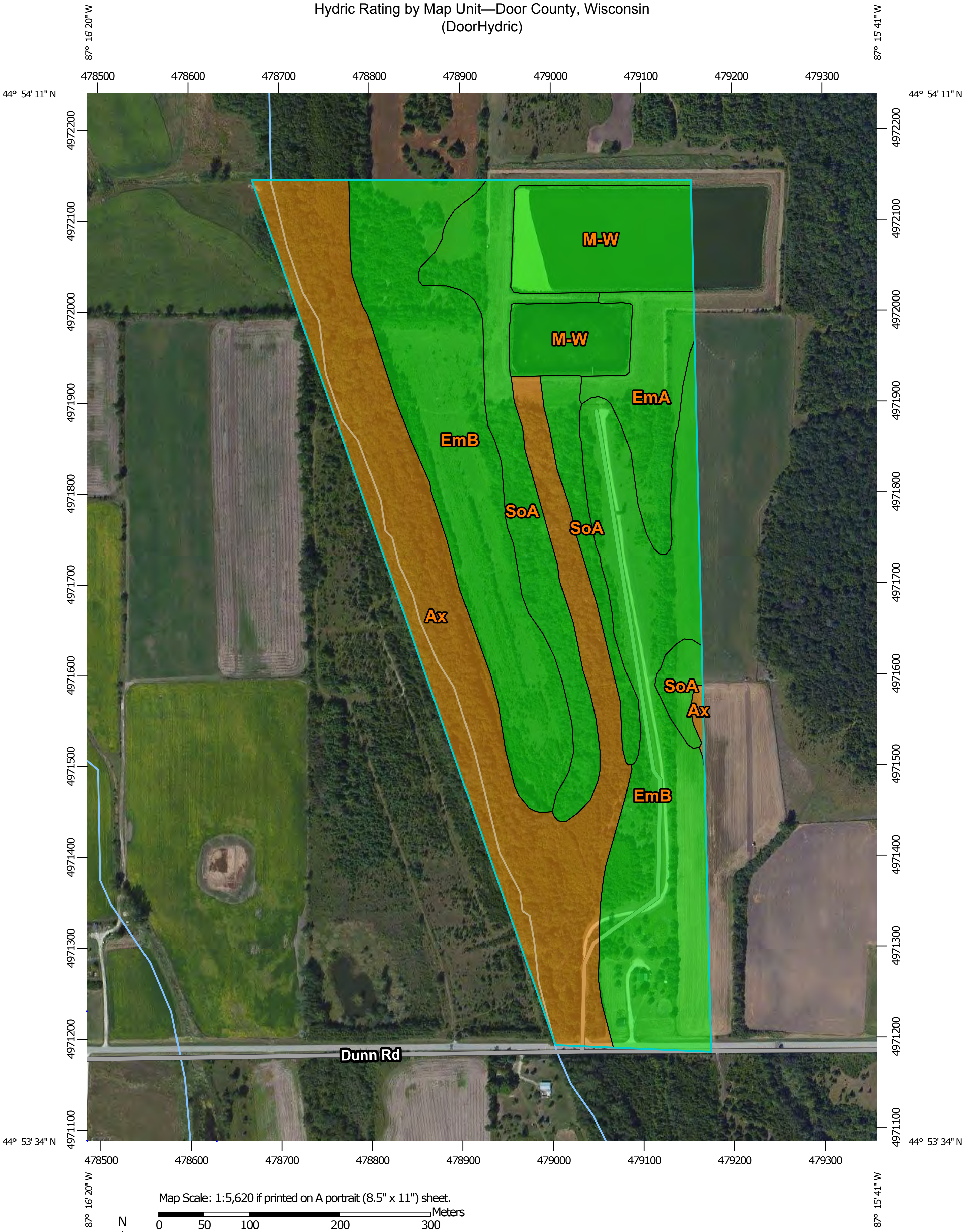
Date(s) aerial images were photographed: Sep 9, 2011—Sep 10, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Door County, Wisconsin (WI029)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
Ax	Angelica loam	23.0	29.6%
EmA	Emmet sandy loam, 0 to 2 percent slopes	4.3	5.5%
EmB	Emmet sandy loam, 2 to 6 percent slopes	30.9	39.7%
M-W	Miscellaneous water	8.4	10.8%
SoA	Solona loam, 0 to 3 percent slopes	11.1	14.3%
Totals for Area of Interest		**77.7**	**100.0%**

Hydric Rating by Map Unit—Door County, Wisconsin
(DoorHydric)



Map Scale: 1:5,620 if printed on A portrait (8.5" x 11") sheet.

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 16N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

Hydric (100%)

Predominantly Hydric (66 to 99%)

Partially hydric (33 to 65%)

Predominatly nonhydric (1 to 32%)

Nonhydric (0%)

Not rated or not available

Soil Rating Lines

Hydric (100%)

Predominantly Hydric (66 to 99%)

Partially hydric (33 to 65%)

Predominatly nonhydric (1 to 32%)

Nonhydric (0%)

Not rated or not available

Soil Rating Points

Hydric (100%)

Predominantly Hydric (66 to 99%)

Partially hydric (33 to 65%)

Predominatly nonhydric (1 to 32%)

Nonhydric (0%)

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Door County, Wisconsin
Survey Area Data: Version 8, Dec 26, 2013

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Sep 9, 2011—Sep 10, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydric Rating by Map Unit

Hydric Rating by Map Unit— Summary by Map Unit — Door County, Wisconsin (WI029)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
Ax	Angelica loam	95	23.0	29.6%
EmA	Emmet sandy loam, 0 to 2 percent slopes	0	4.3	5.5%
EmB	Emmet sandy loam, 2 to 6 percent slopes	0	30.9	39.7%
M-W	Miscellaneous water	0	8.4	10.8%
SoA	Solona loam, 0 to 3 percent slopes	0	11.1	14.3%
Totals for Area of Interest			**77.7**	**100.0%**

Description

This rating indicates the percentage of map units that meets the criteria for hydric soils. Map units are composed of one or more map unit components or soil types, each of which is rated as hydric soil or not hydric. Map units that are made up dominantly of hydric soils may have small areas of minor nonhydric components in the higher positions on the landform, and map units that are made up dominantly of nonhydric soils may have small areas of minor hydric components in the lower positions on the landform. Each map unit is rated based on its respective components and the percentage of each component within the map unit.

The thematic map is color coded based on the composition of hydric components. The five color classes are separated as 100 percent hydric components, 66 to 99 percent hydric components, 33 to 65 percent hydric components, 1 to 32 percent hydric components, and less than one percent hydric components.

In Web Soil Survey, the Summary by Map Unit table that is displayed below the map pane contains a column named 'Rating'. In this column the percentage of each map unit that is classified as hydric is displayed.

Hydric soils are defined by the National Technical Committee for Hydric Soils (NTCHS) as soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part (Federal Register, 1994). Under natural conditions, these soils are either saturated or inundated long enough during the growing season to support the growth and reproduction of hydrophytic vegetation.

The NTCHS definition identifies general soil properties that are associated with wetness. In order to determine whether a specific soil is a hydric soil or nonhydric soil, however, more specific information, such as information about the depth and duration of the water table, is needed. Thus, criteria that identify those estimated soil properties unique to hydric soils have been established (Federal Register, 2002). These criteria are used to identify map unit components that normally are associated with wetlands. The criteria used are selected estimated soil properties that are described in "Soil Taxonomy" (Soil Survey Staff, 1999) and "Keys to Soil Taxonomy" (Soil Survey Staff, 2006) and in the "Soil Survey Manual" (Soil Survey Division Staff, 1993).

If soils are wet enough for a long enough period of time to be considered hydric, they should exhibit certain properties that can be easily observed in the field. These visible properties are indicators of hydric soils. The indicators used to make onsite determinations of hydric soils are specified in "Field Indicators of Hydric Soils in the United States" (Hurt and Vasilas, 2006).

References:

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18.

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service. U.S. Department of Agriculture Handbook 436.

Soil Survey Staff. 2006. Keys to soil taxonomy. 10th edition. U.S. Department of Agriculture, Natural Resources Conservation Service.

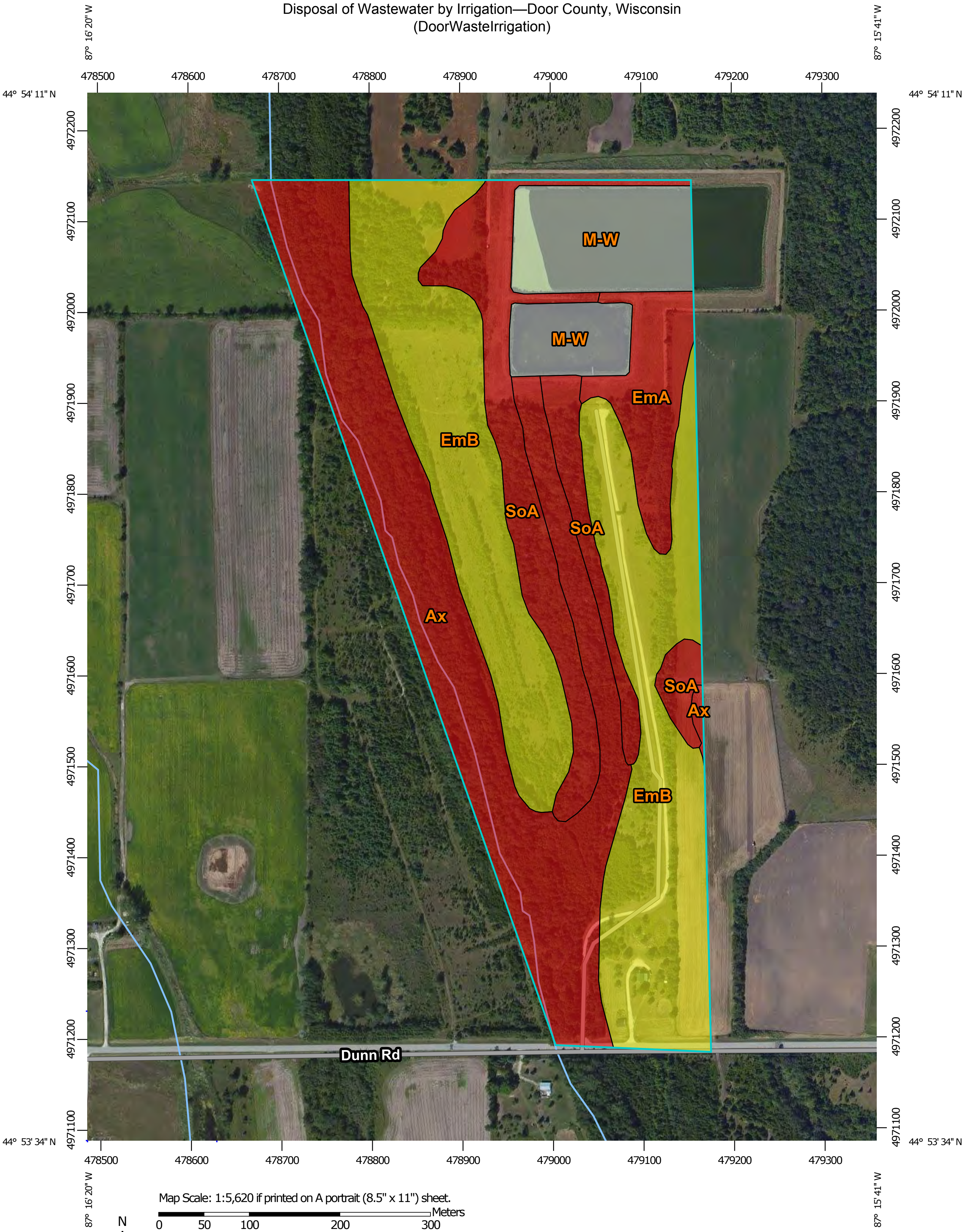
Rating Options

Aggregation Method: Percent Present

Component Percent Cutoff: None Specified

Tie-break Rule: Lower

Disposal of Wastewater by Irrigation—Door County, Wisconsin
(DoorWasteIrrigation)



Map Scale: 1:5,620 if printed on A portrait (8.5" x 11") sheet.

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 16N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

Very limited

Somewhat limited

Not limited

Not rated or not available

Soil Rating Lines

Very limited

Somewhat limited

Not limited

Not rated or not available

Soil Rating Points

Very limited

Somewhat limited

Not limited

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Door County, Wisconsin
Survey Area Data: Version 8, Dec 26, 2013

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Sep 9, 2011—Sep 10, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Disposal of Wastewater by Irrigation

Disposal of Wastewater by Irrigation— Summary by Map Unit — Door County, Wisconsin (WI029)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
Ax	Angelica loam	Very limited	Angelica (95%)	Ponding (1.00)	23.0	29.6%
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Slow water movement (0.22)		
EmA	Emmet sandy loam, 0 to 2 percent slopes	Very limited	Emmet (90%)	Depth to saturated zone (1.00)	4.3	5.5%
				Too acid (0.14)		
EmB	Emmet sandy loam, 2 to 6 percent slopes	Somewhat limited	Emmet (95%)	Depth to saturated zone (0.18)	30.9	39.7%
				Too acid (0.14)		
				Too steep for surface application (0.08)		
M-W	Miscellaneous water	Not rated	Water, miscellaneous (100%)		8.4	10.8%
SoA	Solona loam, 0 to 3 percent slopes	Very limited	Solona (100%)	Ponding (1.00)	11.1	14.3%
				Depth to saturated zone (1.00)		
				Flooding (0.60)		
Totals for Area of Interest					**77.7**	**100.0%**

Disposal of Wastewater by Irrigation— Summary by Rating Value		
Rating	**Acres in AOI**	**Percent of AOI**
Very limited	38.4	49.4%
Somewhat limited	30.9	39.7%
Null or Not Rated	8.4	10.8%
Totals for Area of Interest	**77.7**	**100.0%**

Description

Wastewater includes municipal and food-processing wastewater and effluent from lagoons or storage ponds. Municipal wastewater is the waste stream from a municipality. It contains domestic waste and may contain industrial waste. It may have received primary or secondary treatment. It is rarely untreated sewage. Food-processing wastewater results from the preparation of fruits, vegetables, milk, cheese, and meats for public consumption. In places it is high in content of sodium and chloride. The effluent in lagoons and storage ponds is from facilities used to treat or store food-processing wastewater or domestic or animal waste. Domestic and food-processing wastewater is very dilute, and the effluent from the facilities that treat or store it commonly is very low in content of carbonaceous and nitrogenous material; the content of nitrogen commonly ranges from 10 to 30 milligrams per liter. The wastewater from animal waste treatment lagoons or storage ponds, however, has much higher concentrations of these materials, mainly because the manure has not been diluted as much as the domestic waste. The content of nitrogen in this wastewater generally ranges from 50 to 2,000 milligrams per liter. When wastewater is applied, checks should be made to ensure that nitrogen, heavy metals, and salts are not added in excessive amounts.

Disposal of wastewater by irrigation not only disposes of municipal wastewater and wastewater from food-processing plants, lagoons, and storage ponds but also can improve crop production by increasing the amount of water available to crops. The ratings are based on the soil properties that affect the design, construction, management, and performance of the irrigation system. The properties that affect design and management include the sodium adsorption ratio, depth to a water table, ponding, available water capacity, saturated hydraulic conductivity (Ksat), slope, and flooding. The properties that affect construction include stones, cobbles, depth to bedrock or a cemented pan, depth to a water table, and ponding. The properties that affect performance include depth to bedrock or a cemented pan, bulk density, the sodium adsorption ratio, salinity, reaction, and the cation-exchange capacity, which is used to estimate the capacity of a soil to adsorb heavy metals. Permanently frozen soils are not suitable for disposal of wastewater by irrigation.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

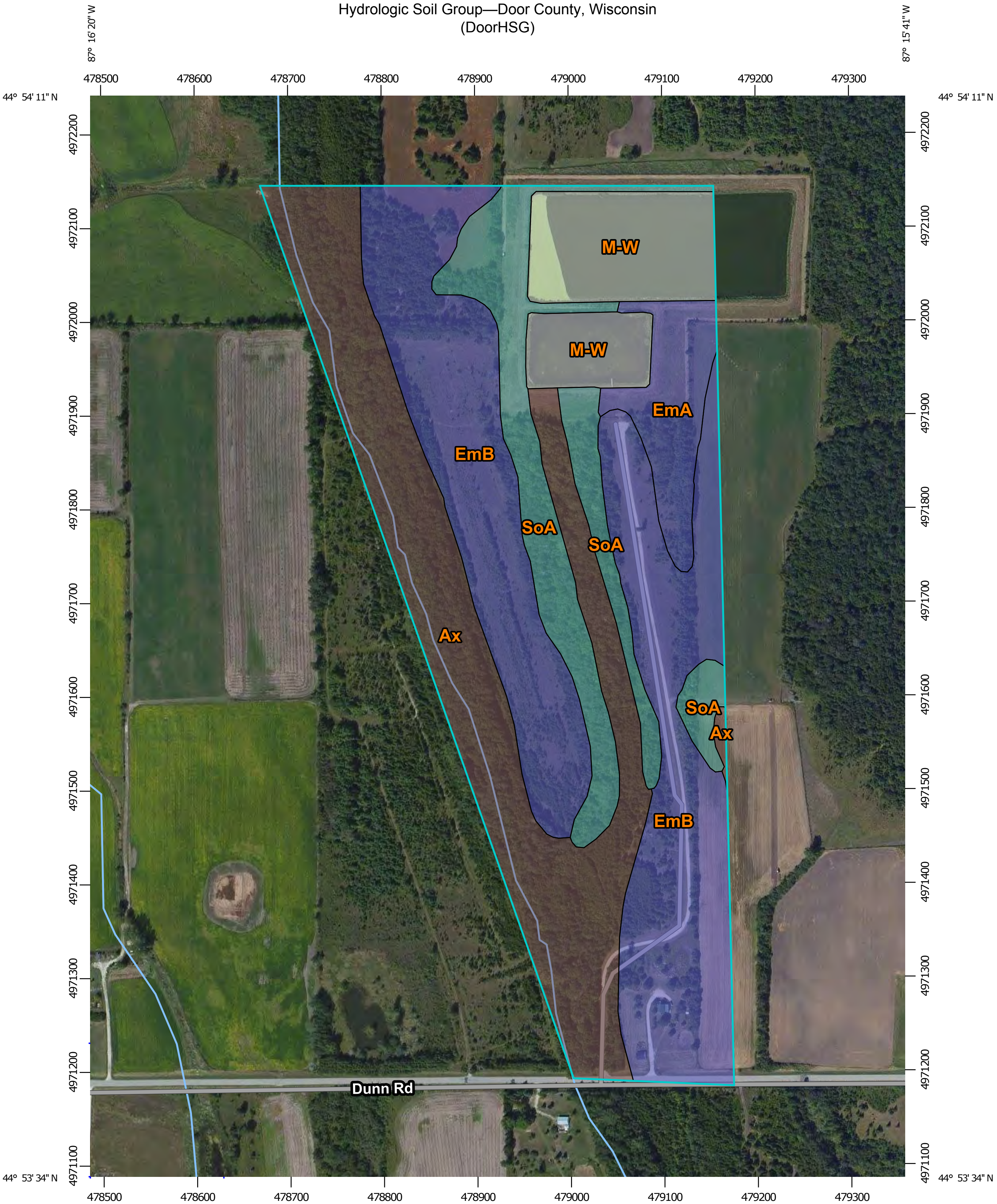
Rating Options

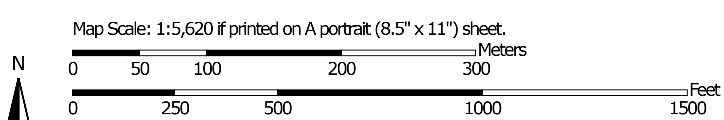
Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Hydrologic Soil Group—Door County, Wisconsin
(DoorHSG)





Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 16N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Door County, Wisconsin
Survey Area Data: Version 8, Dec 26, 2013

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Sep 9, 2011—Sep 10, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Door County, Wisconsin (WI029)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
Ax	Angelica loam	B/D	23.0	29.6%
EmA	Emmet sandy loam, 0 to 2 percent slopes	B	4.3	5.5%
EmB	Emmet sandy loam, 2 to 6 percent slopes	B	30.9	39.7%
M-W	Miscellaneous water		8.4	10.8%
SoA	Solona loam, 0 to 3 percent slopes	C	11.1	14.3%
Totals for Area of Interest			**77.7**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

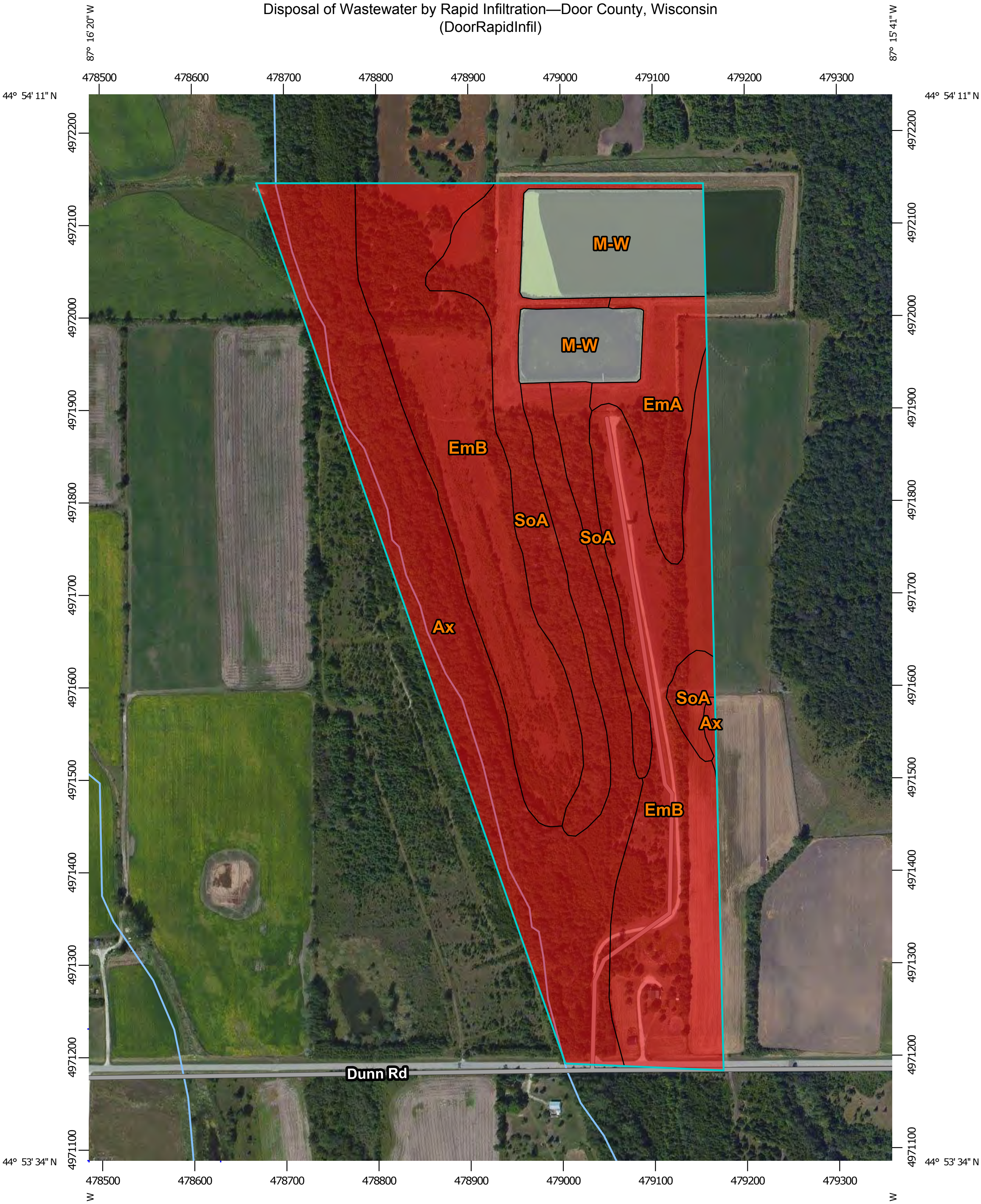
Rating Options

Aggregation Method: Dominant Condition

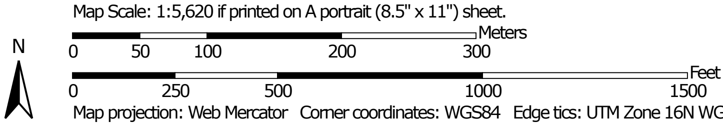
Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Disposal of Wastewater by Rapid Infiltration—Door County, Wisconsin
(DoorRapidInfil)



Map Scale: 1:5,620 if printed on A portrait (8.5" x 11") sheet.



Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 16N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Door County, Wisconsin
Survey Area Data: Version 8, Dec 26, 2013

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Sep 9, 2011—Sep 10, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Disposal of Wastewater by Rapid Infiltration

Disposal of Wastewater by Rapid Infiltration— Summary by Map Unit — Door County, Wisconsin (WI029)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
Ax	Angelica loam	Very limited	Angelica (95%)	Ponding (1.00)	23.0	29.6%
				Flooding (1.00)		
				Slow water movement (1.00)		
				Depth to saturated zone (1.00)		
EmA	Emmet sandy loam, 0 to 2 percent slopes	Very limited	Emmet (90%)	Depth to saturated zone (1.00)	4.3	5.5%
				Slow water movement (1.00)		
EmB	Emmet sandy loam, 2 to 6 percent slopes	Very limited	Emmet (95%)	Depth to saturated zone (1.00)	30.9	39.7%
				Slow water movement (1.00)		
M-W	Miscellaneous water	Not rated	Water, miscellaneous (100%)		8.4	10.8%
SoA	Solona loam, 0 to 3 percent slopes	Very limited	Solona (100%)	Ponding (1.00)	11.1	14.3%
				Depth to saturated zone (1.00)		
				Slow water movement (1.00)		
				Flooding (0.60)		
Totals for Area of Interest					**77.7**	**100.0%**

Disposal of Wastewater by Rapid Infiltration— Summary by Rating Value		
Rating	**Acres in AOI**	**Percent of AOI**
Very limited	69.3	89.2%
Null or Not Rated	8.4	10.8%
Totals for Area of Interest	**77.7**	**100.0%**

Description

Rapid infiltration of wastewater is a process in which wastewater applied in a level basin at a rate of 4 to 120 inches per week percolates through the soil. The wastewater may eventually reach the ground water. The application rate commonly exceeds the rate needed for irrigation of cropland. Vegetation is not a necessary part of the treatment; thus, the basins may or may not be vegetated. The thickness of the soil material needed for proper treatment of the wastewater is more than 72 inches. As a result, geologic and hydrologic investigation is needed to ensure proper design and performance and to determine the risk of ground-water pollution.

Soil properties are important considerations in areas where soils are used as sites for the treatment and disposal of organic waste and wastewater. Selection of soils with properties that favor waste management can help to prevent environmental damage.

Municipal wastewater is the waste stream from a municipality. It contains domestic waste and may contain industrial waste. It may have received primary or secondary treatment. It is rarely untreated sewage. Food-processing wastewater results from the preparation of fruits, vegetables, milk, cheese, and meats for public consumption. In places it is high in content of sodium and chloride. The effluent in lagoons and storage ponds is from facilities used to treat or store food-processing wastewater or domestic or animal waste. Domestic and food-processing wastewater is very dilute, and the effluent from the facilities that treat or store it commonly is very low in content of carbonaceous and nitrogenous material; the content of nitrogen commonly ranges from 10 to 30 milligrams per liter. The wastewater from animal waste treatment lagoons or storage ponds, however, has much higher concentrations of these materials, mainly because the manure has not been diluted as much as the domestic waste. The content of nitrogen in this wastewater generally ranges from 50 to 2,000 milligrams per liter. When wastewater is applied, checks should be made to ensure that nitrogen, heavy metals, and salts are not added in excessive amounts.

The ratings are based on the soil properties that affect the risk of pollution and the design, construction, and performance of the system. Depth to a water table, ponding, flooding, and depth to bedrock or a cemented pan affect the risk of pollution and the design and construction of the system. Slope, stones, and cobbles also affect design and construction. Saturated hydraulic conductivity (Ksat) and reaction affect performance. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

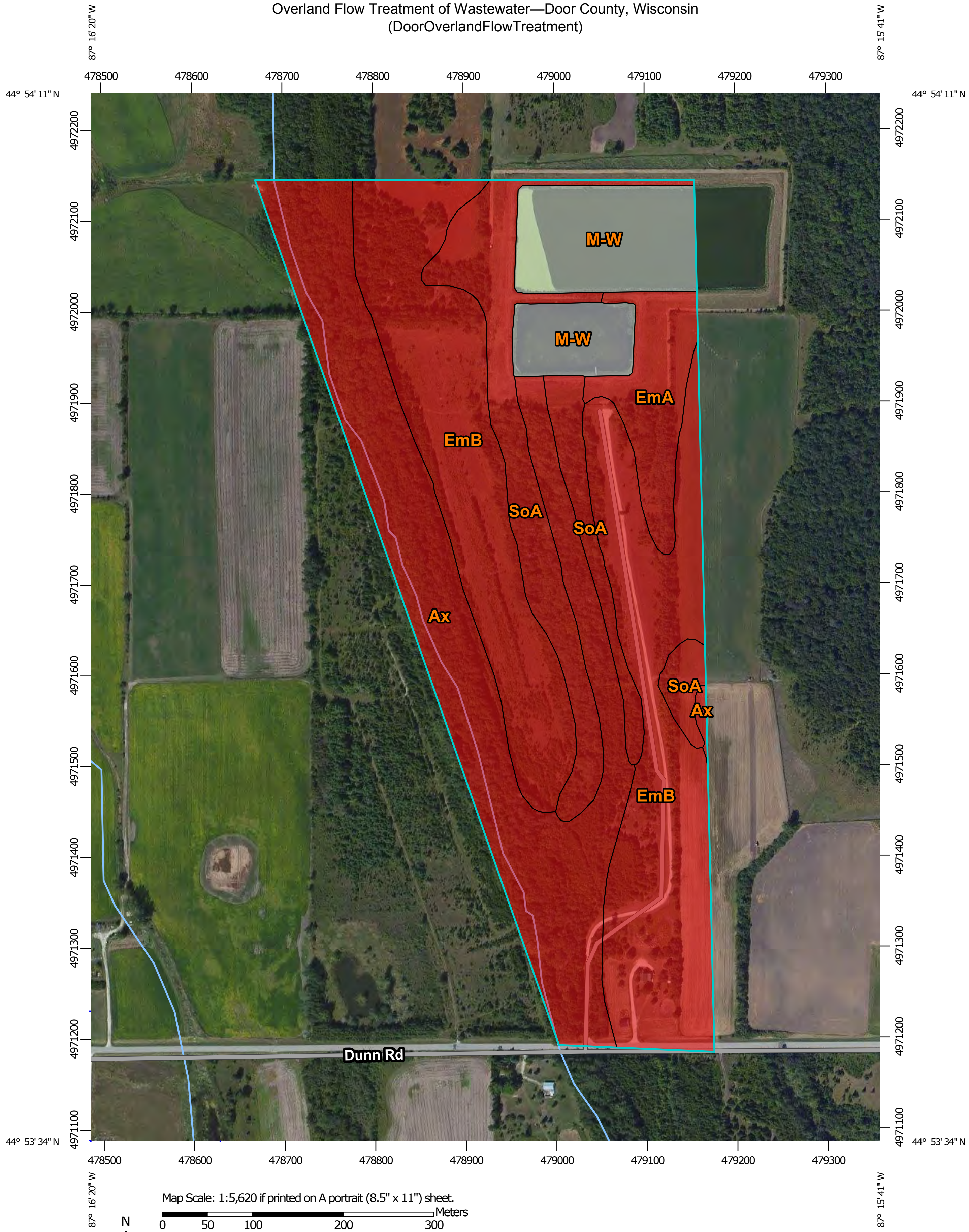
Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher



Map Scale: 1:5,620 if printed on A portrait (8.5" x 11") sheet.

Meters: 0 50 100 200 300

N

Feet: 0 250 500 1000 1500

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 16N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines

- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points

- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Door County, Wisconsin
Survey Area Data: Version 8, Dec 26, 2013

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Sep 9, 2011—Sep 10, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Overland Flow Treatment of Wastewater

Overland Flow Treatment of Wastewater— Summary by Map Unit — Door County, Wisconsin (WI029)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
Ax	Angelica loam	Very limited	Angelica (95%)	Seepage (1.00)	23.0	29.6%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
EmA	Emmet sandy loam, 0 to 2 percent slopes	Very limited	Emmet (90%)	Seepage (1.00)	4.3	5.5%
				Depth to saturated zone (1.00)		
				Too acid (0.14)		
EmB	Emmet sandy loam, 2 to 6 percent slopes	Very limited	Emmet (95%)	Seepage (1.00)	30.9	39.7%
				Depth to saturated zone (0.18)		
				Too acid (0.14)		
M-W	Miscellaneous water	Not rated	Water, miscellaneous (100%)		8.4	10.8%
SoA	Solona loam, 0 to 3 percent slopes	Very limited	Solona (100%)	Seepage (1.00)	11.1	14.3%
				Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
Totals for Area of Interest					**77.7**	**100.0%**

Overland Flow Treatment of Wastewater— Summary by Rating Value		
Rating	**Acres in AOI**	**Percent of AOI**
Very limited	69.3	89.2%
Null or Not Rated	8.4	10.8%
Totals for Area of Interest	**77.7**	**100.0%**

Description

In this process wastewater is applied to the upper reaches of sloped land and allowed to flow across vegetated surfaces, sometimes called terraces, to runoff-collection ditches. The length of the run generally is 150 to 300 feet. The application rate ranges from 2.5 to 16.0 inches per week. It commonly exceeds the rate needed for irrigation of cropland. The wastewater leaves solids and nutrients on the vegetated surfaces as it flows downslope in a thin film. Most of the water reaches the collection ditch, some is lost through evapotranspiration, and a small amount may percolate to the ground water.

Wastewater includes municipal and food-processing wastewater and effluent from lagoons or storage ponds. Municipal wastewater is the waste stream from a municipality. It contains domestic waste and may contain industrial waste. It may have received primary or secondary treatment. It is rarely untreated sewage. Food-processing wastewater results from the preparation of fruits, vegetables, milk, cheese, and meats for public consumption. In places it is high in content of sodium and chloride. The effluent in lagoons and storage ponds is from facilities used to treat or store food-processing wastewater or domestic or animal waste. Domestic and food-processing wastewater is very dilute, and the effluent from the facilities that treat or store it commonly is very low in content of carbonaceous and nitrogenous material; the content of nitrogen commonly ranges from 10 to 30 milligrams per liter. The wastewater from animal waste treatment lagoons or storage ponds, however, has much higher concentrations of these materials, mainly because the manure has not been diluted as much as the domestic waste. The content of nitrogen in this wastewater generally ranges from 50 to 2,000 milligrams per liter. When wastewater is applied, checks should be made to ensure that nitrogen, heavy metals, and salts are not added in excessive amounts.

The ratings are for waste management systems that not only dispose of and treat wastewater but also are beneficial to crops. The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Slow Rate Treatment of Wastewater—Door County, Wisconsin
(DoorOverlandFlowTreatment)

Map Scale: 1:5,620 if printed on A portrait (8.5" x 11") sheet.

Meters: 0, 50, 100, 200, 300

Feet: 0, 250, 500, 1000, 1500

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 16N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

Very limited

Somewhat limited

Not limited

Not rated or not available

Soil Rating Lines

Very limited

Somewhat limited

Not limited

Not rated or not available

Soil Rating Points

Very limited

Somewhat limited

Not limited

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Door County, Wisconsin
Survey Area Data: Version 8, Dec 26, 2013

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Sep 9, 2011—Sep 10, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Slow Rate Treatment of Wastewater

Slow Rate Treatment of Wastewater— Summary by Map Unit — Door County, Wisconsin (WI029)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
Ax	Angelica loam	Very limited	Angelica (95%)	Ponding (1.00)	23.0	29.6%
				Depth to saturated zone (1.00)		
				Flooding (1.00)		
				Slow water movement (0.15)		
EmA	Emmet sandy loam, 0 to 2 percent slopes	Very limited	Emmet (90%)	Depth to saturated zone (1.00)	4.3	5.5%
				Too acid (0.14)		
EmB	Emmet sandy loam, 2 to 6 percent slopes	Somewhat limited	Emmet (95%)	Depth to saturated zone (0.18)	30.9	39.7%
				Too acid (0.14)		
				Too steep for surface application (0.08)		
M-W	Miscellaneous water	Not rated	Water, miscellaneous (100%)		8.4	10.8%
SoA	Solona loam, 0 to 3 percent slopes	Very limited	Solona (100%)	Ponding (1.00)	11.1	14.3%
				Depth to saturated zone (1.00)		
				Flooding (0.60)		
Totals for Area of Interest					**77.7**	**100.0%**

Slow Rate Treatment of Wastewater— Summary by Rating Value		
Rating	**Acres in AOI**	**Percent of AOI**
Very limited	38.4	49.4%
Somewhat limited	30.9	39.7%
Null or Not Rated	8.4	10.8%
Totals for Area of Interest	**77.7**	**100.0%**

Description

Slow rate treatment of wastewater is a process in which wastewater is applied to land at a rate normally between 0.5 inch and 4.0 inches per week. The application rate commonly exceeds the rate needed for irrigation of cropland. The applied wastewater is treated as it moves through the soil. Much of the treated water may percolate to the ground water, and some enters the atmosphere through evapotranspiration. The applied water generally is not allowed to run off the surface. Waterlogging is prevented either through control of the application rate or through the use of tile drains, or both.

Soil properties are important considerations in areas where soils are used as sites for the treatment and disposal of organic waste and wastewater. Selection of soils with properties that favor waste management can help to prevent environmental damage.

Municipal wastewater is the waste stream from a municipality. It contains domestic waste and may contain industrial waste. It may have received primary or secondary treatment. It is rarely untreated sewage. Food-processing wastewater results from the preparation of fruits, vegetables, milk, cheese, and meats for public consumption. In places it is high in content of sodium and chloride. The effluent in lagoons and storage ponds is from facilities used to treat or store food-processing wastewater or domestic or animal waste. Domestic and food-processing wastewater is very dilute, and the effluent from the facilities that treat or store it commonly is very low in content of carbonaceous and nitrogenous material; the content of nitrogen commonly ranges from 10 to 30 milligrams per liter. The wastewater from animal waste treatment lagoons or storage ponds, however, has much higher concentrations of these materials, mainly because the manure has not been diluted as much as the domestic waste. The content of nitrogen in this wastewater generally ranges from 50 to 2,000 milligrams per liter. When wastewater is applied, checks should be made to ensure that nitrogen, heavy metals, and salts are not added in excessive amounts.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, and the application of waste. The properties that affect absorption include the sodium adsorption ratio, depth to a water table, ponding, available water capacity, saturated hydraulic conductivity (Ksat), depth to bedrock or a cemented pan, reaction, the cation-exchange capacity, and slope. Reaction, the sodium adsorption ratio, salinity, and bulk density affect plant growth and microbial activity. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood of wind erosion or water erosion. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

APPENDIX C
DESIGN ALTERNATIVES PRESENTATOIN SLIDES

Alternative Design Concepts
“Innovative Wastewater Treatment“

Door County Soil and Water Conservation Department
Sevastopol Sanitary District

October 20, 2014
10:00 am

Design Parameters / Assumptions

<u>Design Annual Volume</u>

- Wet Year Annual Volume 11.465 MG (2005) (+25%)
- Typical Annual Volume 7.92 – 9.18 MG
- Dry Year Annual Volume 2.22 MG (2012)

<u>Design Effluent Phosphorus Concentration from Lagoon</u>

- 2 mg/L

<u>Assumed Daily Discharge Alternatives</u>

- 30 Day Discharge (current operation) – 382,200 gpd 4.7 in
- 90 Day Discharge (peak growing season) – 127,400 gpd 1.6 in
- 180 Day Discharge (max growing season) – 63,700 gpd 0.8 in

“Crop” Phosphorus Uptake

Crop	Phosphorus Yield (mg/cm^2)
Field Corn for Silage	0.01
Sorghums for Silage	0.03
Alfalfa Hay	0.05
Small Grain Hay	0.05
Other Tame Hay	0.17
Wild Hay	0.17
Grass Silage	0.02
Salt Hay	0.02
Sorghum Hay	0.01

Charles H. Lander, David Moffitt and Klaus Alt (retired). February 1998. Appendix I, Nutrients Available from Livestock Manure Relative to Crop Growth Requirements U.S. Department of Agriculture, Natural Resources Conservation Service Resource Assessment and Strategic Planning Working Paper 98-1.

Crop	Phosphorus Yield (mg/cm^2)
Birch spp.	0.006
Douglas fir	0.053
European beech	0.022
Maple spp	0.059
Oak spp	0.026
Pine spp.	0.008
Red Alder	0.101
Spruce spp.	0.011
Yellow poplar	0.009

Ducnuigeen, J., Williard, K., and Steiner, R.C.. September 1997. Relative Nutrient Requirements of Plants Suitable for Riparian Vegetated Buffer Strips. Virginia Department of Environmental Quality. ICPRB Report Number 97 – 4.

Design Parameters / Assumptions

Assumed Vegetative

<u>Phosphorus Uptake</u>

0.02 mg/cm^2

18.6 mg/ft^2

Acreage of

<u>Phytoremediation</u>

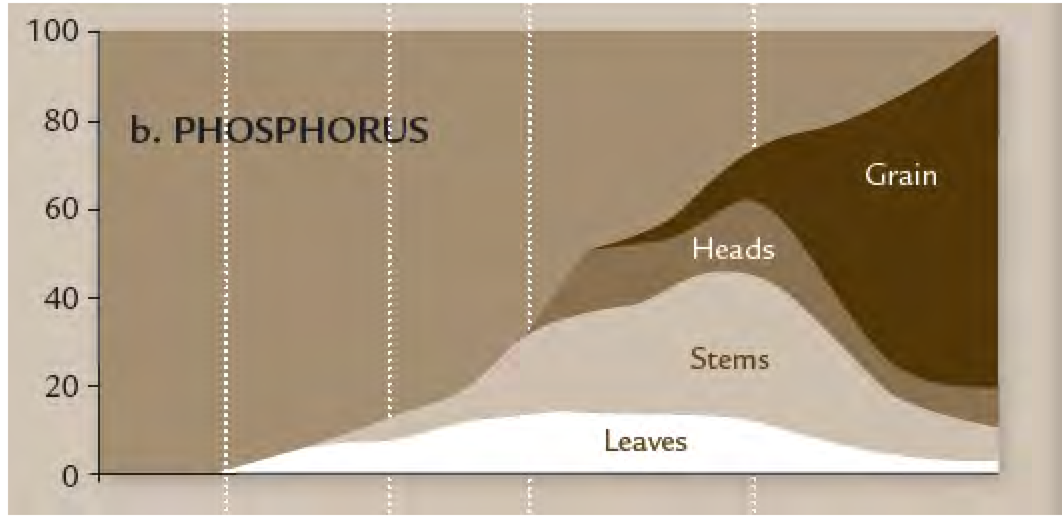
11.465 MG @ 2 mg/L

107 ac

Harvest

<u>Recommendation</u>

July



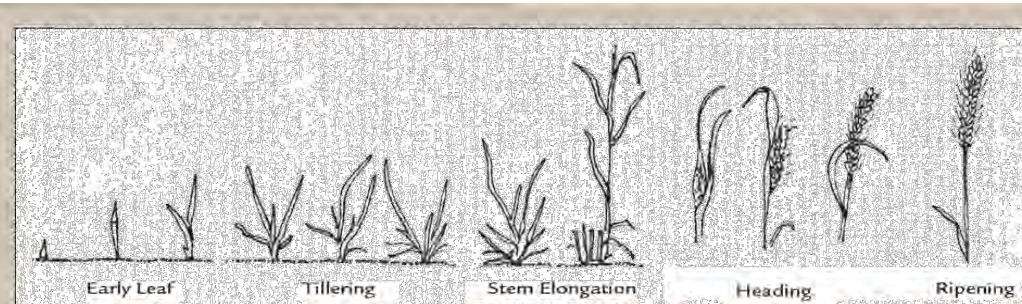


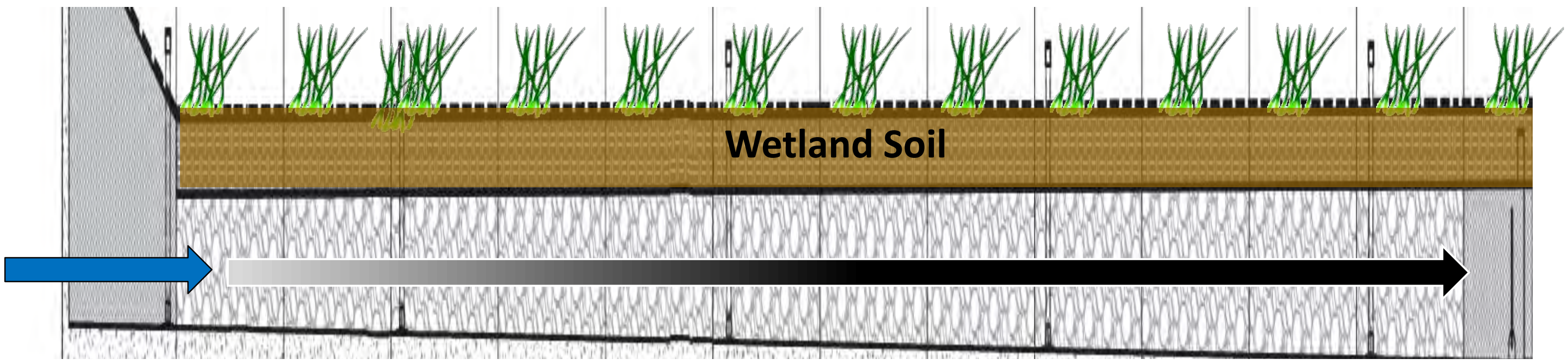
FIGURE 1. Approximate cereal grain growth stages. Flowering may occur before or after head emergence, depending on crop and variety. This figure was modified from its original (2).

Jones, C., Olson-Rutz, K., Dinkins,. C. June 2011. Nutrient Uptake Timing by Crops to assist with fertilizing decisions. Montana State University Extension.

Alternative Design Concepts

- Subsurface Gravel Wetland (SGW)
- Phyto-Treatment Trench
- Hybrid SGW / Phyto-Trench

Subsurface Gravel Wetland Treatment Technology



Aerobic

Anaerobic

Nitrifying Bacteria (*Nitrosomonas*)

$NH_4 + O_2 \rightarrow NO_2 + O_2 \rightarrow NO_3$

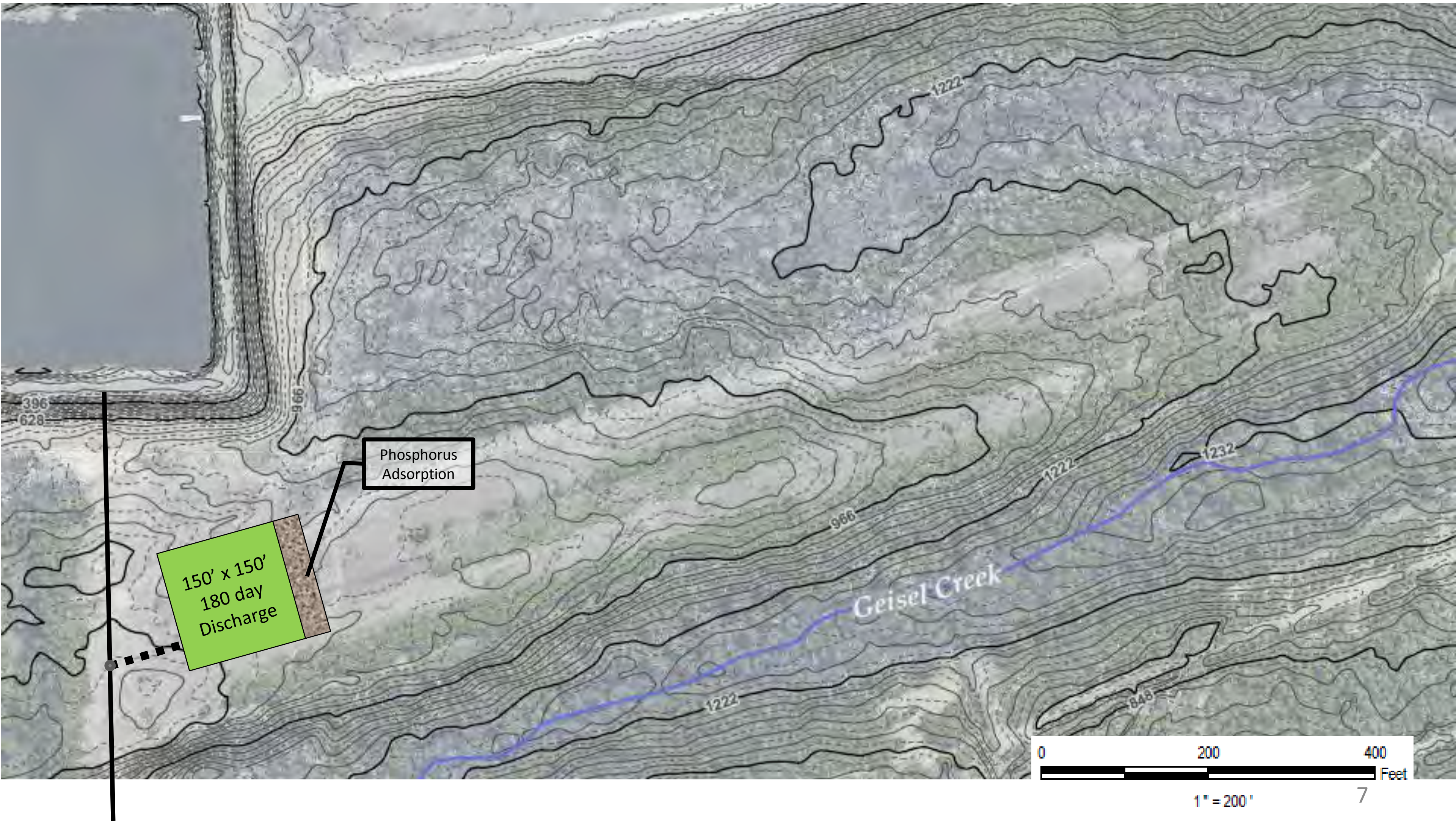
Denitrifying Bacteria (*Thiobacillus*)

NO_3 + Organic Carbon $\rightarrow NO_2$ + Org C $\rightarrow N_2 + CO_2 + H_2O$

Organic Phosphate $\rightarrow$ Orthophosphate PO_4

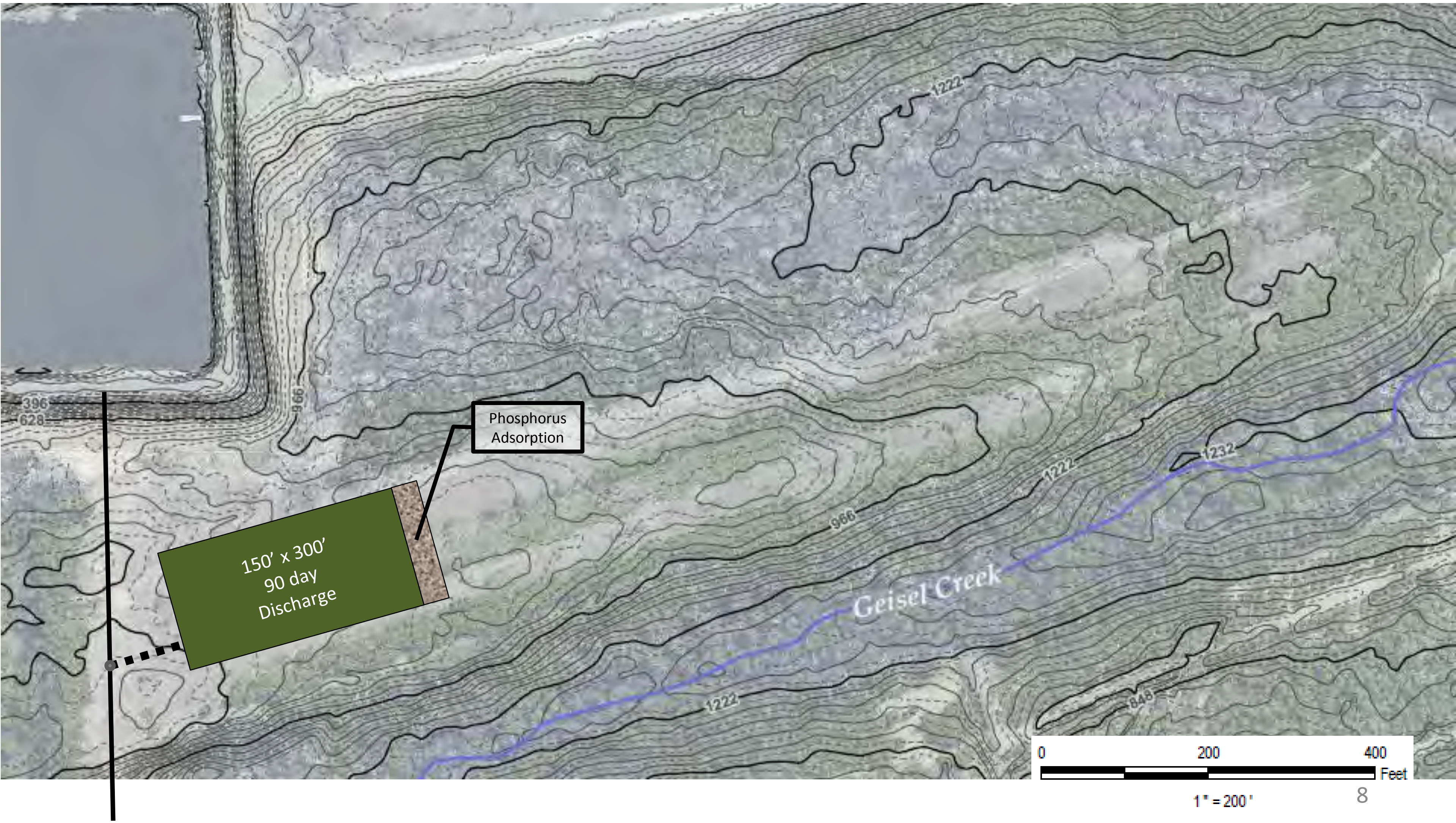
180 Day Subsurface Gravel Wetland

max growing season – 63,700 gpd



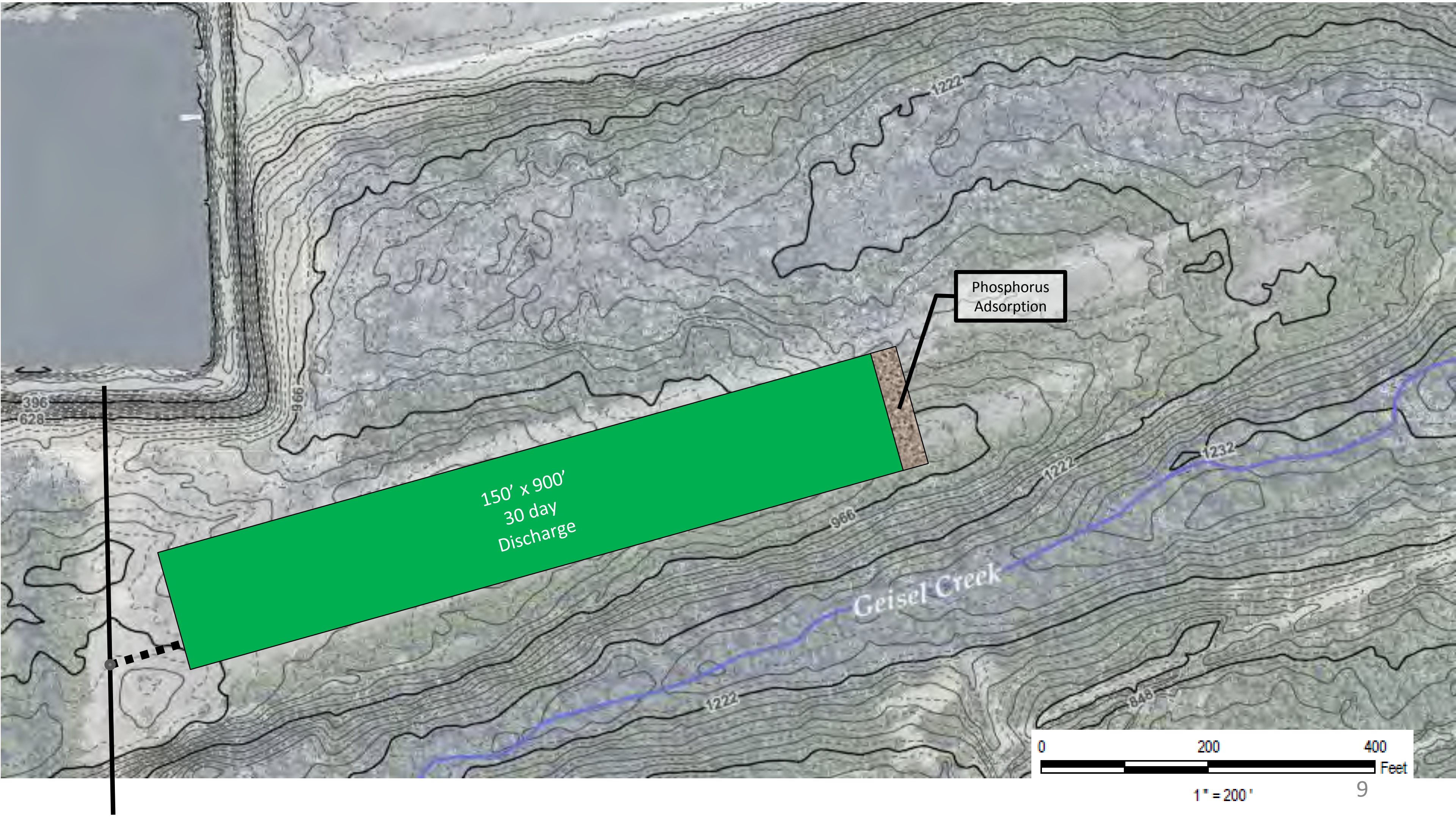
90 Day Subsurface Gravel Wetland

peak growing season – 127,400 gpd

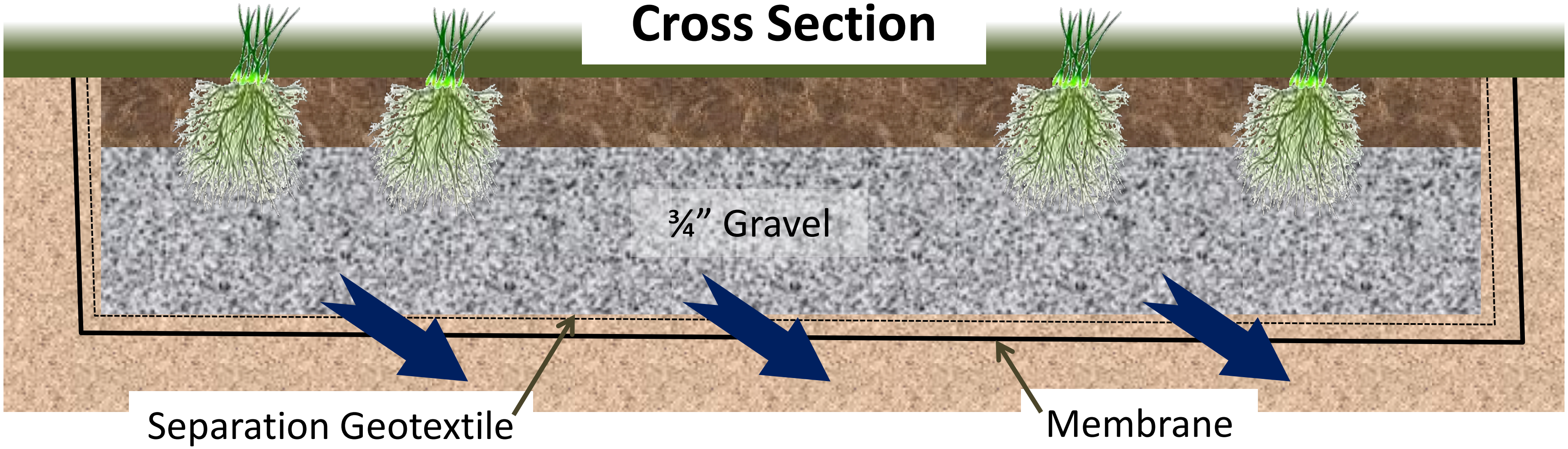


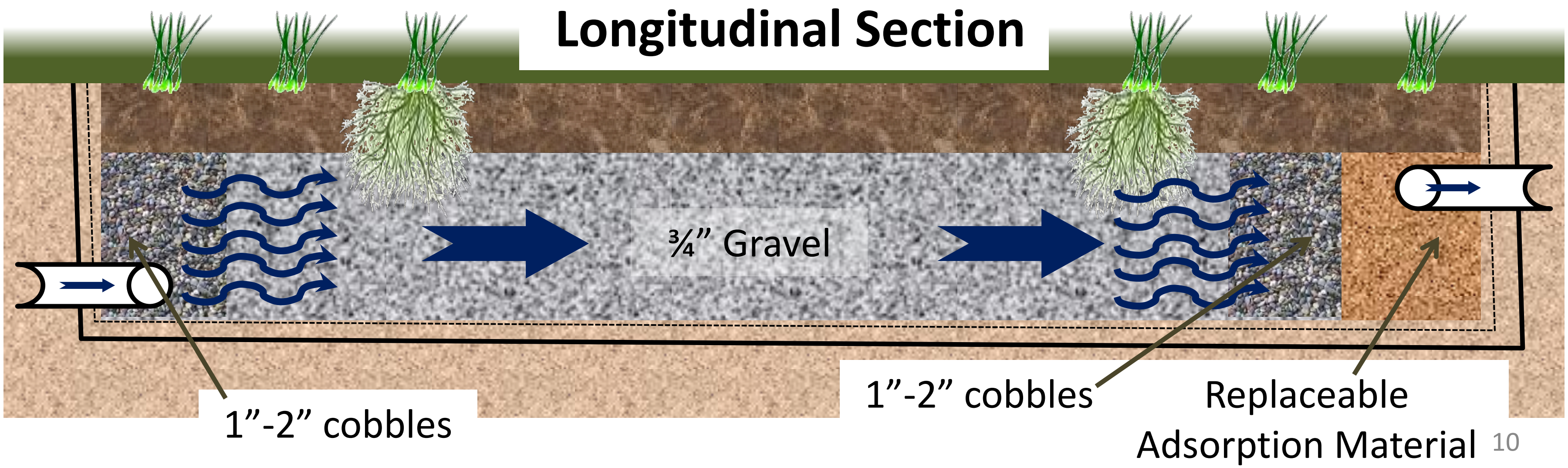
30 Day Subsurface Gravel Wetland

current operation – 382,200 gpd



Conceptual Design Details





Adsorption Material

Product	Manufacture	Bulk Density (lbs/ft^3)	Website	Price per Pound
Sorbtive™ Media	Imbrium, MD	42 to 52	http://www.imbriumsystems.com	\$1.70 to \$2.25
ACT MX®	ESFILTER™ , UT	54	http://www.esfilter.com	\$0.07 to \$0.09
Expanded Clay (Haydite)	Hydraulic Press Brick Company, IN	40 to 60	http://www.escsi.org/membermap.aspx	\$0.04 to \$0.05

Subsurface Gravel Wetland

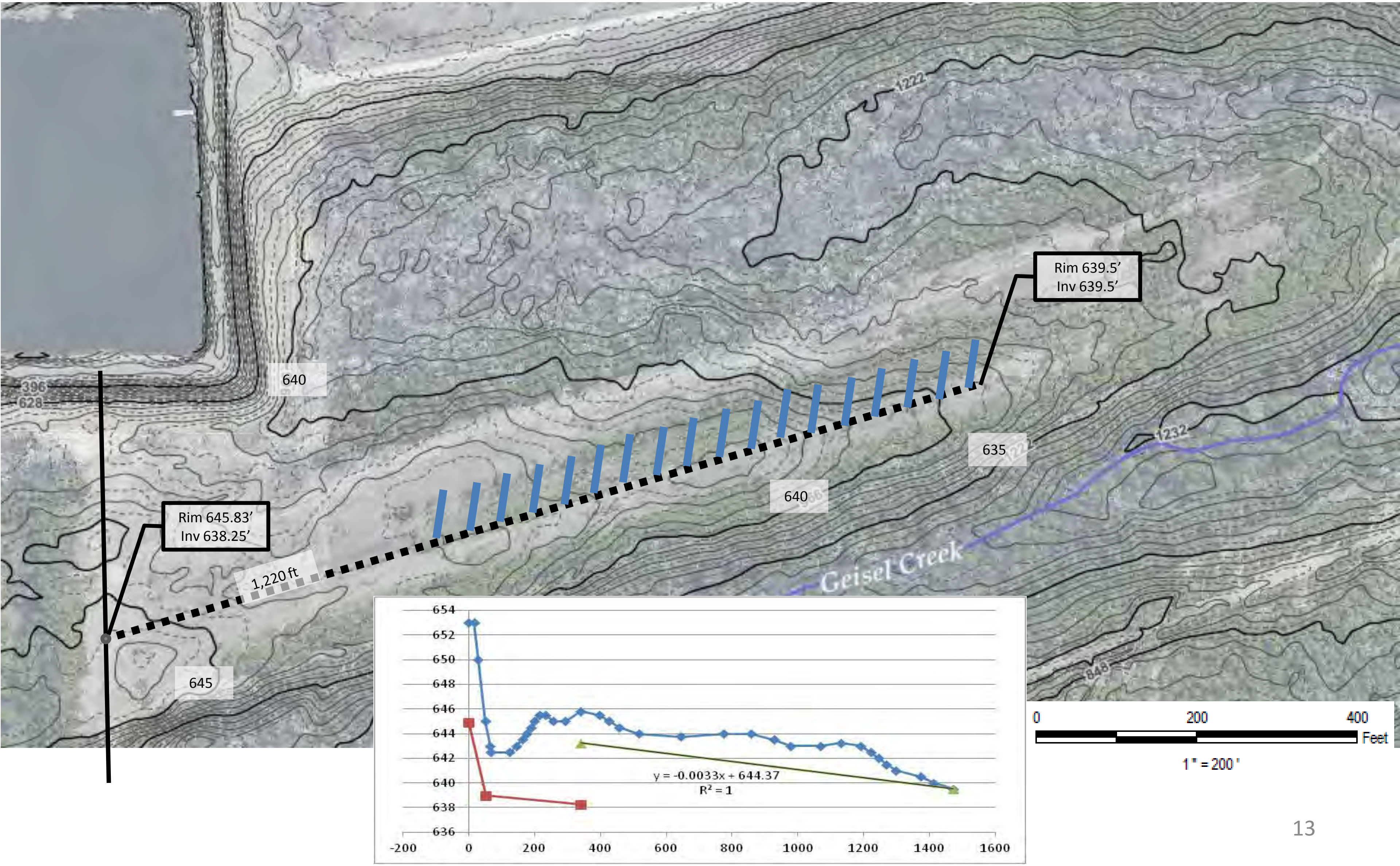
Pros

- Reduced Discharge Rate
- Reduction of P Loads
- SGW Equalize Lagoon Upsets
- Enclosed Treatment System
- Expanded Clay or Other Sorption Media for Polishing

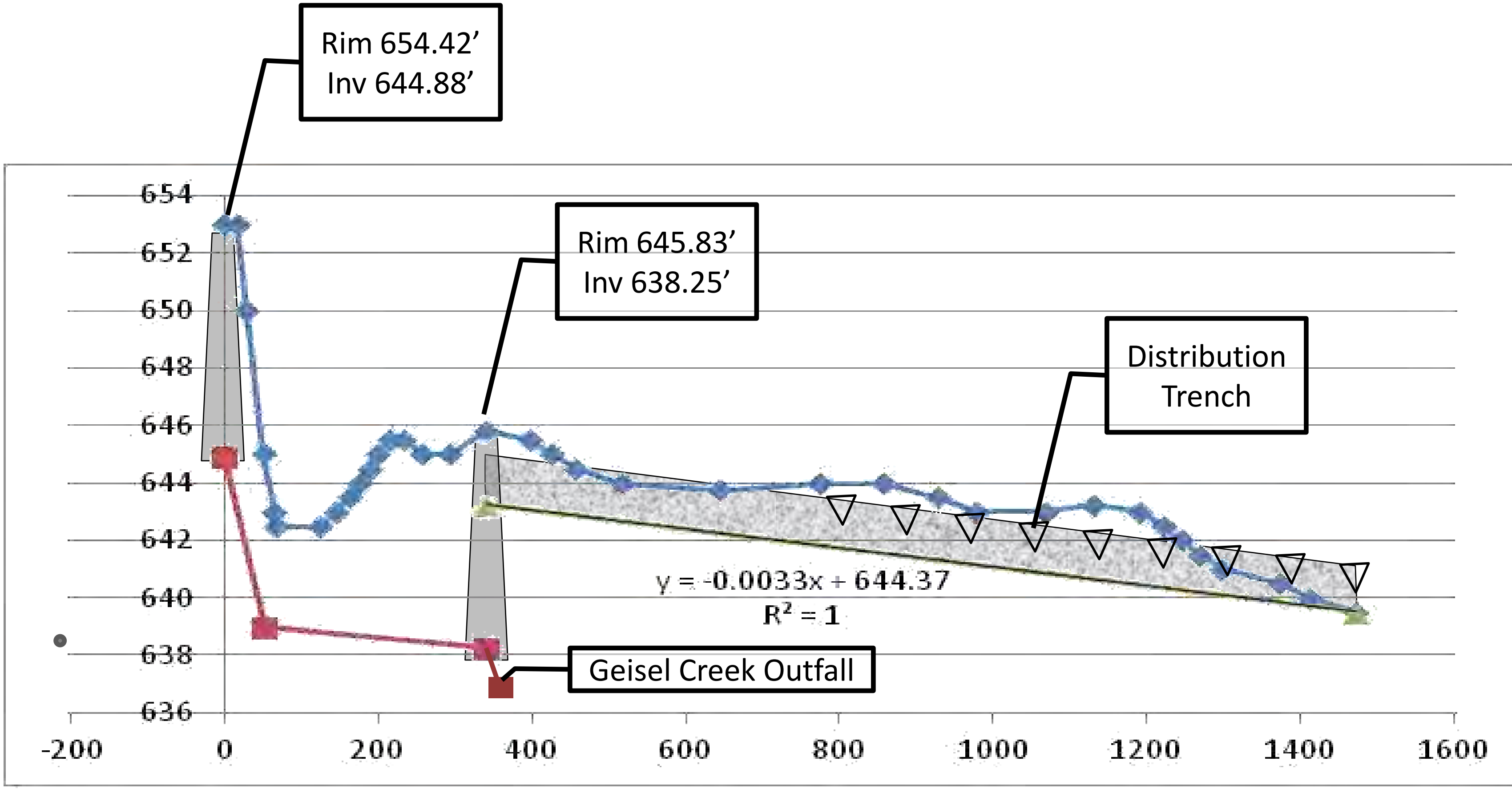
Cons

- Highest Potential for Unfavorable Wetland Impacts
  - Permitting
  - Mitigation ($70,000/ac)
- Requires Secondary P Uptake Practice
- Cost of Annual Harvesting
- Requires Discharge Pipe
- Water/Sediment Trapped in Existing 10” Pipe
- Highest Cost Option

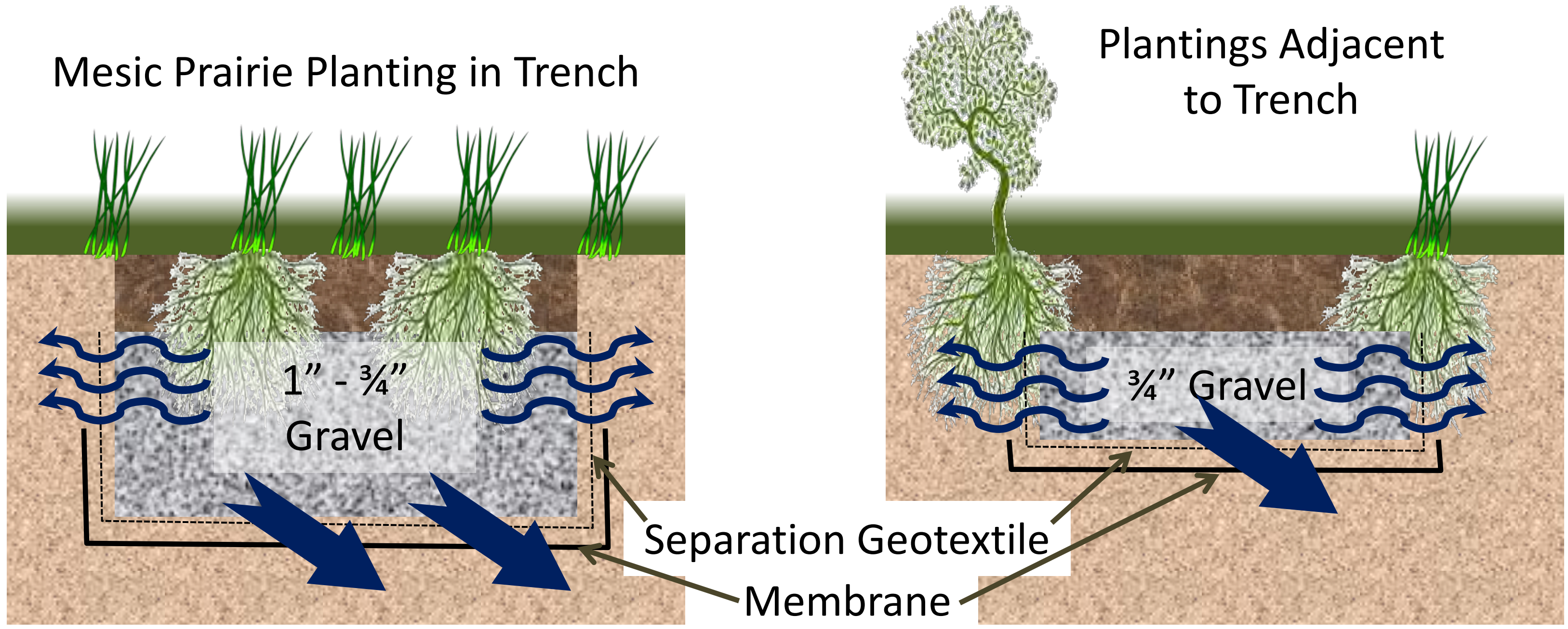
Phyto-Treatment Trench Plan



Phyto-Treatment Trench Profile



Phyto-Treatment Trench Cross Section



Transmission Trench Cross Section

Distribution Trench Cross Section

Phyto-Treatment Trench

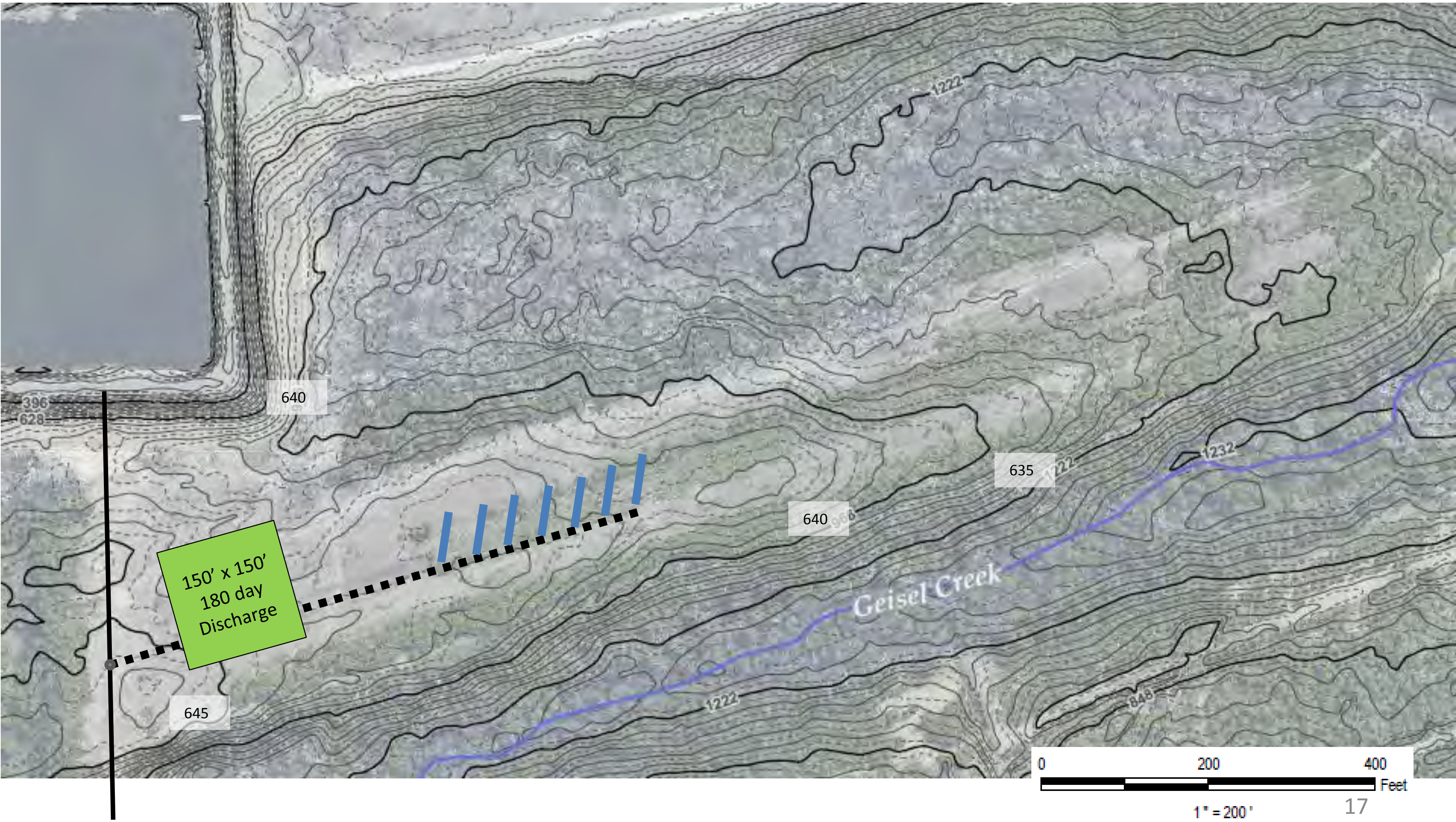
Pros

- Lowest Cost Option
- Reduced Discharge Rate
- Reduction of P Discharge to Dunes Lake
- Multi-P Uptake Mechanisms
  - Vegetation
  - Soil
  - Microbial Film (benthos)
  - Adsorption on Aggregate
- More Flexible Footprint than SGW to Avoid Wetland Impacts

Cons

- Wetland Impacts
  - Permitting
  - Mitigation ($70,000/ac)
- Performance Monitoring Difficult
- Cost of Annual Harvesting
- Treatment Rate limited by Vegetation Uptake
- Potential Impact to Adjacent Habitats

Hybrid SGW-Treatment Trench



Hybrid SGW Phyto-Treatment Trench

Pros

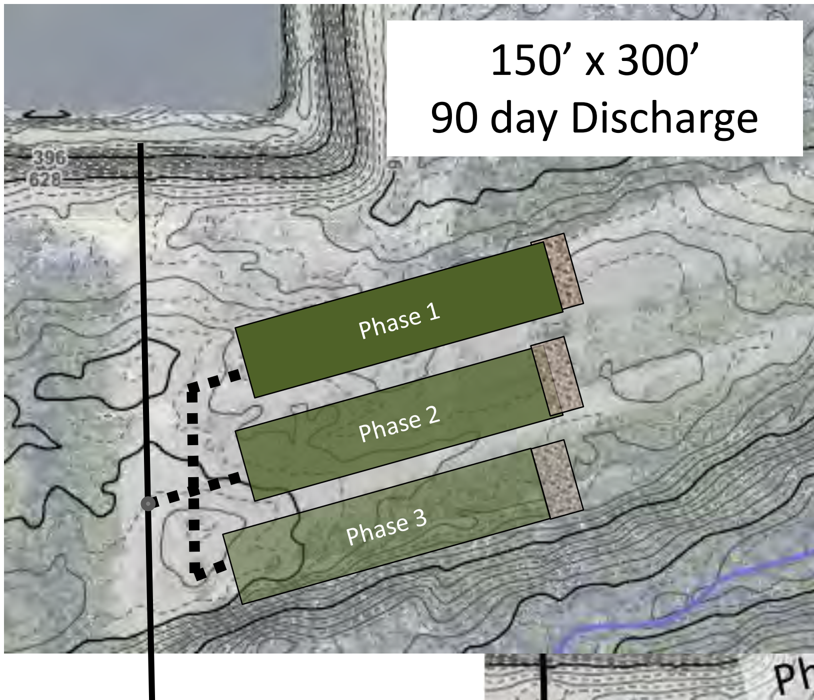
- Reduced Discharge Rate
- Reduction of P Discharge
- SGW Equalize Lagoon Upsets
- Good Initial Filter Treatment Bed
- Potentially Best Option to Avoid Wetland Impacts
- Less Permitting

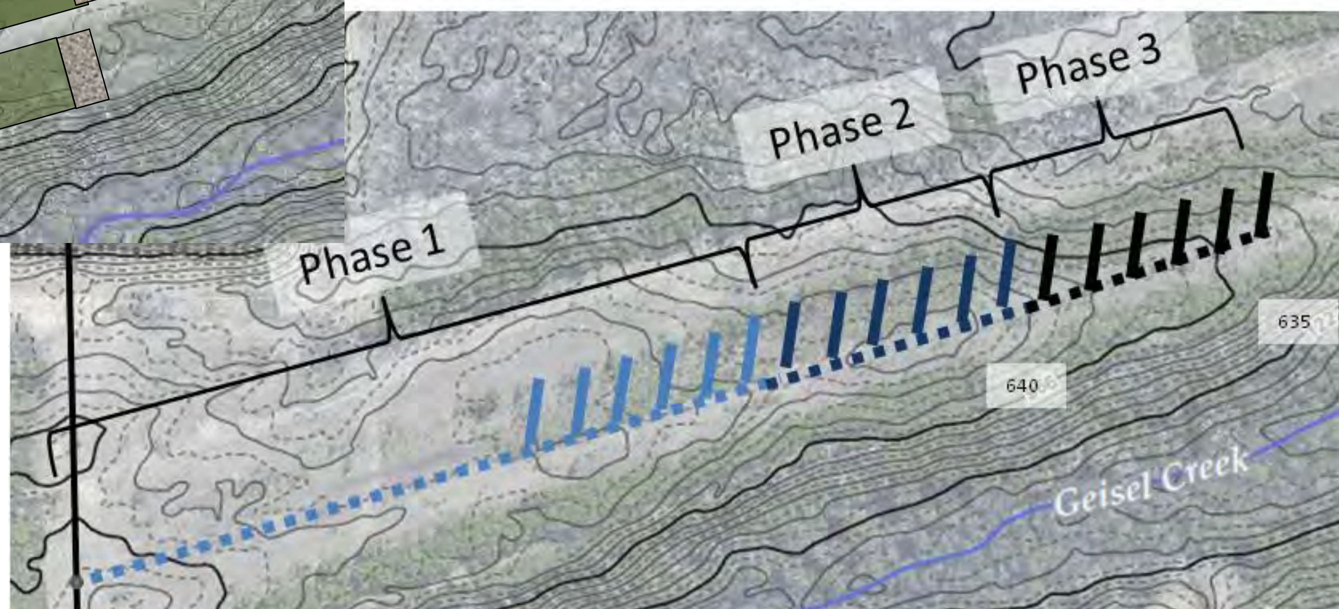
Cons

- Less Reliance on Biological P Uptake
- Operation/Maintenance
- Middle Cost Option

Phased Implementation

Adaptive Management / Budget Constraints





APPENDIX D
FUNDING OPPORTUNITIES

Funding Opportunities

Grant Name	Organization	Funding Type	Available Funds	Notes	Website URL
C.D. Besadny Conservation Grant	Enviromental Education in Wiscoinsin (EE)/Natural Resource Foundation of Wisconsin	Grant	1,000	C.D. Besadny Conservation Grant Program provides financial support organizations/ agencies working on natural resource projects and programs at a small-scale, local level.	http://eeinwisconsin.org
Clean Water Fund Pilot Projects	The Clean Water Fund Program	EIF Loan	N/A	The Clean Water Fund Program (CWFP) provides financial assistance to municipalities for wastewater treatment facilities and urban storm water runoff projects	http://dnr.wi.gov/aid/eif.html
Environmental Solutions for Communities	National Fish and Wildlife Foundation	Grant/ Cost Share	100,000	Grants are given in an effort to support sustainable agricultural practices and private lands stewardship; conserving critical land and water resources and improving local water quality; and restore and manage natural habitat, species and ecosystems.	https://ofmpub.epa.gov/apex/watershedfunding
Fish and Wildlife Management assistance	Fish and Wildlife Service	Federal Grant/Cost Sharing	Variable	The U.S. Fish and Wildlife Service (Service) requests interested entities to submit restoration, research and Regional Project proposals for the restoration of the Great Lakes Basin fish and wildlife resources,	WWW.Grants.gov
Great Lakes Fishery Trust Grants	Great Lakes Fishery Trust	Grant / Cost Share	1,000,000	Grants are available in the following categories: Ecosystem Health and Sustainable Fish Populations Ecological and biological fisheries research to inform management Habitat protection and restorationSocial, economic, and technology research to inform policy and practice	https://www.glft.org/grants
Great Lakes Protection Fund Grants	Great Lakes Protection Fund	Grant / Cost Share	Variable	The Fund invests in project teams that create, test and deploy new ways of improving the physical, chemical and biological health of the basin ecosystem.	http://glpf.org/

Funding Opportunities

Grant Name	Organization	Funding Type	Available Funds	Notes	Website URL
Great Lakes Restoration iInitiative	US EPA	Federal Grant	Variable	Applications are requested for projects involving invasive species control, watershed management implementation, and sediment reduction projects in priority watersheds	http://www.epa.gov/greatlakes/fund
Great Lakes Restoration iInitiative/ Shorline Cities Green Infrastructure Grant	U.S. EPA	Federal Grant	$250,000	Shoreline cities with a population greater than 25,000 and less than 50,000 will be eligible.	http://www.epa.gov/grtlakes/fund/shoreline/
Lake Management Planning	Wisconsin DNR	State Grant/Cost Share	25,000	Funding for qualifying local governments and tribes to collect and analyze information needed to protect and restore lakes and their watersheds	http://dnr.wi.gov/Aid/SurfaceWater.html
Lake Protection Grant	Wisconsin DNR	Federal/State Grant	200,000	Lake Protection Grants improve or protect the quality of water in lakes or the quality of natural ecosystems, implement protection activities for the lakes based on their classification and implement the recommendations of a lake management plan	http://dnr.wi.gov/Aid/SurfaceWater.html
Notice of Intent/Discharge Cost-Share Grants	DNR and the Department of Agriculture, Trade and Consumer Protection (DATCP)	Grant/ Cost Share	Variable	Eligible projects are those designed to implement best management practices (BMPs) for improving water quality impaired by pollution discharges resulting from agricultural activities.	http://dnr.wi.gov/aid/nod.html
Runoff Management Grant	Wisconsin DNR	Grant/ Cost Share	1,000,000	Grants reimburse costs for agriculture or urban nonpoint source pollution control in targeted, critical geographic areas with surface water or groundwater quality concerns.	http://dnr.wi.gov/Aid/Grants.html

Funding Opportunities

Grant Name	Organization	Funding Type	Available Funds	Notes	Website URL
Sustain our Great Lakes Grants	Sustain our Great Lakes	Grant / Cost Share	25,000 - 1.5 million	Grants have been available in the following categories: Habitat Restoration Delisting of Habitat-Related Beneficial Use Impairments	http://www.sustainourgreatlakes.org/Home.aspx
Wetland Program Development Grant	U.S. EPA	Grant/ Cost Share	500,000	Grants are intended to encourage wetlands program development by promoting research, investigations, experiments, training, demonstrations, surveys, and studies relating to the causes, effects, extent, prevention, reduction, and elimination of water pollution.	https://ofmpub.epa.gov/apex/watershedfunding
Wisconsin Coastal Management Grants	Wisconsin Costal Management Grant Program	Grant / Cost Share	N/A	Grants are available in the following categories: Coastal Wetland Protection and Habitat Restoration Nonpoint Source Pollution Control Coastal Resources and Community Planning Great Lakes Education Public Access and Historic Preservation	http://doa.wi.gov/Divisions/Intergovernmental-Relations/Wisconsin-Coastal-Management-Program-WCMP