Infiltrometer Testing

For Assessing & Modeling Grass Swales For Water Quality Credit

Prepared For The

Grand Chute

TOWN OF GRAND CHUTE

OUTAGAMIE COUNTY, WISCONSIN

DECEMBER 14, 2016

McM. No. G0003-9-14-00271

AWS:car

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I. INTRODUCTION

In 2006, the Town of Grand Chute developed a municipal wide Stormwater Management Plan to assist in complying with their WPDES Municipal Stormwater Discharge Permit. The Town's Stormwater Management Plan identified grass swales as a Best Management Practice (BMP) that provides water quality benefits for the community. In 2008, grass swales were evaluated using the best available information, including Wisconsin Department of Natural Resources (DNR) guidance documents, Natural Resources Conservation Service (NRCS) soil survey maps, and design soil infiltration rates. At that time, the design soil infiltration rates were selected from Table 2 of Wisconsin DNR Conservation Technical Standard No. 1002 – Site Evaluation for Stormwater Infiltration.

On November 24, 2010, the Wisconsin DNR issued a new guidance document that provides a basis for assessing and modeling grass swales for water quality credit. The 2010 Wisconsin DNR guidance document outlines a procedure for determining appropriate design infiltration rate(s), including measuring the soil infiltration rate in the field using a double-ring infiltrometer test. The soil infiltration rate is a required input variable within the WinSLAMM water quality computer model that is used to evaluate the water quality benefits provided by a specific grass swale. Since a majority of the Town's surface drainage is comprised of grass swales, the Town decided to perform double-ring infiltrometer tests along swales within their developed urban area.

The purpose of this report is to summarize the results of the performed double-ring infiltrometer tests and describe how the results were used to determine appropriate design soil infiltration rates. For reference, a copy of the 2010 Wisconsin DNR grass swale guidance document can be found within Appendix B.

II. STUDY AREA

The study area is depicted in Figure 1 within Appendix A and defines the developed urban area within the Town. The study area was developed using 2010 census urban maps and other Wisconsin DNR guidance. Figure 1 also depicts the locations of the double-ring infiltrometer tests and the various types of surface drainage present within the study area.

III. SOILS

Soil information was obtained from the U.S. Department of Agriculture (USDA) / NRCS Web Soil Survey at http://websoilsurvey.nrcs.usda.gov/. Specifically, the soil survey from *Outagamie County (WI087)* was needed for the study area. The USDA / NRCS have classified soil types into four Hydrologic Soil Groups (HSG). The four hydrologic soil groups (i.e. A, B, C and D) are classified according to the minimum infiltration rate of the soil column. Group A soils have the highest infiltration rate or lowest runoff potential, whereas Group D soils have the lowest infiltration rate or highest runoff potential. The infiltrometer tests were performed along grass swales with various underlying hydrologic soil textures and HSG's in order to provide representative soil information within the study area. The USDA / NRCS Soils information and locations of the double-ring infiltrometer tests are depicted in Figure 2 within Appendix A.

IV. INFILTROMETER TESTING

The 2010 Wisconsin DNR grass swale guidance document outlines a procedure for measuring the soil infiltration rate of a grass swale in the field using a double-ring infiltrometer test. Specifically, the 2010 Wisconsin DNR grass swale guidance document allows for several modifications to the procedures in ASTM D3385. The purpose of these modifications is to provide a more cost-effective approach to obtaining a reasonable estimate of the soil infiltration rates within existing grass swales. For reference, the field test procedure for the double-ring infiltrometer tests are described in the 2010 Wisconsin DNR grass swale guidance document found in Appendix B.

A total of 20 double-ring infiltrometer tests were performed along various existing grass swales within the study area. The locations of test sites are depicted in Figures 1-3 within Appendix A.

Double-Ring Infiltrometer Test

Per the 2010 Wisconsin DNR grass swale guidance document, the lowest infiltration rate observed at each test location is considered the static soil infiltration rate. The static soil infiltration rate at each test site is then reduced by 50% to represent the dynamic soil infiltration rate. The dynamic soil infiltration rate is ultimately used to model a specific grass swale within the WinSLAMM water quality model. For reference, the infiltrometer test results and photos for each test location are included in Appendix C.

V. RESULTS

The results from the 20 individual double-ring infiltrometer tests are provided in Table 1 within Appendix C. To assist with analyzing the infiltrometer test results, the design infiltration rates based on the underlying USDA / NRCS soil textures at each test location were also provided within Table 1. The design infiltration rates were taken from Table 2 of Wisconsin DNR Conservation Technical Standard No. 1002 – Site Evaluation for Stormwater Infiltration. As shown in Table 1 within Appendix C, the measured dynamic soil infiltration rates are considerably higher than the design soil infiltration rates from Table 2 of Wisconsin DNR Conservation Technical Standard No. 1002. In addition, several test locations had very high measured dynamic soil infiltration rates (> 3.60 in/hr). Table 2 of Wisconsin DNR Conservation Technical Standard No. 1002 – Site Evaluation for Stormwater Infiltration lists 3.6 in/hr as the highest design infiltration rate for a sandy soil. In order to provide more appropriate and representative results, it was determined that any measured dynamic soil infiltration rate that was greater than 3.60 in/hr should be removed from the data set. As such, the results from test locations 4, 7, 8, 10-12, 14, 17, 18 and 20 were removed from the data set due to their measured dynamic soil infiltration rate being greater than 3.60 in/hr.

The 2010 Wisconsin DNR grass swale guidance states that the geometric mean of the test results shall be used to determine an 'average' infiltration rate. However, equally important is to consider whether the measured infiltration rates should be 'grouped' in order to apply separate geometric means to different areas. Grouping of results may be done based on soil type, spatial reasons or done as a method to help provide more representative results. After reviewing the data, it was determined that the remaining measured dynamic soil infiltration rates should be 'grouped' by their associated HSG as depicted in Table 2 within Appendix C. The 'average' dynamic infiltration rate was determined by taking the geometric mean of the data set for each HSG. Table V-1 below summarizes the 'average' dynamic infiltration rates determined for each of the four HSG's.

Table V-1

Dynamic Infiltration Rates

Hydrologic Soil Group (HSG)	'Average' Dynamic Infiltration Rate (in./hr.)
A	0.75
B	0.86
C	0.81
D	0.47

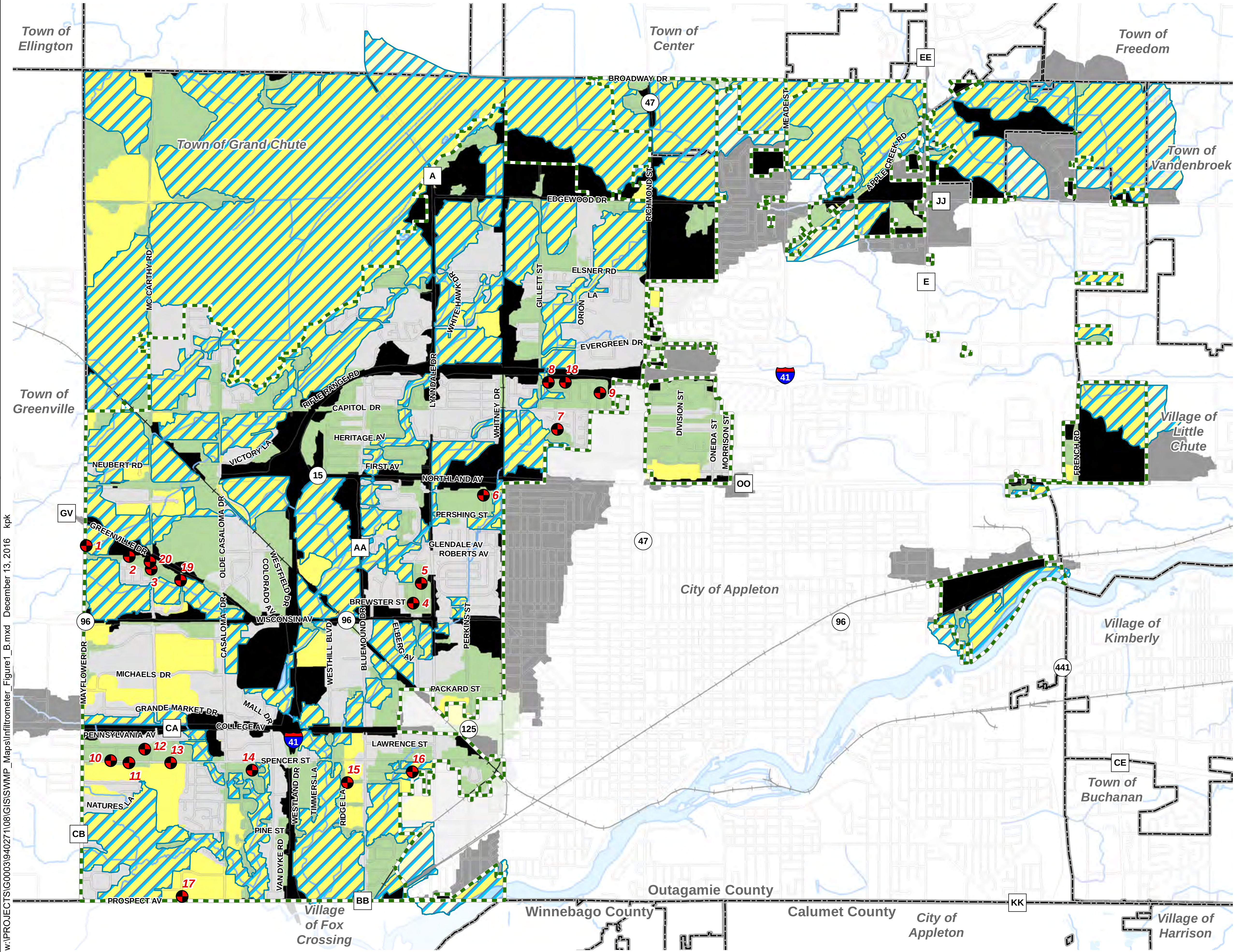
Figure 3 within Appendix A depicts the 'average' dynamic soil infiltration rates based on the underlying HSG within the study area. Ultimately, this information will be used to calculate a composite dynamic soil infiltration rate for a particular grass swale catchment area based on the acreage of the underlying HSG(s) and corresponding average dynamic infiltration rate. This composite dynamic soil infiltration rate will be input to the WinSLAMM water quality model to evaluate the water quality credits provided by any of the Town's grass swales.

VI. SUMMARY

In summary, the double-ring infiltrometer tests performed have provided a basis for determining the representative dynamic soil infiltration rates for grass swales within the study area. The 'average' dynamic soil infiltration rates determined from this report will be used to evaluate the water quality credits provided by any of the Town's grass swales. The water quality credits provided by Town grass swales can be found in the Towns Municipal-Wide Stormwater Quality Management Plan.

APPENDIX A

FIGURES



Surface Drainage

- Curb and Gutter
- No Controls
- Grass Swale

Other Mapped Features

- Infiltrometer Test Location and ID
- Urban Planning Boundary
- Municipal Boundary
- Right-of-Way
- Railroad Centerline
- Stream
- Surface Water
- Riparian Area
- MS4 'A' to 'B' Area

Source: Outagamie County, 2014-15; Winnebago County, 2014-16; Calumet County.

Disclaimer: The property lines, right-of-way lines, and other property information on this drawing were developed or obtained as part of the County Geographic Information System or through the County property tax mapping function. McMAHON does not guarantee this information to be correct, current, or complete. The property and right-of-way information are only intended for use as a general reference and are not intended or suitable for site-specific uses. Any use to the contrary of the above stated uses is the responsibility of the user and such use is at the user's own risk.

0 3,500 7,000 Feet

Grand Chute

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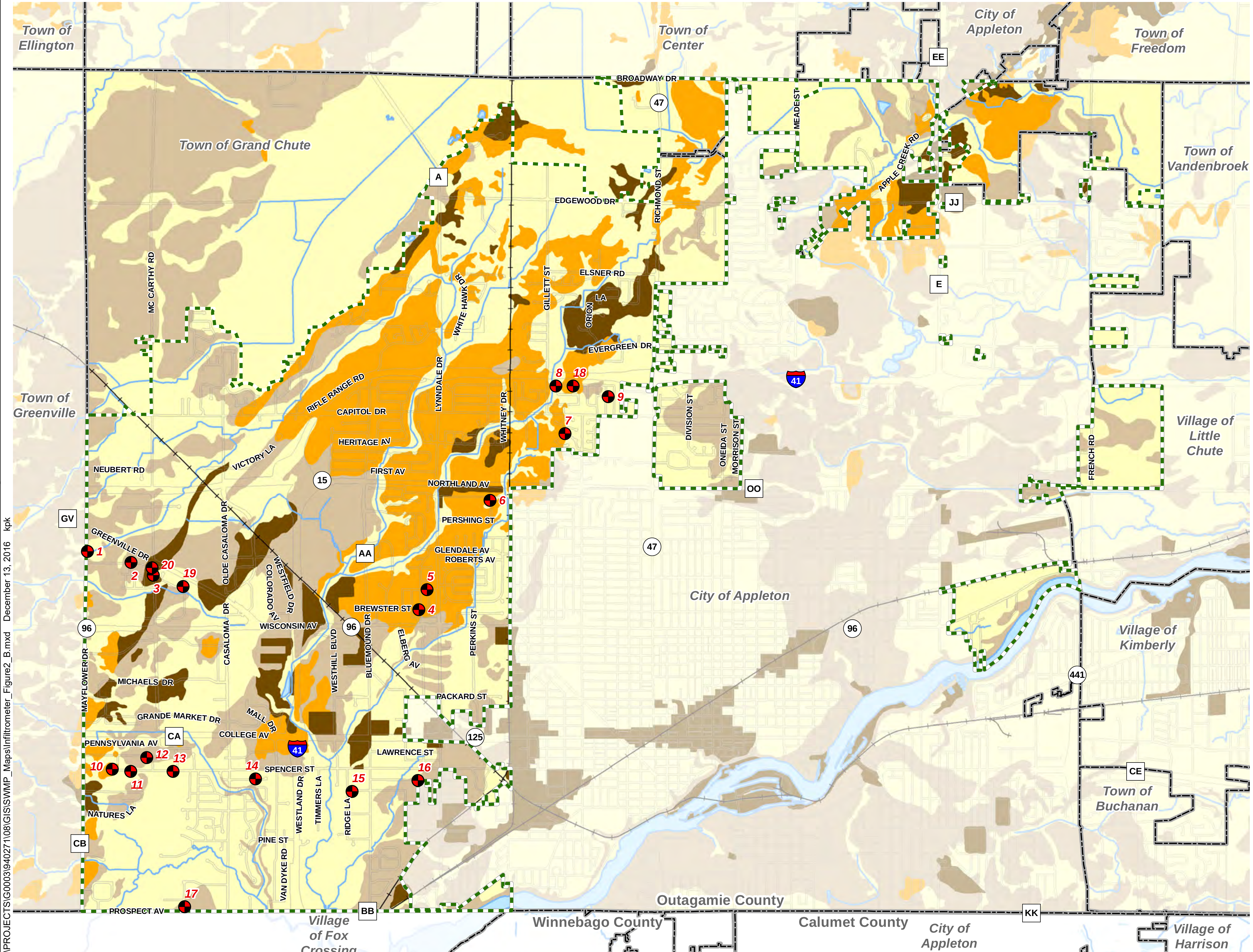
FIGURE 1
STUDY AREA
GRASS SWALE
INFILTROMETER TESTING
TOWN OF GRAND CHUTE
OUTAGAMIE COUNTY, WISCONSIN

w:\PROJECTS\G0003\94027\08\GIS\SWMP_Maps\Infiltrometer_Figure1_B.mxd December 13, 2016 kpk



Hydrologic Soil Group (HSG)

- HSG A
- HSG B
- HSG C
- HSG D

Other Mapped Features

- Infiltrometer Test Location and ID
- Urban Planning Boundary
- Municipal Boundary
- Right-of-Way
- Railroad Centerline
- Stream
- Surface Water

Source: Outagamie County, 2014-16; Winnebago County, 2014-16; Calumet County, 2014-15; USDA, 2014.

Disclaimer: The property lines, right-of-way lines, and other property information on this drawing were developed or obtained as part of the County Geographic Information System or through the County property tax mapping function. McMAHON does not guarantee this information to be correct, current, or complete. The property and right-of-way information are only intended for use as a general reference and are not intended or suitable for site-specific uses. Any use to the contrary of the above stated uses is the responsibility of the user and such use is at the user's own risk.

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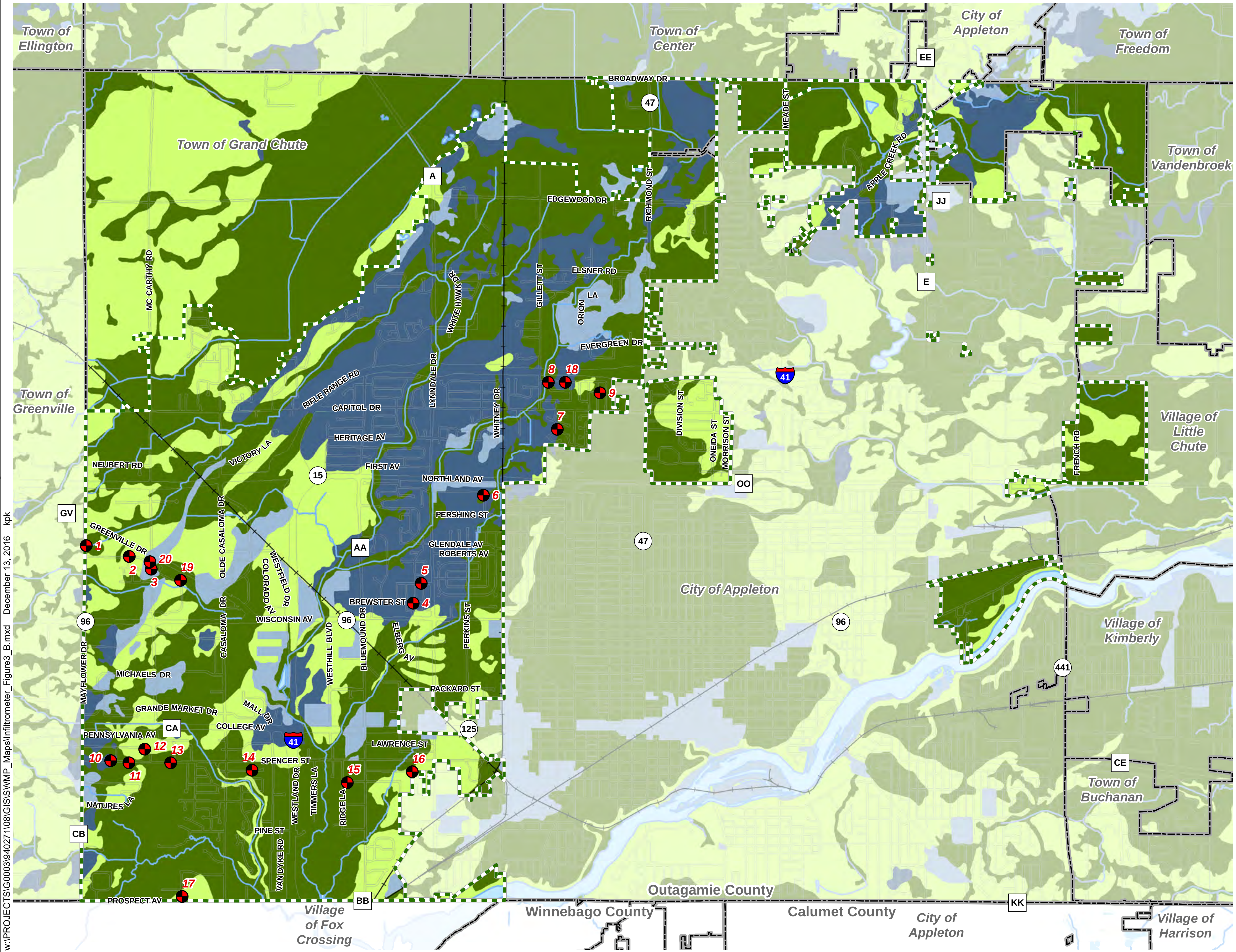
FIGURE 2
SOILS AND TEST LOCATIONS
GRASS SWALE
INFILTROMETER TESTING
TOWN OF GRAND CHUTE
OUTAGAMIE COUNTY, WISCONSIN

w:\PROJECTS\G0003\94027\108\GIS\SWMP_Maps\Infiltrometer_Figure2_B.mxd December 13, 2016 kpk



Grand Chute

Average Infiltration Rates (Inches Per Hour)

- 0.75
- 0.86
- 0.81
- 0.47

Other Mapped Features

- Infiltrometer Test Location and ID
- Urban Planning Boundary
- Municipal Boundary
- Right-of-Way
- Railroad Centerline
- Stream
- Surface Water

Source: Outagamie County, 2014-16; Winnebago County, 2014-16; Calumet County, 2014-15; USDA, 2014.

Disclaimer: The property lines, right-of-way lines, and other property information on this drawing were developed or obtained as part of the County Geographic Information System or through the County property tax mapping function. McMAHON does not guarantee this information to be correct, current, or complete. The property and right-of-way information are only intended for use as a general reference and are not intended or suitable for site-specific uses. Any use to the contrary of the above stated uses is the responsibility of the user and such use is at the user's own risk.

0 3,500 7,000 Feet

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FIGURE 3
INFILTRATION RATES
GRASS SWALE
INFILTROMETER TESTING
TOWN OF GRAND CHUTE
OUTAGAMIE COUNTY, WISCONSIN

APPENDIX B

WISCONSIN DNR GRASS SWALE GUIDANCE DOCUMENT

State of Wisconsin

CORRESPONDENCE/MEMORANDUM

DATE: November 24, 2010

TO: Regional Water Leaders, Basin Leaders and Experts
Storm Water Permit Staff (via email)

FROM: Russ Rasmussen, Director, Bureau of Watershed Management
DNR Storm Water Permit Engineers

SUBJECT: Process to Assess and Model Grass Swales for ss. NR 151.13(2) and NR 216.07(6), Wis. Adm. Code - Total Suspended Solids Reduction

This document is intended solely as guidance, and does not contain any mandatory requirements except where requirements found in statute or administrative rule are referenced. This guidance does not establish or affect legal rights or obligations, and is not finally determinative of any of the issues addressed. This guidance does not create any rights enforceable by any party in litigation with the State of Wisconsin or the Department of Natural Resources. Any regulatory decisions made by the Department of Natural Resources in any matter addressed by this guidance will be made by applying the governing statutes and administrative rules to the relevant facts. ***This guidance document supersedes the guidance document on Dated April 24, 2008 and subsequent erratas dated August, 2008 and April, 2009.***

Issue

Under s. NR 151.13(2), Wis. Adm. Code, a municipality subject to the municipal storm water permit requirements of s. NR 216.07(6), Wis. Adm. Code, must implement a 20% reduction in total suspended solids (TSS), by March 10, 2008 or 24 months from coverage under the Municipal Separate Storm Sewer System (MS4) general permit, and a 40% TSS reduction by March 10, 2013. This memorandum provides DNR staff with guidance to advise affected municipalities and their consultants on how to evaluate grassed swales in the developed urban area for water quality credit. (This guidance does not address design of grassed swales to serve new development. The Vegetated Infiltration Swale, Interim Technical Standard, No. 1005 provides information on construction of new grassed swales.)

Discussion

To meet the requirements of the MS4 permit and the TSS reduction goal of s. NR 151.13(2), Wis. Adm. Code, a municipality must assess existing best management practices (BMPs) for TSS control and propose additional BMPs if the performance standard cannot be met with existing practices. One BMP available to many permitted municipalities is the grassed swale. This guidance provides a basis for assessing and modeling swales for TSS reduction to foster consistent application of this practice in all permitted municipalities. The goals of this guidance are to:

- Determine which water quality swales in the MS4 are eligible to receive TSS reduction credit, and
- Identify a typical swale geometry that can be considered representative. (It may be appropriate to develop more than one typical swale geometry if the swale characteristics in the MS4 are highly variable.)

DNR Guidance

Step 1. Identify which swales in the municipality can be considered water quality swales for the purpose of meeting the 20% and 40% TSS reduction goal.

The following apply to all swales in the developed urban area if they are to be considered water quality swales:

A. Swales are not required to have pretreatment swales or equivalent pretreatment.
B. The longitudinal slope must be less than 4% unless slope interruption devices are installed in the swales to ensure low flow velocities. Slope interruption devices must be consistent with Ditch Check Technical

Standard, No. 1062. Swales with slope interruption devices will be evaluated using a modified longitudinal slope of 1%.

C. The Department is concerned about channel scouring and re-suspension of previously settled particles in swales that are being used for MS4 pollutant removal credit. To address this concern, all swales should be inspected for visual evidence of scour. Swales with visual evidence of scour, such as channel cuts in the bottom or areas of bare soil, can not be included.

There are two ways of identifying water quality swales within an MS4:

A. If swale survey data is available, determine the locations of water quality swales and arrive at typical swale geometry based on statistical methods.
B. In the absence of survey data, a desktop and field survey would be appropriate. The desktop and field procedure is as follows:

1. Identify potential water quality swale areas by using available topographic, land use and soil information.

2. Based on results of the desktop evaluation, select a representative number of typical swale locations in the MS4 by conducting a field survey. A minimum of five locations should be selected. At each location:

   - Measure the width of the swale bottom using a tape measure.
   - For side slopes, measure the vertical drop over the level length using a carpenter's level and tape measure.
   - Select at least three cross-sections of the swale and average the results to determine the bottom width and side slopes.
   - Determine longitudinal slope using 2-ft contour mapping or other available topographic information.

3. Use the typical swale geometry that best represents each drainage area.

Step 2. Model the swales identified in **Step 1.** using a model such as SLAMM or P8.

When modeling swales in SLAMM or P8 the following must be considered:

How should drainage basins with a mix of swale and storm sewer conveyance systems be evaluated?

Drainage basins with a combination of swales and storm sewer should be subdivided by conveyance system type and the subdivisions modeled separately. In SLAMM, swales need to be modeled separately because drainage system type (e.g., swale vs. storm sewer) cannot be assigned to individual source areas.

Where swale density varies within a modeled area, the swale density should be an area weighted average across the model area. For example, if a 100 acre modeled area has 90 acres of residential land use with an average swale density of 359 ft/acre and 10 acres of strip commercial with an average swale density of 412 ft/acre then the area weighted average across modeled area is [(90 x 359) + (10 x 412)] / 100 = 364 ft/acre.

Table 1 identifies the average swale density used in the standard land use files from SLAMM version 9.2. It is recommended that rather than using these averages, the municipality should identify the actual swale density for each of the representative areas.

TABLE 1

Land use	Swale Density (ft/acre)
Low density residential	238
Medium density residential	359
High density residential	385
Strip commercial	412
Shopping centers	92
Industrial	265
Freeway (Shoulder only)	1309
Freeway (Shoulder and Center)	1964

Note: These average swale density figures are from the SLAMM version 9.2 Standard Land Use files available on the USGS website at: http://wi.water.usgs.gov/slamm/

Should swales be modeled using the "wetted perimeter" or "typical swale geometry" option?

The typical swale geometry option must be used. Both SLAMM and P8 calculate wetted perimeter from the geometry for each storm event, which is more accurate than a user selected defined wetted perimeter.

What Manning's "n" should be used for the typical swale geometry[1]?

A Manning's "n" value of 0.30 or less is recommended, based on type of vegetation, mowing height and depth of flow. Supporting documentation should be provided if Manning's "n" values greater than 0.30 are used

How should the infiltration rate be determined?

The guidance provided in the Site Evaluation for Stormwater Infiltration Technical Standard, No. 1002 should be followed. The swale infiltration rate should be determined based on the representative soil texture identified in the NRCS soil survey or other soil data if available. When the representative soil texture has been determined, the appropriate design infiltration rate should be selected from Table 2 of the Technical Standard, No. 1002. If the infiltration rate is measured in the field using a scientifically credible field test method, the measured value can be used for the static infiltration rate without using the correction factors in Table 3 of Technical Standard, No. 1002. **Prior to entering an infiltration rate in the model, the design infiltration rate from Table 2, or the measured infiltration rate must be reduced by 50%.** The SLAMM default "infiltration rate by soil type" values should not be used.

Existing language in Technical Standard 1002 V. Step C. 4.b indicates that a measured infiltration rate using a double-ring infiltrometer test must follow the requirements of ASTM D3385. While this may be appropriate for designing new swales, is there any flexibility for measuring an existing swale using a double-ring infiltrometer test?

To determine the static infiltration rate of existing swales using a double-ring infiltrometer the following modifications to procedures in ASTM D3385 are allowed:

While the dimension and materials used for the double-ring should be based on the requirements of ASTM D3385, the infiltration rate can be measured in a time frame of a minimum of 2 hours instead of 24 hours and the water level in both rings does not have to stay constant during the test. The following procedure is a more cost-effective

[1] SLAMM version 9.3 will adjust Manning's "n" based on flow, swale geometry and vegetative retardance classifications

approach to obtaining a reasonable estimate of the infiltration rate of existing grass swales. For most soil types the infiltration rate measured by the procedure should represent the soils under more saturated conditions. Sandier soil types might not be represented by saturated conditions, but the higher infiltration rate will probably represent reality for the duration of most storm events. The lowest infiltration rate observed is the one to be used for estimating the TSS reduction for the swales and is considered a static infiltration rate. The static rate should be cut in half to represent the dynamic infiltration rate in the model.

Field Test Procedure for Double-Ring Infiltrometer

1. Select a relatively flat test area so that the double-ring infiltrometer will not be placed at an angle.
2. Cut the grass to a height of between two to four inches.
3. Gently drive the infiltrometer into the ground.
4. Inspect the soil seal around each ring to make sure that it is even and smooth.
5. Pour clean water into the inner chamber and allow it to overflow and fill up the outer ring. Maintain a level in the outer ring approximately equal to the level in the inner ring.
6. Add more water to both rings when the level in the inner ring has dropped a measurable amount. For most soil types this should be less than an inch.
7. Repeat this step until the rate the water level drops begins to decline.
8. When the rate of decline begins to slow, bring the water level up to the top and start timing the decrease in water level.
9. Record the start time.
10. Stop timing when the water level in the inner ring has gone down a measureable level (the ASTM standard requires keeping the water level constant). Timing the rate of decline should probably be started almost immediately for more clayey soils, since it might be difficult to observe when the rate change has slowed.
11. Record the time, elapsed time, and change in water level.
12. Refill both rings and restart the timing.
13. Record the time, elapsed time, change in water level, and the elapsed time since the beginning of the first measurement.
14. Repeat the timing steps until the infiltration rate has become relatively constant or the test has been conducted for a minimum of two hours. (The ASTM standard requires 24 hours).
15. The measured rate of infiltration is considered a static infiltration rate. The dynamic infiltration rate is ½ the static rate. Be aware some models, such as WinSLAMM, call for the dynamic rate for swales.

I have taken a number of measurements along a swale length and have several infiltration rates to average. How do I average the results of my in-field tests?

The geometric mean(s) of infiltration testing results should be used. However, equally important is to consider whether the measured infiltration rates should be 'grouped' in order to apply separate geometric means to different areas in order to provide representative TSS results across a municipality. Grouping of results might be done based on soil type, spatial reasons or simply done as a method to help provide representative results. For instance, if there are several relatively low infiltration rates measured and the geometric mean of the entire data set is quite high, it may be prudent to group the relatively low rates together and assign them to a representative area.

Note: In order to calculate a geometric mean, the data set of values must be greater than zero. Where the infiltration rate is too low to measure, a rate of 0.03 in/hr may be used to calculate a geometric mean of the data set.

Are velocity calculations required?

The swales that were not eliminated by visual inspection should be evaluated for scour and re-suspension using the results of velocity or shear stress calculations conducted at the representative swale locations from **Step 1**. Velocity or shear stress calculations should be conducted based on the peak discharge rate for a 2-yr, 24-hr design event (or a reasonably equivalent event from the SLAMM or P8 rainfall file for the area) to verify that scour and re-suspension will not be a problem.

Do water quality swales need to meet the slope parameters identified in Vegetated Infiltration Swale, Interim Technical Standard, No. 1005?

If functioning as vegetated conveyance systems, swales with longitudinal slope less than 1% can be used. However, there is concern that swales with slopes less than 1% can clog. Where visual evidence indicates that the infiltration rate has been reduced (e.g., significant duration of ponded water or evidence of wetland vegetation), infiltration rates appropriate for clay soils should be used.

How do I model road runoff that sheet flows off the road and is dispersed with no apparent concentrated flow path?

For roads where runoff sheet flows off to the side of the road and is dispersed into adjacent pervious areas with no concentrated flow path in the vicinity, the roadway would be considered a disconnected impervious surface. Currently, SLAMM does not have the option of disconnecting a roadway, whereas rooftops and driveways can be disconnected. Therefore, an alternative method is needed to give treatment credit for such a system. If there is no concentrated flow path near the roadway and the runoff is dispersed as sheet flow across healthy vegetated areas, model this as a very broad, flat swale unless there is an option to model it as a vegetated filter strip.

Approved By:

Gordon Stevenson

Gordon Stevenson, Chief
Runoff Management Section

Errata for Process to Assess and Model Existing Grass Swales (TSS Reduction)
Modifications to Double-Ring Infiltrometer Test Procedures in Technical Standard 1002

Existing language in Technical Standard 1002 V. Step C. 4.b.:
Measured Infiltration Rate - The tests shall be conducted at the proposed bottom elevation of the infiltration device. If the infiltration rate is measured with a Double-Ring Infiltrometer the requirements of ASTM D3385 shall be used for the field test.

Modifications to procedures in ASTM D3385:

If the infiltration rate is measured with a Double-Ring Infiltrometer, the dimension and materials used for the double-ring should be based on the requirements of ASTM D3385. The following procedure should be used when using the double-ring infiltrometer for a field test in an existing grass swale. The procedure differs from the field procedures in ASTM D3385 by accepting the infiltration rate measured in a time frame of a minimum of 2 hrs. instead of 24 hours and the water level in both rings does not have to stay constant during the test. The procedure is a more cost-effective approach to obtaining a reasonable estimate of the infiltration rate of existing grass swales. For most soil types the infiltration rate measured by the procedure should represent the soils under more saturated conditions. More sandy soil types might not be represented by saturated conditions, but the higher infiltration rate will probably represent reality for the duration of most storm events. The lowest infiltration rate observed is the one to be used for estimating the TSS reduction for the swales and is considered a static infiltration rate. The static rate should be cut in half to represent the dynamic infiltration rate required by WinSLAMM.

Field Test Procedure for Double-Ring Infiltrometer

1. Select a relatively flat test area so that the double-ring infiltrometer will not be placed at an angle.
2. Cut the grass to a height of between two to four inches.
3. Gently drive the infiltrometer into the ground.
4. Inspect the soil seal around each ring to make sure that it is even and smooth.
5. Pour clean water into the inner chamber and allow it to overflow and fill up the outer ring. Maintain a level in the outer ring approximately equal to the level in the inner ring.
6. Add more water to both rings when the level in the inner ring has dropped a measurable amount. For most soil types this should be less than an inch.
7. Repeat this step until the rate the water level drops begins to decline.
8. When the rate of decline begins to slow, bring the water level up to the top and start timing the decrease in water level.
9. Record the start time.
10. Stop timing when the water level in the inner ring has gone down a measureable level (the ASTM standard requires keeping the water level constant). Timing the rate of decline should probably be started almost immediately for more clayey soils, since it might be difficult to observe when the rate change has slowed.
11. Record the time, elapsed time, and change in water level.
12. Refill both rings and restart the timing.
13. Record the time, elapsed time, change in water level, and the elapsed time since the beginning of the first measurement.
14. Repeat the timing steps until the infiltration rate has become relatively constant or the test has been conducted for a minimum of two hours. (The ASTM standard requires 24 hours).
15. The measured rate of infiltration is considered a static infiltration rate. The dynamic infiltration rate is ½ the static rate. Be aware some models, such as WinSLAMM, call for the dynamic rate for swales.

APPENDIX C

INFILTROMETER TESTING RESULTS & PHOTOS

TOWN OF GRAND CHUTE
INFILTROMETER TESTING / DESIGN INFILTRATION RATES

TABLE 1
GRASS SWALE INFILTROMETER TEST RESULTS

Test #	NRCS Soil Symbol	NRCS Soil Name	Hydrologic Soil Group (HSG)	NRCS Surface Soil Texture	[2]Design Infiltration Rate	[1]NRCS Representative Soil Texture	Measured Static Infiltration Rate (in/hr)	[3]Measured Dynamic Infiltration Rate (in/hr)
1	Pe	Pella	B/D	silt loam	0.13	silt loam	4.50	2.25
2	HrB	Hortonville	C	silt loam	0.13	silt loam	4.50	2.25
3	MeB	Manistee	A	loamy fine sand	0.50	sandy loam	1.50	0.75
4	MfB	Manistee	A	fine sandy loam	0.50	sandy loam	18.75	9.38
5	GrB	Grays	B	silt loam	0.13	silt loam	4.50	2.25
6	MuA	Mundelein	B	silt loam	0.13	silt loam	0.25	0.13
7	NfB	Nichols	B	very fine sandy loam	0.50	sandy loam	28.13	14.07
8	Ke	Keowns	B/D	silt loam	0.13	silt loam	52.50	26.25
9	KhB	Kewaunee	C	silt loam	0.13	silt loam	0.33	0.17
10	CcB	Casco	B	loam	0.24	loam	41.25	20.63
11	MtA	Mosel	C	silt loam	0.13	silt loam	51.00	25.50
12	HeB	Hebron	B	loam	0.24	loam	29.25	14.63
13	Po	Poygan	D	silty clay loam	0.04	silty clay loam	0.94	0.47
14	WnB	Winneconne	C	silty clay loam	0.04	silty clay loam	12.75	6.38
15	WnA	Winneconne	C	silty clay loam	0.04	silty clay loam	5.25	2.63
16	BtA	Briggsville	C	silt loam	0.13	silt loam	3.00	1.50
17	KoB	Kolberg	C	silt loam	0.13	silt loam	15.00	7.50
18	NfB	Nichols	B	very fine sandy loam	0.50	sandy loam	120.00	60.00
19	MtA	Mosel	C	silt loam	0.13	silt loam	0.47	0.24
20	MeB	Manistee	A	loamy fine sand	0.50	sandy loam	30.00	15.00

- Removed from the data set, measured dynamic infiltration rate greater than 3.60 in /hr

[1]Least permeable soil horizon 5' below infiltration system

[2]From 1002 Code (Site Evaluation for Stormwater Infiltration)

[3]Dynamic infiltration rate is 50% of static infiltration rate; Input into WinSLAMM for grass swale modeling

TABLE 2
GRASS SWALE INFILTROMETER TEST RESULTS

Test #	NRCS Soil Symbol	NRCS Soil Name	Hydrologic Soil Group (HSG)	Measured Static Infiltration Rate (in/hr)	Measured Dynamic Infiltration Rate (in/hr)
3	MeB	Manistee	A	1.50	0.75
5	GrB	Grays	B	4.50	2.25
6	MuA	Mundelein	B	0.25	0.13
1	Pe	Pella	B	4.50	2.25
2	HrB	Hortonville	C	4.50	2.25
9	KhB	Kewaunee	C	0.33	0.17
15	WnA	Winneconne	C	5.25	2.63
16	BtA	Briggsville	C	3.00	1.50
19	MtA	Mosel	C	0.47	0.24
13	Po	Poygan	D	0.94	0.47

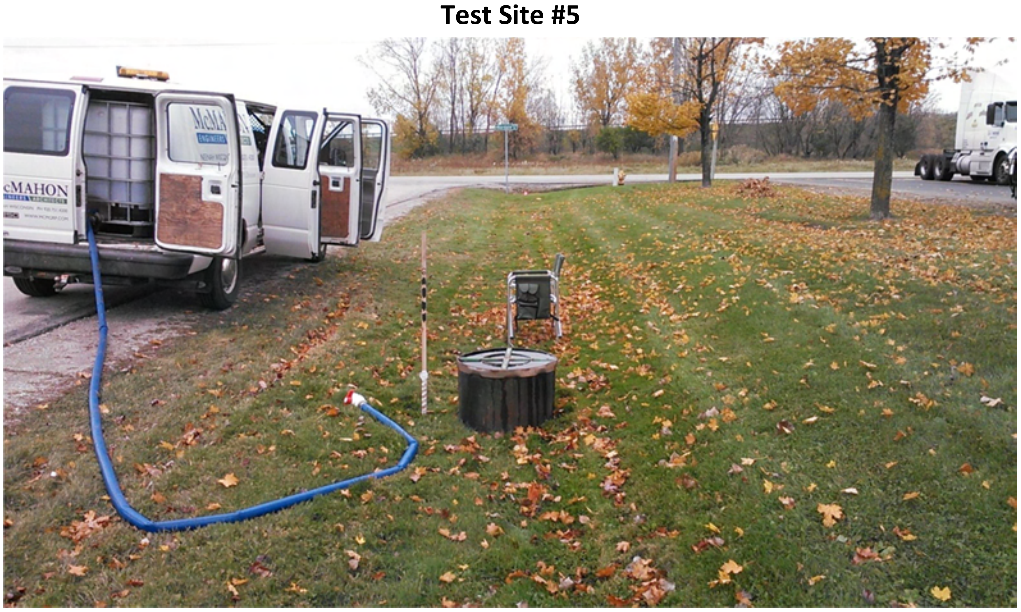
Test Site #1

Test Site #2

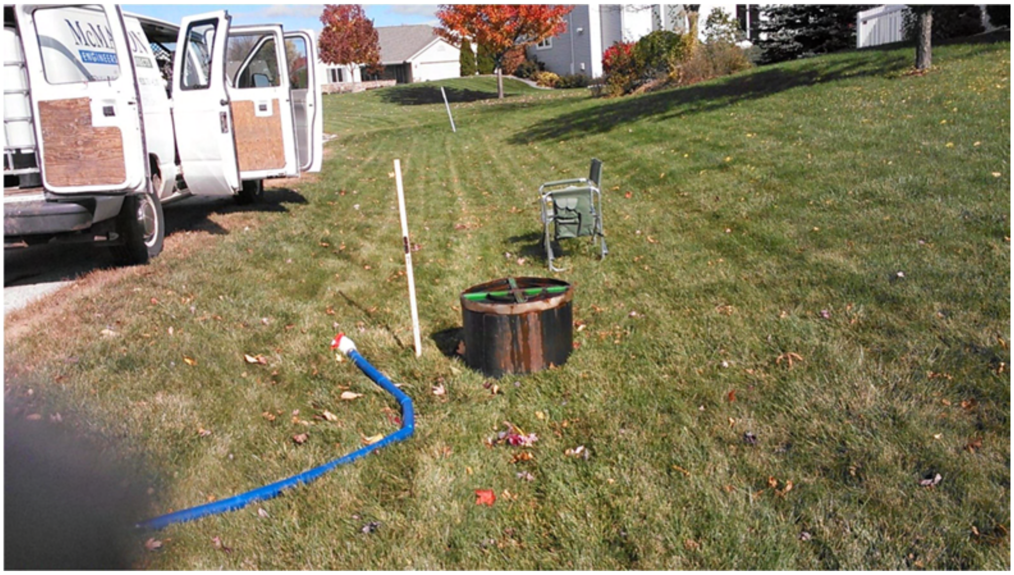
Test Site #3

Test Site #4

Test Site #5



Test Site #6

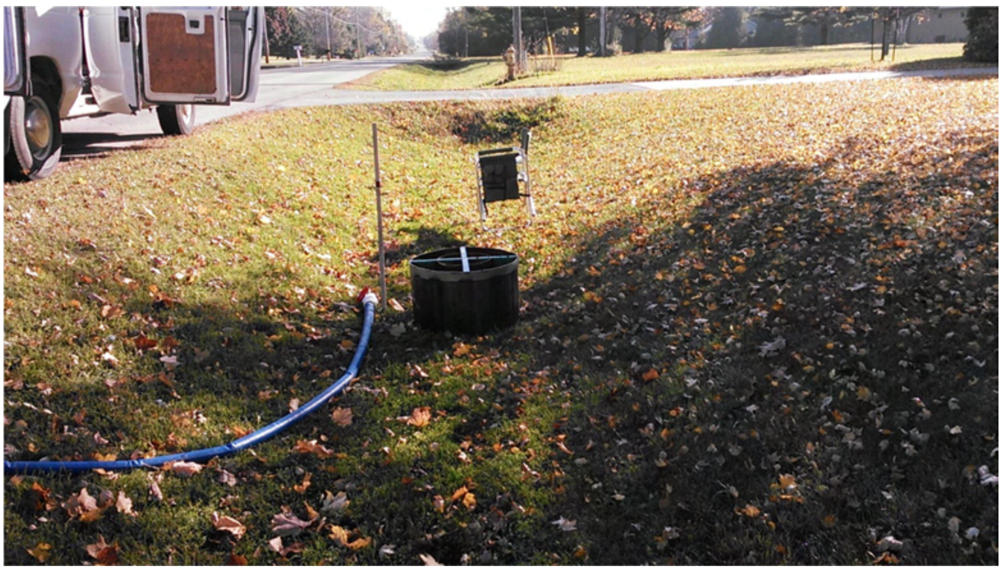


Test Site #7

Test Site #8

Test Site #9

Test Site #10



Test Site #11

Test Site #12

Test Site #13

Test Site #14

Test Site #15

Test Site #16

Test Site #17

NO PHOTO AVAILABLE

Test Site #18

Test Site #19

Test Site #20