UNIVERSITY OF MINNESOTA

Septic System Evaluation at MnDOT Rest Stops, Truck Stations and Weigh Scales

Final Report

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The University of Minnesota (UM) and the Minnesota Department of Transportation (MnDOT) performed a unique evaluation of the 52 existing subsurface sewage treatment systems at safety rest areas (SRA) travel information centers, truck stations and weigh scales at MnDOT facilities across Minnesota. This three year partnership brought together the septic expertise of the UM with the MnDOT wastewater unit’s agency and site knowledge. The goal of the assessments was to evaluate risk and provide a risk analysis ranking system. The project began with an extensive record search where many documents were digitized and a database of information created. The next step was development of a draft assessment protocol. This draft protocol was pilot tested on five systems and refined based on those experiences. The full assessment included a preliminary review of the site, a facility assessment, effluent sampling, septic tank inspections, evaluation of advanced treatment units when present and an assessment of the soil treatment system. The information from the assessment was used to develop a risk ranking of all systems. The risk assessment created can be used for planning purposes to prioritize capital upgrades, but only if a sustainable process is created and incorporated into the day to day workload.

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The project would also like to thank all the septic professionals who assisted in the project, particularly all the maintainers that cleaned and assisted with the evaluation of the septic tanks.

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Executive Summary

The University of Minnesota (UMN) and the Minnesota Department of Transportation (MnDOT) performed a unique evaluation of the 52 existing subsurface sewage treatment systems (SSTS) at safety rest areas (SRA) travel information centers (TIC), truck stations (TS) and weigh scales (WS) at MnDOT facilities across Minnesota. This three-year partnership brought together the septic expertise of the UMN with the MnDOT wastewater unit's agency and site knowledge. The goal of the assessments was to evaluate risk and provide a risk analysis ranking system. The project began with an extensive record search where many documents were digitized and a database of information created. The next step was development of a draft assessment protocol. This draft protocol was pilot tested on five systems and refined based on those experiences. The full assessment included a preliminary review of the site, a facility assessment, effluent sampling, septic tank inspections, evaluation of advanced treatment units when present, and an assessment of the soil treatment system. The information from the assessment was used to develop a risk ranking of all systems. This project and process is one that could be modified to evaluate facilities in other states or owned by other entities. Throughout the course of the investigation data was collected on over a 100 characteristics of the SSTS at each of the 52 facilities. Generally, the individual characteristics investigated fell into certain categories or high-level groups. These general categories are:

1. Facility Types and Flows
2. Septic Tanks and Filters
3. Environmental Conditions
4. Soil Treatment Systems
5. Management Methodologies

While the number of parameters that could be analyzed is extensive, this report focuses on those that were determined to have the greatest influence on risk. For each characteristic, a value was given on a scale of 1 to 5 with 1 being the highest or most risk and 5 being the lowest or smallest risk. This 1 to 5 ranking scale was purposefully selected to conform to the State of Minnesota Facility Condition Assessment process (FCA). To overcome the limitation of a 1 to 5 system, a case-based reasoning process was used to further classify characteristics into Low, Medium or High risk to relate overall impact of concern over time.

Overall, 45 of the 52 wastewater systems evaluated were in average to above average condition. Five facilities were found to be excellent with a score of 5. Fourteen were found to be above average with some areas for improvement with a score 4. Twenty-six systems scored 3 or average. The remaining seven are most in need of repairs and/or replacement with a 2 or <70% of an ideal system score. In addition, all systems with public safety and health issues are viewed to be below average until these issues are rectified. The risk assessment created can be used for planning purposes to prioritize capital upgrades, but only if a sustainable process is created and incorporated into the day-to-day workload. A fact-based, rational, transparent, reproducible and systematic level of service needs to be identified. This risk analysis must be performed periodically to document changes in the system.

Over the course of the three-year project, numerous future research questions were identified and included later in the report.

Chapter 1: Introduction

The Minnesota Department of Transportation (MnDOT) is the State of Minnesota's principal agency to develop, implement, administer, consolidate and coordinate state transportation policies, plans and programs. To help achieve this mission MnDOT has a coordinated Safety Rest Area (SRA) Program to help motorists travel safer, smarter and more efficiently and a coordinated truck station program to help maintain the state highway system. These facilities are often necessary in locations that do not have access to municipal drinking water and wastewater utility services so MnDOT serves these buildings with both onsite drinking water systems and onsite wastewater treatment facilities. MnDOT owns and operates 62 wastewater systems, of which 52 are Subsurface Sewage Treatment Systems (SSTS). This project focuses on evaluating the 52 SSTS.

This project began by reviewing existing literature regarding SSTS serving SRA and found there is little data and published studies by the scientific community and state regulating bodies. A study from 2006 found that only 0.054% of 500 million onsite sewage treatment systems around the world are service station systems (Conn et al., 2006). Although SRA are a small percentage of the systems installed there are other similar facilities receiving primarily toilet flushing and hand washing such as convenience stores, churches, office building, etc. and for MnDOT, 100% of their systems are unique so the lack of research inhibits their ability to simply rely on published data or codes. In a few cases, there have been state departments of transportation which have monitored performance and sought to improve rest area onsite systems due to underperformance of systems. Of these cases, many of them have observed issues with systems only a few years after construction (Sylvester, R., 1972; Etzel, J., 1982, Scharfe, C., 1987).

Evaluating published information, highway safety rest area onsite wastewater systems have long been a challenge to operate and maintain. Challenges presented for these systems include being located in remote areas where a significant amount of travel is required. Another challenge is that the waste stream itself, which due to the installation of low flow toilets and faucets results in concentrated load. In addition, there is typically limited trained personnel which results in a lack of manpower to properly monitor and maintain these systems. MnDOT is moving towards remote monitoring if flows and systems to alleviate several of these concerns.

Little research exists on the characteristics of modern rest stops. Much of the existing literature was generated in the 1970s with little understanding of the impacts of variable flow and the high level of organics present. One of the primary design documents, FHWA Technical Advisory TA 5140.8, was written in 1979 and contains many outdated system design parameters based on current knowledge. The design process documented in this document uses the number of urinals and toilets to calculate a design flow or the average daily traffic passing the rest area with an estimate of percentage of drivers stopping. Actual flow data was not typically collected at the time of design. This flow data was then used to size the septic tanks and percolation data informed the size of the drainfield. This document does not address separation to the limiting condition. A lack of requirements and guidance regarding the proper maintenance needed for a SRA septic systems is result of past procedures and publications. The MnDOT maintenance manual 5-791.400 (2007) has vague language regarding when tanks need to be pumped, siphons cleaned and water levels checked in the drainfields. Lack of clear requirements may contribute to a lack of monitoring of the performance of these systems. Rest area wastewater system problems can be complex and this complexity is recognized by the EPA, where the agency provides a guide to how one should evaluate failure and uses a failing rest stop as a case study. In this case, the system was likely being hydraulically and organically overloaded and re-grading over the dispersal site prior to installation had damaged the soil. This document also recognizes the fact that rest area wastewater systems can be difficult to maintain due to differences in the influent daily flow and waste strength, along with high concentrations of TSS, BOD and nitrogen (U.S. Environmental Protection Agency, 2002). In addition, the challenging soil and site conditions present at rest stops is not addressed in the design materials. Another challenge with some of the existing literature is that systems are in multiple climatic regions and regulatory structures which greatly impact system design and limit direct comparisons.

The primary project evaluated the performance of 52 MnDOT safety rest areas, travel information centers, truck stations and weigh scales and provided valuable feedback to the agency about the state of each facility's onsite wastewater system. This evaluation is holistic in nature. The study spent time and resources in the field evaluating each system, but the evaluation was limited to those characteristics accessible to monitoring. Where suitable information already existed the study did not seek to recreate or replicate data. A system operational analysis was conducted using a combination of field, design and maintenance data to develop a risk assessment system database. The Onsite Sewage Treatment Program (OSTP) then analyzed the risk assessment database to rank the risk based on a review of current subsurface sewage systems body of knowledge including, but not limited to MN Rule Chapters 7080-7083. Minnesota state rules and federal requirements were used as a baseline for evaluation, but in many instances the evaluation went above and beyond those requirements. A portion of this analysis also included a comprehensive assessment of aquifer sensitivity using a combination of field data and readily available data on the internet. This ranking system was also developed to help decision-makers allocate funding to sites on a need-basis, with up-to-code systems which protect public health and the environment ranked highest on the list. This investigation was also performed so MnDOT can update the data used to design and operate their systems. These results will be carried through to all the facilities in Minnesota and the results will be exportable to similar facilities across the United States.

Chapter 2: Materials and Methods

2.1 Records Search

This project began with a large record search of existing information available from MnDOT. Much of the existing information was not electronic and was digitized. The data available varied from site to site but included:

- Septic permit
- Soil survey information
- Septic system drawings and specifications
- Septic design basis
- Well permit
- Well log
- Sanitary survey from MDH
- Water usage
- Drinking water testing results
- Past inspections

One of the largest challenges was determining the design basis for the septic system. What was often available in the files were engineering drawings and specifications with varying levels of detail of the site including the septic system.

2.2 Pilot Testing Phase

The pilot study was done to validate field data collection methods to ensure the process was correct. Five facilities in one district were evaluated to minimize the impacts on MnDOT operations. The data collected in the field was then validated to determine if a facility condition risk assessment could be developed. The goal of the pilot study was to identify both positive and negative features of the process and to make necessary adjustments. The benefits were to first develop the protocol to further evaluate the remaining systems and assess risk based on compliance with current standards, knowledge and environmental sampling. During this pilot stage we 1) determined what data we thought needed to be collected onsite, 2) went to sites and identified features, 3) evaluated what we suspected about versus what we identified, 4) updated the procedure. This step was critical as it was important we were getting the data necessary to build the risk model before all 52 sites were visited. The preliminary protocol is listed below:

1. Develop risk assessment model to prioritize evaluation.

2. Apply risk assessment model to select five sites

3. Gather existing information on selected five sites including but not limited to:

    i. Design information

    ii. Maintenance record

iii. Soil survey information

4. Work with MnDOT to schedule five site visits.
5. Develop draft field assessment procedure. Key items for evaluation will include:
    i. Verification of system installed versus design documentation
    ii. Flow data
    iii. Field soil evaluation
    iv. Septic tank water tightness and performance evaluation
    v. Effluent sampling
    vi. Soil treatment system inspection
6. Perform assessments. Update assessment procedure through field evaluations. Tank pumping and sampling of the wastewater for organics, solids, bacteria, nutrients and chemicals will be conducted at each site.

2.3 Full Assessments

After the initial five site visits, OSTP and MnDOT determined a number of refinements and details to be added to the protocol to make efficient and effective use of time at each facility. The first realization was a risk model cannot be based on only five sites. The entire spectrum of site conditions and facilities would need to be investigated before we could develop a clear and accurate risk model that would address all the variations in facilities. So steps 1 and 2 of the initial protocol were moved to a final data summarization step.

With the risk assessment model development moving to the reporting phase of the study, all potentially useful data needed to be collected accurately and consistently at each facility for later analyses. That began with a thorough review of all existing data during our preliminary assessment. Along with familiarizing ourselves with each site and SSTS, this also allowed us to be prepared with questions to be addressed during our site assessments. We also were able to begin to assess the accuracy of documents to field observable and field quantifiable conditions. A detailed discussion of our methodology follows, while the MNDOT Facility Assessment from is found in Appendix A.

2.3.1 Preliminary Review of Site

2.3.1.1 Records Review

The UM OSTP reviewed all existing wastewater site plans, design paperwork and condition reports for each location prior to field visit. This allowed for field staff to anticipate concerns unique to each site as well as preliminarily locate all system components. The plans vary in detail and accuracy with many systems having minor to major component changes that were not ascertainable without supplementary exploration. The plans for SRA reviewed are not as-built drawings or record drawings, but the design location of components, many of which may have shifted during construction due to unforeseen conditions. For many of the WS and TS the design plans were simplistic, often lacking needed information such as septic tank capacity or dimensions of the drainfield. The project specifications often lacked the design flow and soil observations. Preliminary locations and capacities were calculated or recorded for use during our on-site inspections as well as during data compilation. Well log records were also reviewed, when available, to determine source of water, depth to drinking water supply and local geologic conditions. Any potential concerns such as shallow wells or previous contamination were noted for our field inspections and further consideration. Two sites had well water quality issues which also raised concerns, but it is important to note that all sites had safe drinking water. At these sites the aquifer assessment might be able to determine the potential for contamination from the SSTS on site versus off-site sources of contaminants.

Operation and maintenance records were not available for most MnDOT facilities. Information obtained for our investigation primarily came verbally from MnDOT staff and onsite interviews with custodial staff. The only source of maintenance records would have come from a compilation of purchase orders from MN DOT to contractors that service these systems across the state. This was outside of the scope of this project

2.3.1.2 Flow

Flow data was reviewed during the off-site preliminary review. Flow data is recorded daily by Greenview staff at Rest Area and Travel Information Centers. The data was evaluated to determine both the peak month and the average monthly. Daily flow data was reviewed to assure that no peak days were missed through the averaging process. Flow data was not available at truck stations or weigh scales because water meter data is not recorded by anyone. This information attempts to capture the variability both monthly and seasonally that these facilities experience for various reasons.

2.3.1.3 Soils

A review of the soil survey information using the USDA Web Soil Survey (websoilsurvey.nrcs.usda.gov) in the area was instrumental in establishing a base level understanding of the site conditions. We also attempted to utilize the soil survey preliminarily to identify any potential for placement of replacement systems with more suitable soil conditions. We specifically focused on the predicted soil textures at the system depth and the predicted depth to the periodically saturated soil (a limiting condition). However, as we experienced during the first several in-field verifications, the soils within these properties tend to be highly disturbed via cut, fill and compaction. This finding rendered the soil survey information only useful in understanding the deeper parent material conditions and the surrounding landscapes. After these first site visits, we ceased using the soil survey as a preliminary evaluation tool. It was used to determine soil texture information for our aquifer sensitivity assessments or where soil borings to the appropriate depth were not feasible due to coarse fragments. Any areas of concern were noted for follow-up field evaluation. Any follow-up work to place a new soil treatment area on these parcels will require a detailed on-site soils investigation due to the amount and types of disturbance prevalent on these sites.

2.3.1.4 Aquifer Sensitivity

The preliminary data collection was also used to determine aquifer sensitivity according to the Minnesota Pollution Control Agency (MPCA) Design Guidance (2013). The MPCA Design Guidance was used as technical resource that has been vetted by engineers and scientists at the MPCA and University of Minnesota as technically sound. This included soil survey information, well logs, exact location of the soil treatment area(s), distance to wells, information on system BMPs, DNR Aquifer Sensitivity analysis, location of nearby Drinking Water Supply Management Areas (DWSMA) and deep soil investigations were included after an on-site inspection.

2.3.2 Facility Assessment

In order to evaluate each facility in the study, an indoor facility assessment was conducted with observations from field personnel and a brief facility interview. We inventoried each water-using device. We also determined any additional water quantity and water quality concerns related to daily operation of each facility. Specifically we investigated irrigation, water treatment (including softeners and iron removal) and cleaners. This information will assist with developing a complete understanding of water use data as well as provide context for septic tank effluent grab sample results. At sites where drinking water chemistry or constituents could impact the wastewater system, a tap water sample was taken. The facility and site assessment form is included in Appendix B.

2.3.3 Effluent Sampling

Grab samples of septic tank effluent were taken during the field inspection. Samples were collected from the last component before distribution into the soil treatment area. At sites where pre-treatment was installed, sampling of effluent was after the last treatment device before loading the soil treatment area. Effluent was extracted using a peristaltic pump which pumped directly into the prepared sample bottles. Samples were collected and analyzed for Total Kjeldahl Nitrogen (TKN), Total Suspended Solids (TSS), Total Phosphorus (TP), and Biochemical Oxygen Demand (BOD). These are established wastewater constituents and are commonly used to characterize waste strength, wastewater quality and wastewater treatment concerns and are described below in Table 2.1. The analytical methods used are described in Table 2.2. The data was evaluated to see how the wastewater is characterized by 7083.4030 as shown below in Table 2.3. 7083.4030 sets the levels for what is considered to be highly-treated effluent, residential wastewater and high strength wastewater. Treatment level A & B are typically associated with the effluent from pretreatment units such as aerobic treatment units and media filters. Treatment level C is the treatment system performance level expected after appropriate sized septic tanks with domestic strength wastewater or after pretreatment units on commercial type sites. These levels impact the size of soil treatment units, the required separation and if additional treatment is necessary. At a few sites quaternary ammonia levels were checked.

Table 2.1: Summary of Wastewater Parameters

Parameter		Description
BOD_5	5-day Biochemical Oxygen Demand	Indicates waste strength; defined as the oxygen consumed by microorganisms over a five-day period, in milligrams per liter (mg/L)
TKN	Total Kjeldahl Nitrogen	Indicates waste nutrient strength; defined as the total content of organic nitrogen (N) and ammonia/ammonium, in mg/L as N
TP	Total Phosphorus	Indicates waste nutrient strength; defined as the total amount of all forms of phosphorus (P), in mg/L as P
TSS	Total Suspended Solids	Indicates waste strength and treatment efficiency; defined as the amount of solid matter suspended in a given volume of wastewater, as mg/L
pH	Acidity/Basicity	Chemical characteristic; a measure of acidic reactivity
DO	Dissolved Oxygen	Physical characteristic; the amount of oxygen in the wastewater
Temp.	Temperature	Physical characteristic; a measure of how hot/cold the wastewater is

Table 2.2: Summary of Analytical Methods

Component	Method	Holding Time	Testing Laboratory
Biochemical Oxygen Demand	Hach 10360 Rev 1.1	48 h (4°C)	Pace
Total Kjeldahl Nitrogen	EPA 351.2	28 d (4°C w/ H_2SO_4)	Pace
Total Phosphorus	SM 4500-P E	28 d (4°C w/ H_2SO_4)	Pace
Total Suspended Solids	SM 2540D	7 d (4°C)	Pace
pH	SM 4500-H+B	N/A	UM OSTP (onsite)
Dissolved Oxygen	SM 4500-O	N/A	UM OSTP (onsite)
Temperature	SM 2550	N/A	UM OSTP (onsite)

Table 2.3: Treatment System Performance Levels

Level	$CBOD_5$ (mg/L)	TSS (mg/L)
A	15	15
B	25	30
C	125	60

2.3.4 Septic Tank Inspection

Levels of sludge and scum were determined with a Sludge Judge® in each tank at the influent and effluent ends of the tank. pH, effluent temperature and dissolved oxygen were also recorded in each tank prior to pumping.

1. Septic tanks allow the separation of solids from wastewater as heavier solids settle and fats, greases, and lighter solids float. The solids content of the wastewater is reduced by 60-80% within the tank. The settled solids are called sludge, the floated solids are called scum, and the liquid layer in between is called the clear zone. The scum, sludge and clear zones were measured and verified. The depth of the sludge and scum determines the need for their removal, and the appearance of the clear zone can tell much about the performance of the system. The sludge is caused by the settling of solids. The scum layer should be present. A missing scum layer can be the result of a loss of the outlet baffle or the chemicals that are being added to the tank. The clear zone should be at least 75 percent of the tank depth. The appearance of flocculent, (small floating bacteria) will also speak to tank operation. A clear zone with little flocculent means the tank is working well. A cloudy clear zone usually identifies high BOD content. An absent clear zone may indicate lack of bacterial action.
2. High pH (basic conditions) can be caused by certain laundry detergents, cleaning agents, chemicals, and high alkalinity source water. As the pH rises, the microbial population changes to organisms less efficient in the breakdown of wastewater. Low pH (acidic conditions) can be influenced by cooking habits, low alkalinity in the water supply or acid-based cleaners. Just like high pH levels, low pH levels will only allow certain microbes to survive, adversely influencing wastewater treatment. The microbes at low or high pH are not as efficient as the microbes that can survive at an average pH level. Normal pH levels are between 6.5 and 7.5.
3. Septic tank effluent on average is approximately 20°F warmer than the ambient ground temperature. If the temperature is too high, it will damage or kill the microbes that are providing treatment. The opposite effect occurs: as temperature decreases, so does microbial activity. It has been found that microbes used in wastewater treatment become dormant at 39.2°F (4°C). Normal temperatures of septic tank effluent will range from 45-70°F.
4. Dissolved Oxygen (DO) is the amount of oxygen dissolved in water. The septic tank is typically considered an anaerobic treatment component. For the most part, septic tank microbes assimilate the waste constituents in the absence of a respiration process and are commonly referred to as anaerobic microbes. Normal DO levels in a septic tank will be <1.0 mg/l.

After this initial data collection at each location every effort was made to pump every operational septic tank and lift station in order to accurately and consistently evaluate component integrity. A MPCA licensed Maintainer was contracted to remove all liquids and solids from every septic system component to be inspected. Some lift stations and siphon tanks did not have enough liquid or solids to require pumping to determine functionality or status. After a complete evacuation of contents, UMN OSTP personnel inspected each component using artificial lights (if required) and an AquaView camera or sanitary sewer pole camera. Tank walls, joints, corners, bottoms and lids were all closely examined for signs of cracks, infiltration/exfiltration and root intrusion. Any of these conditions would be evidence of a lack of water tightness in the component. In addition, construction and the material used for the risers were also noted. Cracking, water staining, soil or root intrusion of riser material is evidence that the riser may allow additional landscape water to enter into the wastewater system and could cause overloading of certain system components. All concrete risers and lift stations were also inspected for concrete corrosion and noted when significant. The inlet and outlet baffles were evaluated as they are critical for the tank's performance. If a baffle was in the septic tank it was evaluated and cleaned as needed. Any maintenance access that was not at ground elevation was also noted for correction. Manhole covers were also inspected and safety concerns noted.

2.3.5 Advanced Treatment Units

When secondary treatment was present the unit was inspected and evaluated and samples were obtained post treatment. Across the 55 sites there were several media filters, aerobic treatment units and one UV disinfection unit. For the ATUs, a general assessment of the unit was performed by checking that the air supply was hooked up and providing air to the unit by a visual inspection of hoses, clamps, and bubbling action during the visit. A DO meter was used to evaluate the oxygen supply which should be greater than two mg/L in the ATU chamber where air is supplied. For the media filters all components were inspected including the recirculation tank, pumps, distribution, media, and a sample taken of the effluent quality.

2.3.6 Soil Treatment Area Inspection

After review of site plans, the soil treatment area was located with assistance from MnDOT personnel, a tile probe, presence of inspection ports and landscape indications. Once confirmed, the dimensions of the area were measured to compare to site plans. Inspection ports were opened to determine depth of the distribution pipes and to determine ponding within the soil treatment area. Where possible, we probed to the bottom of the distribution media to verify thickness and overall depth. A complete walk around of the area was completed to assess current or past evidence of surfacing, vegetative issues and other condition issues including evidence of burrowing animals. At a minimum, one soil observation was conducted to determine the natural depth to periodically saturated soil (MN Rules Chapter. 7080, 2013). This location was positioned 10-20 feet outside of the influence of the existing soil treatment area along the same elevation contour. Observations were dug by hand soil bucket augers to the depths of periodically saturated conditions, a standing water level and/or three feet below the existing distribution media bottom. We also determined USDA soil textures by the feel method to determine proper sizing according to MPCA Minnesota Rules Chapter 7080. In a few locations, depth of observation was limited by extremely coarse soils, in these situations we supplemented our field data with information gathered from the USDA soil survey report.

Chapter 3: Results, discussion and conclusions

3.1 Overview of Risk Analysis

The State of Minnesota utilizes Archibus and a standardized facility condition assessment process to track the condition of state-owned facilities. Minnesota Statutes 16A.633, Subdivision 1 requires each state agency to report the condition of state owned facilities to the Department of Administration for administration of a statewide database. The facility condition assessment (FCA) process and database, however, do not adequately characterize subsurface sewage treatment system assets and the Department of Transportation determined that a risk based approach to assessing SSTS systems was necessary. The risk assessment approach was loosely based on FCA concepts. The goal of the risk assessment process is to create a standardized, agreed upon approach to:

1. assess subsurface sewage infrastructure
2. create a system based on current scientific knowledge
3. create a system that is repeatable and sustainable
4. characterize both static and dynamic features
5. rank each facility numerically independent of cost considerations

The distinction of static versus dynamic features is important. As this project was underway and the various features investigated it was determined that there are features that change with time, flow, and loading rates (i.e. dynamic) and there are features that do not change with time such as location, soil (i.e. static features). The static features that were identified include features such as aquifer sensitivity and shore land protection zones. The static features are important from a risk perspective but do not require repeat analysis.

As the data was collected a spreadsheet was developed. Over a 100 site and SSTS characteristics were identified and determined for each of the 52 facilities included within this report with SSTS, the risk analysis focuses on those parameters that were determined to have the greatest influence on the risk to public health and the environment. Many of these characteristics were excluded from our risk determination because they were found to vary little from typical SSTS values or were not a major contributor to the overall risk on site. This information is discussed below in the relevant section. Each characteristic was evaluated for overall impact to the system and those that had had the most significance were included in the risk assessment. Significance to risk was defined as parameters that have the potential to impact public health or the environment significantly. It is important to note that this risk assessment is not a code assessment. The goal of the risk analysis is to develop a system approach to infrastructure management that assesses and prioritizes facility against each other to ensure state funds are being allocated to the correct infrastructure.

To maintain consistency with established, well supported systems the risk rating values were initially chosen to coincide with the State of Minnesota's Facility Condition Assessment Report values of 1-5. However, since this is a risk assessment analysis, not a condition assessment, there are some differences in the development and interpretation of the values that merits further discussion. Condition is described as the current state of a particular component of a facility whereas risk can be defined as the exposure to the chance of injury or loss. Further, risk can relate to public health and human safety and/or the environment. It can also be considered relatively static, such as a distance to a surface body of water, or dynamic, such as evidence of surfacing effluent. For this specific analysis, the risk assessment parameters do not consider physical condition of the components, but rather address the dynamic and static risk status. Physical asset condition is important however. Asset condition can readily be correlated to a level of service and a decreasing asset condition corresponds to a higher risk of failure. Risk assessment parameters should not be considered condition assessments as they often do not address the just the condition of a parameter, but address a more complete risk status of not only the current condition but into the future (either static or dynamic). So for example, an aquifer sensitivity analysis considers many parameters that may not be considered a problem currently for a FCA but over the life of a SSTS would place it as a higher risk site. So while the condition of a related component may be acceptable, the risk of this component is a more complete analysis of the status now and into the future. As such, we reviewed all site data when determining the most important contributors to overall risk at each site. It is important to note that sub-setting this dataset (e.g. by environmental, public health risk factors or any other specific values) will yield erroneous results because the risk analysis parameters and values are considered only as a composite facility/site risk. If sub-setting is necessary, a reexamination of the included parameters and risk values will be needed in consultation with qualified personnel.

In accordance with the FCA model and for each characteristic included in risk evaluation, a value was given on a scale of 1 to 5 with 1 being the highest or most risk and 5 being the lowest or smallest risk. Additionally, each characteristic was weighted utilizing a case-based reasoning (CBR) technique that weighted each characteristic as Low, Medium or High based on the potential impact the parameter has now and into the future to the overall site risk as shown in Table 3.1 (Kolodner, 1993). The addition of a weighting factor allowed us to describe the importance of specific features and better define the importance of certain higher-risk parameters. This was added after the initial risk values were summarized and the results did not clearly differentiate the highest risk systems (those with evidence of surfacing effluent, etc.). The addition of a CBR weighting factor allowed us to maintain the 1-5 rating values, but place more importance on the selected parameters known to present substantial risk to the environment and/or public health and safety. This weighting is used when determining the overall risk of the facility

Table 3.1: Risk and Weight Values Used in Risk Analysis

Risk	Value
Low	5
Medium	2-4
High	1

Case-based Reasoning Weighting	Value
Low	1.0
Medium	1.5
High	2.0

The sections below describe the ranking and CBR weighting that was developed for each characteristic included in the risk assessment. All of these characteristics are viewed from a risk perspective.

3.2 Facility Type

The Department of Transportation has two main types of facilities, Safety Rest Areas and Truck Stations. This is a static risk factor. This parameter was given a CBR weighting of high.

1. Safety rest areas (SRA) or travel information centers (TIC) have high usage by the traveling public, have high, variable flows and loadings, and are public facilities open year round 24 hours a day. Safety Rest Areas pose more risk because malfunctions may result in closure of safety facilities and higher flow rates may result in the release of high volume of wastewater in the event of an emergency. These facilities are also served by public drinking water systems and serve hundreds of thousands of visitors per year. The potential exists for the public to access the wastewater infrastructure and bypass security devices designed to keep the public away from the infrastructure. Safety Rest Areas were given a risk factor of 1.
2. Truck Stations and weigh scales are only used by the MnDOT employees, have low, consistent flows, and are not public facilities. The perimeter of each truck station is secured at all times and the public has no access except for access gained illegally. Truck Stations were given a rating of 4.

The age of the facility was determined from the existing information, but for some sites was uncertain due to lack of plans with dates. The sites with and unknown construction dates have an “NA (not available)” in the spreadsheet.

installation and subsequent use and management and maintenance. Age by itself was not determined as an independent risk factor. This is part of a FCA as each component within a SSTS will have varying useful life and was outside of the scope of this study.

3.3 Average Flows

Flows are recorded daily at SRAs and TICs. This is a dynamic risk factor. The flow data used to evaluate the riskiness was the flow during the busiest month of recorded data removing any data that was incorrect due to faulty data entry. Monthly peak data was used as newly designed systems at MnDOT facilities typically include time dosing at these facilities which assist in treatment on peak days. The number of water using devices inside the facility was determined and indirectly this data is included in the flow determination.

No flow data is collected at TS and WS. For these facilities, the estimated flow was determine by taking the number of full-time employees multiplied by 17.5 gallons per person as indicated in Minnesota Rules 7081.0130 (2013) which is in-line with the EPA Design Manual (2002). Additionally, truck stations do not consist of employees working an 8-hour shift in the building. Crews are typically in the building at the beginning and end of shift so the accepted flow rate will likely over estimate flow. For some facilities the number of employees was unknown due to the rotating shifts and seasonal employee rotation. For these facilities with no employee data a number of five employees was assumed. The facilities with a design flow of 88 gallons per day (gpd) as shown in spreadsheet were those assumed at five employees. We were interested in average flow rates for these facilities, and because these facilities are remote in location and are small facilities, a conservative assumption of five full time equivalents was deemed appropriate.

The flow was assigned a CBR weighting of moderate (value = 1.5) as the flow is an important variable when evaluating the overall risk. The specific risk is related to the amount of flow at the facility and this was captured using the following factors:

Table 3.2: Risk Factors for Various Flows

Flow Value (gpd)	Number of Systems	Risk Factor
0 - 999	30	5
1,000 – 2,499	6	4
2,500 – 4,999	14	3
>5,000	2	1

From this data it can be seen that 58% of systems have flows under 1,000 gpd which inherently have a reduced risk due to the lower flow.

There was data collected related to flow that was not directly included in risk assessment, but indirectly was. This includes:

- number of toilets, urinals and sinks in the bathrooms
- volume of flush for the toilets
- sink operation (automatic or hand operated)
- water conditioning
- water treatment
- water fountains
- irrigation
- mop sink

For sites that had previously identified drinking water issues with either elevated nitrogen levels or coliform present a water well sample was evaluated. One site came back positive and the well has subsequently been replaced.

3.4 Percentage of Use Compared to Design Flows

The design flow (DF) for most of the facilities is unknown. For the RAs and TICs, unless listed in the design plans, the DFs were estimated by back calculating the flow using the tank sizing and the equation of [DF-1125)/0.75] which is first referenced in the Manual of Septic Tank Practices (US Department of Health, 1967) and was subsequently in Minnesota Rules from 1979 - 2008. For the TS and WS a value of 500 gpd was used. This is a dynamic risk factor.

The percentage of use was determined using the average flow calculated in section 3.3.   The percentage of use is an important variable as it compares the month versus flow compared to the design flow. The calculation is dividing the average flow by the estimated design flow. If the percent use was less than <100% it was assigned a low risk value of 5. Design flows calculated are flow maximums, meaning that the systems should not actually receive this amount of wastewater daily to ensure long term performance. If the facility was operating at greater than 100 percent of design flow it was given a risk factor of 2 as these systems receive flows greater than design. Since most the facilities were operating under 100% further delineation of the data was not warranted.

This was CBR weighted with a moderate value (1.5) as the percentage of flow is an important variable related to treatment and longevity. Only one facility had a percentage greater than 100%. This finding is very positive as the facilities were built with potential growth and/or a safety factor included which helps explain why many older systems are still functioning.

3.5 Septic Tank Characteristics

Septic tanks receive the wastewater discharged from the truck stations and safety rest areas. The purpose of the septic tank is to provide an environment for the first stage of treatment in onsite systems by promoting physical settling, flotation, and the anaerobic digestion of sewage.

Because of the multi-natured features of the simple septic tank there are multiple risk categories associated with this structure.

3.5.1 Septic Tank Capacity

The septic capacity was determined by evaluating the design plans and then comparing them to the current required septic tank size in Minnesota Rules Chapter 7080.1930, Subp 5 (2013). This is a static risk factor. If the effluent reaches the septic tank via gravity the sizing is three times the flow or if it pumped [under pressure] the multiplier is four times the flow. These values are reasonable for design (EPA, 2002). If the tank capacity versus the code requirement are greater than 100 percent it was given a risk factor of 5. If it was less than 100% the risk assigned was 2.

This factor was CBR weighted with a moderate value (1.5) as tank capacity is an important variable related to treatment as septic tank capacity is positively correlated to treatment efficiency and the more capacity the more treatment occurs.

Nine of the 52 systems had septic tanks less than the current requirements. Of these nine, five of the systems had effluent concentrations above domestic levels (BOD_5< 170 mg/L, TSS<60mg/L) indicating the septic tank capacity is not sufficient based on the flows and organic loading. Two of the sites had advanced treatment so the additional pretreatment allows the septic tank capacity to be reduced.

3.5.2 Septic Tank Safety Concerns

Septic tank lids must be secure to prevent the public and animals from accessing the tank and potentially falling in. This is a dynamic risk factor. Unsafe lids were identified as lids that do not meet the minimum weight requirement or were otherwise not fastened to the riser. Lack of weight or security is more prevalent in newer technologies such as HDPE and PVC lids; whereas the older cast iron lids were still functional. Repairs needed were more associated with lids or casting that needed some maintenance work but are otherwise operable or safe. An example of this would be a lid that is not removable or frozen. Safety issues with tanks were not a prevalent problem and is not a unique feature of DOT facilities; however, this criterion was included because of the serious nature an unsecured lid can pose (loss of life). Long term assessments will capture any changes to this factor so any change can be addressed.

This was given a CBR high priority due to the risk to safety risk using the following risk values:

Table 3.3: Risk Factors Based on Tank Lid Risk

Risk Factor	Number of Systems	Value
Unsafe	3	1
Repair needed	6	3
No issue	43	5

3.5.3 Effluent Filter

An effluent filter is generally considered a beneficial attribute of a septic tank because they provide additional filtering and prevent the passage of gross solids through the tank. They require regular maintenance and if they are not maintained they can cause backups, but generally the benefit of filters outweigh the potential risks. This is a static risk factor.

A value of 5 was given if a filter was present, understanding they must be maintained and a value of 3 if absent.

It was given a low CBR weighting (value = 1) as the use of an effluent filter did not correlate with the effluent quality. Eight of the systems that have an effluent filter with three of these have effluent levels that were high strength waste (HSW), two meeting treatment level C and three with advanced pretreatment meeting treatment level A or B (Chapter 7083.4030). At the various MnDOT facilities an effluent filter did not correlate to a higher effluent quality. The main benefit of a filter appears to be the reduction of large solids from getting in the lift station, so these devices aid in operation more than anything.

3.5.4 Wastewater Quality

Wastewater quality was evaluated at each site to determine the characteristics of MnDOT water and if there were variations between facilities. This is a dynamic risk factor. Various characteristics were evaluated in relation to the quality of the effluent after the septic tank or secondary treatment unit, when present. Most of the systems were only sampled once with a grab sample so the data is limited. The presence of a water conditioning device was evaluated, but was not considered to be a significant risk factor. Quaternary ammonia levels at two sites was measured and found to be below 2 mg/L which is the limit identified to be inhibitory to nitrifying bacteria.

3.5.4.1 Organic Loading

In this evaluation, organic loading is measured by the BOD_5 and the TSS. This is a dynamic risk factor. Minnesota Rules 7083.4030 (2013) defines wastewater as shown below in the table 3.4 and therefore risk was assigned accordingly. Strength is directly correlated with loading rates and studies have evaluated how loading to the soil impacts the longevity of the system (Siegrist and Van Cuyk, 2001b). We did distinguish the varying levels of high strength wastewater (HSW) beyond Minnesota Rules Chapter 7080 as there is a difference as organic loading increases. When the loading was greater than a BOD_5 of >500 mg/l the HSW+ designation was used.

This characteristic was given a CBR moderate weight (1.5) as the organic loading impacts system performance and longevity. Organic loading relates to system performance and longevity; however, high organic loading rates do not result in instantaneous failure.

37% of systems meet the definition of HSW. It should be noted that this is based on one grab sample from the last septic tank and pump tanks and subject to variability based on the past maintenance interval and current usage. It is recommended that additional sampling be done to determine variability.

Systems with pretreatment installed should be meeting treatment level A or B (See Table 2.3). However, a majority of MnDOT designs may not warrant the treatment levels as indicated if the soil treatment areas are appropriately oversized and no vertical separation reductions are taken. In these systems the effluent dissolved oxygen levels were determined in the field. The data was found to be in normal operating range in the aeration chamber. To truly assess the performance of the systems, additional testing is recommended. Of the systems with pretreatment only 50% (3/6) met treatment level A/B at the time of sampling.

Table 3.4: Treatment Levels and Risk Values

Treatment Level	Maximum BOD_5/TSS (mg/L)	Number of Systems	Risk Value
A/B	<25/30	3	4
C	<170/60	30	3
HSW	>170/60	17	2
HSW+	>500/100	2	1

3.5.4.2 Total Nitrogen

The second wastewater characteristic considered was the concentration of total nitrogen (TN). This is a dynamic risk factor. Nitrogen is a risk to ground and surface waters. Nitrogen in raw wastewater is primarily in the form of organic matter and ammonia. After the septic tank, it is primarily (more than 85 percent) ammonia. After discharge of the effluent to the soil treatment area, aerobic bacteria in the biomat and upper vadose zone convert the ammonia in the effluent almost entirely to nitrite and then to nitrate.

Typical domestic wastewater has a value of less than 60 mg/l of total nitrogen and therefore was assigned a value of 5. As the TN concentration rose to a value of up to 120 mg/l a value of 3 was given whereas if the value was greater than 120 mg/l the value decreased to 1. The EPA Manual (2002) supports these values as the range for septic tank effluent range is 40-100.

This was given an overall CBR weight of moderate (value = 1.5) due both perceived and real risk to human health and environment.

Fourteen systems had nitrogen concentrations over the 120 mg/l threshold and another 24 exceeded 60 mg/l therefore over 73% of the systems have elevated nitrogen levels compared to typical domestic wastewater. The levels of total nitrogen are likely higher these MnDOT facilities due to the preponderance of blackwater versus graywater. Blackwater is the portion of the wastewater stream that originates from toilet fixtures, dishwashers and food preparation sinks while graywater is the water captured from non-food preparation sinks, showers, baths, spa baths, clothes washing machines, and laundry tubs. Due to these elevated levels at the time of system upgrades or replacement additional nitrogen monitoring and/or nitrogen best management practices should be considered to evaluate the loading of nitrogen to the environment from these facilities.

3.5.4.3 Total Phosphorous and Shore land Proximity

While design guidance exists indicating setback distances, there is no simple method to determine if phosphorous is impacting surface waters.

Most of the systems had phosphorous levels in the range of domestic wastewater (<15 mg/L), although a few were higher. When evaluating the risk associated with phosphorus, the distance to shoreland was considered the most important factor. This distance was determined by identifying the location of drainfield using GPS coordinates by evaluating the design plans and Google Earth. Google Earth was used because you can see the exact location of the drainfield by the difference in the color of the overlaying vegetation compared with the surrounding environment. Then using Google Earth the distance was measured between the drainfield and shoreland. If this value was greater than 300 feet (MPCA, 2013) a risk value of 3 was assigned; whereas if the value was less than 300 the risk was set at 5. This is a static risk factor

This was given a CBR low weighting due to the inability to determine if the drainfield effluent is impacting the surface water. There are six systems within 300 feet of a lake, river or stream.

3.6 Aquifer Sensitivity

Nitrate-nitrogen is the common drinking water pollutant of concern that is routinely found in groundwater below septic systems. Regions with karst terrain sandy soils or high water tables are at particular risk for rapid movement of bacteria, viruses, nitrate-nitrogen, and other pollutants to groundwater. Nitrogen contamination of groundwater below infiltration fields has been documented by many investigators (EPA, 2002). This report found nitrate-nitrogen concentrations in groundwater in exceedance of the drinking water standard of 10 mg/L near the infiltration field (EPA, 2002). When nitrate reaches the groundwater, it moves freely with little retardation.

To evaluate the risk of nitrogen contamination at these sites, the 2013 Minnesota Design Guidance sensitivity of the aquifer was determined for nitrogen contamination by evaluating the five characteristics in 3.6.1 – 3.6.5. This reference was chosen as it can be done without extensive deep field observations and presents a conservative approach at evaluating the risk to groundwater. This is not cumulative so multiple answers did not increase the sensitivity. Generally, this methodology utilizes existing sensitivity maps and allows combination with on-site observations to develop a scientifically defensible and site-specific assessment. The original development of this approach was done by committee with representation from MPCA, MN DNR, MDH, USDA-NRCS and University of Minnesota.

If one or more of the factors was present a value of 4 was given and if one was not a value of 2 was assigned. This is a static risk factor. This was given an overall low weight as more a more in-depth evaluation is needed including more performance data to evaluate the effectiveness of the existing BMPs. Seven of the systems have an installed BMP, four media filters and three mounds with one site having both.

3.6.1 Distance to public or private well

Using Google Earth, the distance between the drainfield and the nearest well was measured. The County Well Index (http://www.health.state.mn.us/divs/eh/cwi/) was also evaluated to ensure that the public well located on MnDOT property was the closest well to the drainfield. If this value was less 200 feet the well is considered to be sensitive.

3.6.2 Drinking Water Supply Management Area with a High or Very High Rating

A Drinking Water Supply Management Area (DWSMA) is the surface and subsurface area surrounding a public water supply well, including the wellhead protection area. The potential contamination risks are required to be managed to limit contamination by the Source Water Protection group of the Minnesota Department of Health. For some public wells the Minnesota Department of Health source water protection has developed a DWSMA map and established a rating map (http://www.health.state.mn.us/divs/eh/water/swp/maps/). Many public wells do not have DWSMA or do not have a rating. If it was identified as having high or very high susceptibility to contamination the aquifer was identified as sensitive.

3.6.3 Soil Survey

The "Aquifer Assessment (MN)" tool was used in the Minnesota Web Soil Survey. If the site was rated sensitive as determined for the majority of the land area, within a quarter mile radius of the soil dispersal system the aquifer was identified as sensitive.

3.6.4 Deep Borings

When available the soil texture of the soil dispersal system was determined by evaluating a well log that went at least six feet below the bottom of the soil dispersal system. If the soil was a United States Department of Agriculture texture of sand (i.e., fine sand, loamy sand, etc.) the site was considered to be sensitive.

3.6.5 Protective Layer by Department of Natural Resources Sensitivity Map

DNR maps (http://www.dnr.state.mn.us/waters/groundwater_section/mapping/status.html) were also consulted to determine a sensitivity rating. Google Maps was used to manually pinpoint where each site is by where it is relative to county boundaries, lakes, or other physical features. If the sensitivity rating is "sensitive" for the majority of the land area, within a quarter mile radius of the soil dispersal system it was considered sensitive. Many sites do not have a corresponding map.

3.6.6 Overall Aquifer Sensitivity

If any of the items above (3.6.1 – 3.6.5) were determined to be sensitive the aquifer is considered to be sensitive according to design guidance (2013). This is not cumulative so multiple answers did not increase the sensitivity. If it is sensitive it was given a value of 1 or a value of 4 if not. Overall this was given a moderate weight (value = 1.5) in the overall risk assessment due to the potential impact to public health and the environment. The aquifer for 30 of the 52 systems was identified as sensitive based on this analysis.

3.7 Nitrogen Best Management Practices (BMP)

Nitrogen BMPs are required to be employed for systems with a design flow between 2501 and 5000 gallons per day, which discharge above a sensitive aquifer, and systems with design flows >5,000 gallons per day which do not discharge above a sensitive aquifer, to mitigate water quality impacts to groundwater. The presence of a BMP was documented for all sites since it is beneficial at all flows particularly considering the often higher than typical nitrogen levels in the wastewater. The best management practices identified include mounds built over heavier textured soils and recirculating media filters. These BMPs have the potential to remove 20-50% of the total nitrogen.

3.8 Soil Treatment System

Suitable soil is an effective treatment medium for sewage tank effluent because it contains a complex biological community. Microorganisms in soil treat wastewater physically, chemically, and biologically before it reaches the groundwater, preventing pollution and public health hazards. Because a majority of the treatment occurs in the soil treatment system, it has many risk items assigned to it. The following risk characteristics were identified and quantified.

3.8.1 Uniformity of Loading

The soil treatment system was evaluated to determine if the loading to the soil treatment system is being uniformly applied. This is a static risk factor. If a siphon or gravity is used to distribute the wastewater it is less likely to be uniform and a risk factor of 2 was given, whereas if pressure distribution is utilized the distribution is more uniform and the value assigned was 4. It is possible for some of the systems with pressure distribution that the pumps may not be sized properly to assure even distribution but the details in the design did not allow for this to be assessed. In order for adequacy of pump size to be calculated, the diameter of the pipe, manifold design and size of perforation would be needed for every design along with the gallons per minute and total dynamic head for each pump. For most sites a portion or all of this data was not available. The current operating head can be confirmed if there are cleanouts on the end which can be removed for verifying squirt heights. It is recommended that all sites have cleanouts installed if they currently do not have one and squirt heights determined and lines flushed. Maintenance of these systems is also critical for the long-term performance to be realized.

This was given a moderate (value = 1.5) weight as the distribution method affects treatment and longevity. Nineteen of the systems use gravity or a siphon as their distribution method.

3.8.2 Type of Soil Treatment System

The majority of MnDOT facilities consisted of bed systems or trench systems. Only a few mound systems are installed. This is a static risk factor. Many of the older systems were installed by removing all the natural soil (usually due to limiting or restrictive conditions) and engineering a bed system in the area with fill material. There is more risk associated with these systems due to damage during installation due to compaction, changes to the drainage patterns, surrounding soil conditions, etc. Therefore a risk factor of 2 was assigned for engineered beds whereas if natural soil conditions were maintained they were given a lower rating using the factor of 4.

Type of soil treatment systems were given a CBR value of moderate because it affects treatment, hydraulic acceptance and longevity. Sixteen of the soil treatment systems have engineered soil materials.

3.8.3 Size of Soil Treatment Area (Based on Hydraulic Loading)

The actual square footage installed was calculated from the design plans and confirmed on site. This was compared to required square footage based on the soil boring logs and observations taken onsite and the average monthly peak flow assuming domestic wastewater. This is a dynamic risk factor. If this percentage was less than 100% a risk value of 2 was set whereas if it was greater than 100% the value was assigned to 5.

This was given a CBR moderate (value = 1.5) weight as it affects longevity. Five of the systems were undersized based on hydraulic loading.

3.8.4 Size of Soil Treatment Area Existing (Based on Organic Loading)

The actual square footage installed was calculated from the design plans and confirmed on site. This was compared to required square footage based on the soil boring logs and observations taken onsite and the average monthly peak flow using the actual measured organic loading (higher of BOD_5 and TSS) as laid out in the Design Guidance (2013). This is a dynamic risk factor. If this percentage was less than 100% a risk value of 2 was set whereas if it was greater than 100% the value was assigned to 4.

This was given a CBR moderate (value = 1.5) weight as it affects longevity. Six systems were undersized based on organic loading.

3.8.5 Amount of Separation

The amount of separation from the bottom of the distribution media to the limit condition is a critical component of septic system treatment. To provide adequate time for treatment of septic tank effluent, it is necessary to have at least three feet of aerated or unsaturated soil and limit the loading of effluent. A specific kind of mottle (color variation) occurs in soils that are subject to seasonal saturation, known as redoximorphic features. These color changes are the result of chemical and biological reactions that typically occur in wetter soil horizons. Minnesota state regulations require the identification of these features in order to accurately determine the suitability of each site for a SSTS. In the past these characteristics have been overlooked and misunderstood on many sites and in some soil situations. It is only within the past 20 years that the field of Soil Science has studied these features in relation to periodically saturated soil conditions. Prior interpretation of suitable soils was commonly determined based on a depth to a physical water level observation in the soil or a restrictive condition such as bedrock. The replacement of soil in many locations may be an improper choice as a response to interpretation of these soil features. If the soil treatment system had more than three feet of separation it was assigned a risk value of 5, from 1 – 3 feet a value of 3 and with less than one foot a value of 2. This is a static risk factor.

Because of its importance it was evaluated and was assigned a CBR high (value = 2.0) weight as it directly affects treatment and longevity. If seasonally saturated conditions occur in the soil outside the trench, aerobic conditions will no longer exist, which will prevent aerobic bacteria from breaking down the biomat. Under these conditions the biomat will thicken, reducing its permeability and the effectiveness of effluent entering the soil. Ultimately this will shorten the soil treatment area's life due to excessive biomat development and restricted permeability.

Table 3.5: Amount of Separation and Risk Values

Amount of Separation (feet)	Number of Systems	Risk Value
> **3**	11	5
1 – 3	12	3
< **1**	29	2

3.8.6 Surfacing of Effluent

The risk of untreated sewage is well documented. There are numerous studies that directly correlate sanitation and mortality and waterborne diseases spread through water contaminated with human and animal feces or urine. Surfacing sewage is an indication of some type of failure, whether it is a broken pipe, overloaded system, or some other type of failure and immediate response to resolve the issue is appropriate. If no evidence of surfacing is determined, the risk is minimal and assigned a factor of 4. If there is past evidence of surfacing the risk is assigned a factor of 2. If active surfacing is witnessed the risk is assigned a value of 1 and immediate action is warranted. This is a dynamic risk factor.

If the system is surfacing or has evidence of surfacing there is a high potential for contact and is considered to be an imminent threat to public health and safety and was assigned a CBR high (value = 2.0) weight..

Table 3.6: Surfacing and Risk Values

Evidence of Surfacing	Number of Systems	Risk Value
None	36	4
Past Evidence	8	2
Surfacing	8	1

3.8.7 Ponding

There are many reasons for a drainfield to pond – compacted soil, excessive biomat, poor pump selection, and high strength waste to name a few. Ponding is assessed by evaluating the drainfield inspection ports and noting any standing water, and if present the depth of standing water. If the system had monitoring ports to measure ponding this was evaluated. Ponding indicates that effluent is being stored in the soil treatment system and was given a risk value of 2 while if none was recorded the risk value was 4. This is a dynamic risk factor. This was given CBR moderate (value = 1.5) weight in the overall risk assessment as it indicates a reduced system longevity. Sixteen systems had measurable ponding.

3.8.8 Compaction

On some sites compaction was identified by doing hand augered soil observations. If it was identified a risk factor of 2 was applied and if not identified in the onsite visit and noted a lower value of 4 was assigned. This is a static risk factor. This was not given the CBR lowest weight because the soil observations were done outside the system where compaction may not be observable. Seven systems had observable compaction.

3.8.9 Vegetation Issues

Trees, shrubs, deep-rooted plants, or hydrophilic plants should not be planted on septic system soil treatment systems. These roots can interfere with and possibly destroy the distribution system. Trees should be planted a minimum of 20 feet from the edge of the mound. Trees known for seeking water reservoirs, such as poplar, maple, willow, and elm, should be planted at least 50 feet from the mound. In addition trees do not provide adequate year-around erosion control and interfere with septic system infrastructure with varying root depths and rooting structure that depends on site, soil, origin of the tree/ shrub and tree/shrub species. Trees were given a risk value of 1 for this reason. If other vegetation issues were noted during the field, such as mowing needed, indication of gopher activity, or a lack of vegetation evaluation, they were assigned a risk value of 3, as over the long term they could lead to issues. This is a dynamic risk factor. Overall the vegetation issues were given a CBR low weighting as they have less impact on treatment and longevity than other characteristics.

Table 3.7: Vegetative Issues and Risk Values

Vegetation Issue	Number of Systems	Risk Value
Trees	4	1
Other issues	25	3
No issues	23	4

3.9 Maintenance

The last issue in the overall risk evaluation is if maintenance is being done at appropriate intervals. If the septic tanks exceeded the allowable amount of sludge and scum according to Minnesota Rules Chapter 7080.2450 when more than 25% of the tank capacity is being used to store sludge and scum, a value of 2 was assigned whereas if the combination of sludge and scum was under 25%, the risk assigned was 4. This is a dynamic risk factor. The effluent filters were not included as part of this factor since none of the installed filters were in need of maintenance at the time of our visits indicating proper service intervals.

This was given a CBR moderate weight (value = 1.5) in the overall risk evaluation as it impacts longevity. Thirty-three of the systems either had no pumping data on last pumping or were in need of maintenance at the time of our assessment. For the systems with no data the interval had been greater than three years which is the minimum time frame recommended by OSTP and allowed by MN Rules even for small residential systems.

3.10 Summary Risk Value

For each of the 21 characteristics their risk value (1-5) was multiplied by their CBR weighting factor (1 – 2). These weighted values were summed and a comparative total risk was established. We then compared this total risk value to the perfect score to get a relative percentage. This result generated a normal distribution of number of systems per risk value (1-5), with none in the risk value of 1 category. A system with a low summary risk value is posing a greater risk to public health and the environment than a system with a higher overall risk value.

After summing the weighted totals across all variables for each MnDOT facility, we converted the sum into a percentage of total ranking points available. This allows for a simplified overall comparison of facilities risk. The value also represents the deviation from least risk (i.e. 100%). For MNDOT's Facility Condition Assessments, a further simplification has been requested. We suggest further summarizing this overall risk information in the following manner for MnDOT (see Table 3.8). In general, these results are very positive, although the long term plan should be to have all systems with >90%.

Table 3.8: Summary of Overall System Risk as a Percentage

Relative Percentage	Number of Systems	Risk Value
>90%	5	5
>80%	14	4
>70	26	3
>60%	7	2
<60%	0	1

3.11 Characteristics Evaluated with Minimal Impact

Many characteristics were evaluated beyond what was included in the risk assessment. The breadth of characteristics observed was necessary because it was impossible to predict what characteristics would have the greatest impact prior to the investigation. What was found after the data was collected and analyzed was that many items didn't positively or negatively impact risk, or there wasn't enough variability across the systems for any meaningful impact to the overall risk assessment to occur. This is not to say that there are not other characteristics or emerging issues that would impact the analysis, just that the impacts when evaluated did not significantly impact risk. A few of examples of this are described below:

- Septic Tanks: all of the septic tanks were found to be watertight and without visible cracks or damage. There was one site where the inlet baffle was found to be not in place, but aside from that the septic tanks were operating as designed.
- Effluent Wastewater quality, pH, DO and temperature: The effluent of the septic tank was monitored for pH, DO and temperature. All the values were found to be in the normal range for septic tanks. This analysis was also performed on the process waters of the aerobic treatment units and recirculating media filters. The levels in the ATUs were in the acceptable range although some of the RMF levels were high in the recirculation tank which can limit denitrification and indicates that the recirculation ratio should be reduced.
- Chlorides: Chloride levels were monitored to determine if the water was being over softened. Sites with elevated chloride levels have notes included in the database, but since there is little research documenting the impact of sodium chloride on treatment the variable was not included in overall analysis.

- Chemical Oxygen Demand: Chemical oxygen demand (COD) of the wastewater was evaluated. COD is a measure of the amount of organic matter oxidized by a strong chemical oxidant. COD is used to measure organic matter in commercial, industrial, and municipal wastes that contain compounds toxic to biological life where the BOD_5 test would not work. The COD levels in a wastewater sample are almost always greater than BOD_5 levels because more compounds can be chemically oxidized in the COD test than can be biologically oxidized in the BOD test. For these facilities the COD/BOD_5 ratios were found to be in a normal range for the most part and therefore this value was not included in risk evaluation, although a few facilities were on the high side indicated a higher than normal amount of cleaners and chemicals were present. The use of cleaners and chemicals containing high amounts of sanitizing or antibacterial agents should be avoided. All of the SRA use the same set of 3M products for cleaning. As part of the facility survey chemicals aside from these were identified and evaluating the impacts of these cleaning regimes should be investigated particularly at the two vacuum sewer locations that had abnormally high levels of organic material.

Chapter 4: Recommendations

4.1 Risk Assessment Process

The risk assessment created should be used for planning purposes to prioritize capital upgrades, but only if a sustainable process is created and incorporated into the day-to-day workload. A fact-based, rational, transparent, reproducible and systematic level of service needs to be identified. This risk analysis must be performed periodically to document changes in the system. Without continual evaluation this analysis and the results will quickly become stale. It is common knowledge that water infrastructure systems in the United States are deteriorating at an accelerated rate. The American Society of Civil Engineers produced a report card on the current status of America's infrastructure and water infrastructure both of which recently received a "D." A systematic assessment program with an identified level of service goal will allow MnDOT to identify program priorities, communicate clearly and consistently with Agency leadership legislatures, and create a 4/10/20 plan in line with both the Buildings Facility Improvement Plan and the Highway Statewide Transportation Improvement Plan.

Also, over 100 characteristics were evaluated at 52 sites across the State of Minnesota. The majority of these parameters did not make it into the risk assessment protocol because there wasn't sufficient variability or the impact of the variable could not be determined. Nevertheless, this does not mean these unused parameters are not important. Research, testing, and further evaluations should be continually made to make sure appropriate factors are being used to make decisions. For instance, all of the analytical data was obtained via grab samples during the spring, summer and fall. This time period is a high use time period for Rest Areas but a low use time period for Truck Stations. Further understanding of the nature of the waste stream and how this waste stream changes with the season could impact risk assessments. There are also further contaminates of concern (quaternary ammonia, hormones, etc.) that may be present and affect risk or design. Some of these items require an advancement in understanding by the scientific community before risk can be better quantified or eliminated.

The following recommendations are made to assist MnDOT in managing subsurface sewage infrastructure. Many of these recommendations are not directly related to the risk assessment process but are ideas to be evaluated and feasibility determined.

4.2 Record Drawings

The drawings associated with each facility are bid documents. These drawings represent the site features that were present at the time of construction and may not be reflective of features present today. The Archibus system provides a framework for maintaining plans, well logs, sampling results, and other site information for facilities. As the State of Minnesota Archibus system is developed and implemented in the State of Minnesota the subsurface sewage infrastructure should be included.

4.3 Flows

The Governor of Minnesota issued Executive Order 11-13 which sets targets for water conservation. A further reduction in water consumption at the MnDOT facilities connected to subsurface sewage may concentrate wastewater strength and result in higher strength waste streams. Flow meter infrastructure is present at most facilities but these meters are aging and may not be accurate. It is recommended that a flow meter replacement program be implemented to install meters where not present and replace meters that are aging. These meters should be connected to building automation so data is recorded continuously and stored on MnDOT servers for retrieval.

The goal should be to obtain enough data for a statistical analysis of wastewater flow rate. Ideally two-three years' worth of data should be required and the following parameters determined:

1. Average values
2. Maximum values (day, week, month, season)
3. Minimum values (day, week, month, season)

It is important to note that influent flow rate at MnDOT facilities will be highly dependent on factors such as time of day, season, size and characteristics of the contributing flow. It is believed that the characteristics of the contributing flow can be accurately determined with a sampling and analysis study. Efficacy of treatment may change seasonally.

4.4 Septic Tanks

The risk assessment purposefully placed high importance on some parameters. The risk assessment program takes a holistic approach, but some items are so critical that immediate action is required. Septic tank lids, for example, pose an immediate risk and should be dealt with accordingly.

4.5 Standard Designs

Many MnDOT facilities have been in operation for over 30 years and do not exhibit signs of distress or systematic failure. These facilities and the design features should be determined for information to determine what design features appear to have the most impact on longevity. Furthermore, there are a few low cost design changes not presently implemented that may increase the life of these facilities:

1. New septic tanks should have effluent filters with alarms to reduce the size of particles that can pass from the tanks.
2. Existing tanks should be retrofitted with effluent filters.

The FHWA design charts should be updated to include advancements in soil science and the plumbing code. These changes need to be recorded so changes in personnel do not result in changes of design philosophy; changes in scientific knowledge should change design philosophies.

Moving forward, pressurized systems are recommended for all facilities and with systems with flows greater than 1,000 gpd and the dispersal area should be zoned to allow for resting. Many of the existing systems were installed in an area where the native soil was removed and backfilled with engineered soils. Evaluating the current water table will provide additional information regarding treatment and needed upgrades.

Monitoring of effluent ponding levels of in-ground gravity-fed or siphon-fed systems could assist MnDOT staff in timing of maintenance and replacement. Installing and maintaining inspection ports on these systems and twice-yearly ponding inspections would be the minimum requirements to encourage better wastewater treatment over the life cycle of these soil treatment systems. This effort would also reduce the likelihood of surfacing effluent at these facilities.

Automation should be implemented at each facility. Many of these facilities are remote in nature and automation has the potential to reduce the number of services calls where a person needs to go to the site. While automation increases the complexity of these systems, the benefit of automation is seen in a reduction in personnel trips to the site.

4.6 Waste Stream Characteristics

High strength wastewater for BOD, TSS or both occurs at rest areas and travel information centers. All samples were grab samples that occurred at one point in time – no repeat samples occurred. Waste strength is a design parameter that is and should continue to be considered in every design moving forward. Nitrogen was high or very high at 38 of the sites. Much of this is likely due to the nature of use at the facilities, but all nitrogen based cleaners should be removed from the stream and tertiary treatment of nitrogen should be considered on systems with large flows particularly when a sensitive aquifer could potentially be impacted. Background nitrogen levels from the water supply would also affect the waste stream. The data used to determine aquifer sensitivity was suitable for an initial estimate, but it is recommended that the data be recorded digitally and compiled regionally or centrally to ensure consistent quality and utility. This would also facilitate troubleshooting any wastewater system issues, as well as plumbing issues within the structure. Trends and complete analysis of this data over the life of each facility would greatly assist in future design of similar facilities. For the six systems that are within 300 feet of a surface water body phosphorous treatment should be evaluated when the system is being upgraded near a surface water body.

4.7 Management

A centralized management approach should be implemented on all wastewater infrastructures. Codes, regulations, and requirements are getting more restrictive with time and the wastewater field is becoming more specialized. In the septic industry alone nine unique certifications exist and a certification consolidation or simplification effort is not likely to occur. Operational knowledge management needs to be maintained. To effectively manage the wastewater infrastructure a centralized certified service provider/operator should be identified and managed through the MnDOT Water Services Unit or one hired from the private sector. While ownership and maintenance of the facilities would remain with the district, process operation would occur through Water Services.

Site specific operation and maintenance manuals exist for few MnDOT systems. Site specific management plans should be developed for all systems. For instance, many of the septic tanks were past the time period for typical maintenance. Maintenance activities should be tracked through the State of Minnesota Archibus program. Once a sufficient amount of activities are logged, this database should then be data mined to determine trends and outcomes. This could then allow for revised manuals for existing systems or better-informed manuals for those new or replacement wastewater treatment systems. For the RA and TICs it is recommended that the tanks be evaluated quarterly and only the tanks in need of pumping (>25 volume storage of sludge and scum) be pumped.

The 29 systems that had vegetation related issues that should be addressed and many have been already. Over the long term keeping the areas mowed is recommended to prevent brush and trees from growing in the area and while encouraging evapotranspiration.

4.7.1 Overall Risk

It is recommended that MnDOT focus their available funds to correct public health and safety issues first as identified by systems that are surfacing (8 systems) and those with unsafe septic tanks lids. As these repairs are made the spreadsheet should be updated. Corresponding activities should focus on those facilities that received a 3 in the overall risk matrix. After those activities have been completed, a closer evaluation of the facilities labeled “4” should be performed.

Chapter 5: Future Research Needs

During the course of this project many areas for further research have been identified as outlined below. Further research into these areas will benefit not only the Department, but the industry and policy makers in Minnesota and other state DOT's. Information learned from investigating DOT facilities may be incorporated into the MPCA Design Guidelines to advance the practice of the industry.

5.1 Groundwater Mounding and Vertical Separation

Groundwater mounding and vertical separation is the primary design parameter of subsurface sewage systems. Separation of the groundwater table and the point where sewage is injected into the ground is necessary because this is where pathogens are treated. Groundwater mounding is a rising of the near-surface groundwater due to the addition of effluent under a soil treatment system.

Groundwater mounding and vertical separation are concerns at every SSTS facility in the state. At MnDOT facilities, intensive groundwater monitoring is taking place via a series of water table monitoring devices and deeper groundwater monitoring wells under the 2014 installed soil treatment systems at Fuller Lake RA and Rum River RA. This data collection and analysis effort is expected to continue indefinitely as weather and climatic trends vary as well as use of these facilities will also vary. Expected outcomes from this work would include:

1. Groundwater quality impacts from Fuller Lake and Rum River soil treatment systems; and
2. Timing, frequency and magnitude of water table fluctuations underneath soil treatment systems.

Modeling studies have attempted to address heights of mounding, but a complex and often require expensive and highly variable field parameterizations. Field-based monitoring of groundwater mounding has not been widely conducted and related back to various septic system characteristics and site and soil properties. We will field validate our data with two common groundwater mounding models (i.e. ANTM and Kahn). The outcome of this data collection and validation effort will also provide ranges of values for groundwater mounding that can be related to various site conditions.

Extensive monitoring of vertical separation below the soil treatment systems was also a concern raised by this project. Given the prevalence of fill soils and compacted original soils, it is difficult to accurately assess the amount of vertical separation that is being maintained on many MnDOT sites. We have begun to install automated water table monitoring devices at 30 MnDOT Rest Areas around MN that were found to have vertical separation during the site assessments. This data collection and analysis effort is expected to continue indefinitely as weather and climatic trends and use of these facilities will vary. The outcome of this work is a direct measurement of vertical separation over time. Those systems not maintaining this separation would be added to an upgrade list (or kept on it) and those maintaining required separation could be removed, but continued monitoring would be recommended.

5.2 Water Usage

MnDOT created the first rest area water use study in the nation. This study, FHWA Technical Advisory T5140.8 created the design standards for potable water systems and wastewater systems utilized by the State of Minnesota. Advances in the plumbing code and water conservation activities have unintentionally introduced errors into the original FHWA design guidelines; however, this does not reduce the importance or functionality of these guidelines. The MnDOT guidelines are important because they relate wastewater flow to vehicles and population and allow MnDOT to project future wastewater flows based on traffic analysis.

Data is currently being gathered at six facilities. This data is correlated to vehicles and people to determine a new FHWA standard guideline. This research should be continued at these sites for three years to determine seasonal variations and to further vet the design information. The study should be expanded to include additional locations.

5.3 Design Manual

In conjunction with the FHWA study a detailed design manual is needed. This manual would highlight the critical design parameters and procedures for the design of rest areas, truck stations, and weigh scales. This manual should capture expertise to provide a consistent framework moving forward to promote consistent design and installation of septic systems. This consistency would make the design, installation and maintenance procedures uniform across the state and streamline the upgrade process.

A secondary benefit to a design manual is that the Department can manage consultant expectations, code changes, and client expectations consistently. Given the unique status of the Water Services Unit within the State of Minnesota, it is vitally important the knowledge retention and management is considered a high priority.

5.4 Potable Water Treatment

Along with providing sewer collection, treatment, and disposal at MnDOT sites the MnDOT also provides its buildings with potable water. Sixteen of the 52 sites had potable water treatment systems to remove undesirable components form the drinking water such as hardness, iron, and manganese. Most potable water treatment systems are located at SRAs. It is unknown if these units are impacting the wastewater treatment process in the tanks, advanced treatment units and soil or if impacts are occurring, to what degree. Some manufacturers of advanced treatment units void their warranty if the backwash water from these units discharges into the septic system. Further complicating the issue are the industry lobbyist groups. These lobbyist groups are pushing an agenda, and their positions on the water treatment debate closely align with the industry they represent. Science, research and the specific facility waste characteristics should be the deciding factor for how to deal with drinking water treatment waste. It is possible chloride present in the wastewater stream could impact down gradient wells or surface water. An in-depth evaluation of these systems would measure performance and down gradient impacts.

5.5 Flammable Waste Trap Wastewater

Truck stations and weigh scales had flammable waste traps to catch water from facility floor drains. These tanks and waste streams were not evaluated as part of this project since they are not considered to be sewage under State Rules as flammable waste traps and wastewater are regulated under the Minnesota Plumbing Code, MN Rule 4715. Wherever flammable waste traps are located they discharge to a holding tank and are managed in accordance with the Minnesota Department of Transportation, Office of Environmental Stewardships, and Regulated Materials Management Guidance (Section 11). The tanks and wastewater streams should be evaluated to determine pollutants in the wastewater and alternative management options determined.

5.6 Effluent Quality

At all of the sites a grab sample was taken from the effluent side of the septic tanks. This sample was grab sample and does not accurately represent the sewage characteristics of the facility. For some systems this sample may have been taken when maintenance was needed, while for other sites the tanks had recently been pumped, both of which impact the results. A more robust data base of effluent quality would provide a more accurate baseline of the effluent quality and this data could be used to identify and codify MnDOT design standards under the research need identified in paragraph 5.3.

5.7 Secondary Treatment Efficiency and Effectiveness

Secondary treatment is an effective method for treating wastewater prior to subsurface injection of the wastewater. Secondary treatment often reduces the organic strength of the wastewater as well as reducing the amount of pathogens present. Treatment prevents the formation of the biomat in new systems and it has been shown to reduce or eliminate the biomat in existing systems. There are seven sites which have secondary treatment to reduce the organic loading. The monitoring done showed mixed results in effectiveness of the treatment unit processes. As noted in the sampling research paragraph, the samples were based on a single event and are not representative of the facilities overall performance. It is also important to keep in mind that treatment systems are designed to achieve a certain outcome and require more effort and energy to maintain. The additional efforts that are required to maintain these facilities are also their greatest downfall. Passive treatment units that require little to no maintenance appear better suited to rural, remote facilities than active treatment systems. A more in-depth optimization evaluation should be done to evaluate these systems, including the influent and effluent waste streams.

5.8 Nitrogen Removal Optimization

There are five recirculating media filters at SRA which if designed and operating properly reduce nitrogen levels. The monitoring done showed mixed results in reduction of total nitrogen, but this observation is based on a discrete point in time and further investigation is warranted. Most recirculating media filters are designed to reduce the organic strength of wastewater and nitrogen reduction is a secondary benefit. A more in depth study could evaluate these systems and offer recommendations to optimized nitrogen reduction.

5.9 Tank Maintenance Operation and Maintenance

The Minnesota Department of Transportation discourages the land application of septage when a wastewater treatment facility is nearby and willing to accept septage. This issue was brought up to the State Advisory Board by MnDOT but the MPCA elected to not pursue any investigation into this issue. It was generally felt by the committee that MnDOT prohibiting the land application of septage was a bad precedent for Minnesota (MPCA SSTS Advisory Committee Minutes, 2014); however, just like many public facilities, MnDOT septic sludge contains needles, jeans, sanitary devices, and other non-biodegradable items. No regulatory agency has quantified what the regulatory or public health risk is when these non-biodegradable devices are land applied. Complicating this issue for MnDOT is that not all regions in the state have Public Owned Treatment Works (POTW) that are willing and able to accept septage so an outright ban creates operational problems for MnDOT. .

During this investigation, a significant variance on when septic tanks were maintained was noted. Some variance maybe appropriate based on tank capacity, use, and waste stream characteristics. An evaluation of these variances along with further data gathering of septic tank performance would result in site specific maintenance recommendations and an operating and maintenance manual. The risk due to land application should be more fully evaluated as land application of the septage would result in cost savings for MnDOT. Further, identifying which tanks need to be pumped would result in a cost savings.

5.10 Hydrogen Sulfide

Hydrogen sulfide is produced in septic tanks. If this gas is not properly vented and the appropriate conditions exist these gases can damage the concrete. Further, as denitrification systems are investigated the risk associated with hydrogen sulfide increases. Denitirifiers and sulfide bacteria are produced in similar conditions and the denitrification reactors need to be sized appropriately. This research effort is closely related to a few other research recommendations. Systems that exhibited corrosion due to hydrogen sulfide should be investigated to develop recommendations to mitigate this issue.

5.11 Urine diversion

The wastewater streams at Minnesota Department of Transportation facilities consists mainly of water and solids from toilets and sinks. Most nitrogen present in wastewater comes from urine. MnDOT uses few cleaning chemicals that contain nitrogen and all cleaning compounds comply with the Department of Administration Master Contract C-252 which stipulates products must meet Green Seal, EcoLogo, or be recognized under the US EPA Design for the Environment Safer Product Labeling Program. The Minnesota Pollution Control Agency is the technical advisor for contract C-252. Background nitrogen may be present based on the source water quality. Urine at rest areas has a potential positive reuse value if captured separately to be used as fertilizer, although concerns exist about pharmaceuticals and other over the counter medicines being concentrated in the urine. Further research is needed into this issue to determine if urine diversion is a valid method to reduce nitrogen issues at MnDOT facilities.

5.12 Phosphorus Reduction

A majority of the phosphorus in septic systems is from human waste, but a percentage of it comes from cleaners. The MnDOT cleaning chemicals should be evaluated for their phosphorus content and low to no phosphorus options be considered and evaluated to potentially reduce the overall levels.

5.13 Hazard Classification of Space

The National Fire Protection Association (NFPA) has issued a Standard for Fire Protection in Wastewater Treatment and Collection Systems (NFPA 820). It should be determined if the MnDOT waste streams creates a hazard or the potential for a hazard. If it can be determined that no hazard exists design requirements can be lessened resulting in a substantial cost savings to MnDOT. The air space in the tanks is currently classified as Class I, Div. 2 for explosive potential. The State of Minnesota SSTS Advisory Committee was asked to investigate what the explosive environment of septic systems is (MPCA, 2015 Committee Meeting Minutes).

5.14 Solid Waste Management

Most SRA and TICs do not have garbage cans to improve the cleanliness of the facilities and limit worker exposure. This decision has resulted in users of these facilities flushing items that are not easily handled through the building sewer and septic system including feminine products, diapers, needles, clothing and other garbage. The option of installing large grinders in the systems has been considered, but the option of reinstalling garbage cans should be evaluated.

5.15 Toilet Paper Options

After human waste, toilet paper is the most common waste product introduced to MnDOT systems. The toilet paper does not always effectively break down in the first septic tank/compartment of the SSTS. Toilet paper options should be evaluated to determine the optimum product for these systems.

5.16 Public Education

MnDOT SFAs and TIC have a unique opportunity to educate the public about proper septic operation and maintenance. An education and outreach plan should be developed to take advantage of this opportunity. This could result in less solid waste entering the SSTS which would benefit the operation.

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Appendix A
Facility Assessment Protocol

MnDOT Facility Questionaire

Date: ______________________

1. Facility Info

Name ______________________

Location ______________________

Manager ______________________

Type ______________________

2. Water Using Devices

Womens: Toilets: ______________________ #

Sinks: ______________________ #

Mens: Toilets: ______________________ #

Sinks: ______________________ #

Sinks (circle) automatic hand operated

Toilets (circle) low flow standard

Water conditioning No Yes: ______________________

Water treatment No Yes: ______________________

Water fountains (circle) inside outside none

Irrigation (circle) yes no

Mop sink (circle) yes no

Other ______________________

3. Usage

Approximate gallons per day? ______________________ gpd

How often are readings taken? Daily Other: ______________________

Chemicals aside from standard 3M? None Other: ______________________

Has well ever been shocked? No Yes (collect sample for analysis) - date(s): __________

Other ______________________

4. SSTS

Pumping frequency and date of last pumping ______________________

Problems/issues ______________________

Appendix B
Facility and Site Assessment Form

MnDOT Field Checklist

Date: ____________________

Facility: ____________________

Tanks

Operating depth normal in all tanks Yes No

#	Type	Depth (ft)	Capacity (gal)	Sludge (in)	Scum (in)	pH	DO	Temp (F)	Effluent Screen	Comments (lids, leaks, concrete, etc)
1										
2										
3										
4										
5										
6										

- ☐ Collect sample for lab analysis from septic, siphon or last tank in treatment train
- ☐ Verify pump, pumps or siphon is operational along with alarm if possible

Number of pumps ☐

Pretreatment

Describe: ____________________

Testing performed: ____________________

- ☐ Collect sample for lab analysis

Soil Treatment Area

Distribution method (circle) gravity siphon pump

Drainfeld dimensions ____________________

Depth of ponding in inspection reports (circle) na none yes: ____________________

Vegetation issues:

Effluent surfacing no yes ____________________

Depth to top of distribution media ____________________ in

Depth to bottom of distribution media ____________________ in

- ☐ Perform soil boring or borings (attached)
- ☐ Draw site sketch (attached)

Appendix C
System Database

	FACILITY		FLOWS				SEPTIC TANK - SIZING AND CHARACTERISTICS											
	Type	RISK Type	Avg Flow (gal/day)	RISK Avg Flow	% Design Flow	RISK % Design Flow	% of Required Size	RISK % of Required Size	Tank Lid Safety Concerns	RISK Tank Lid Safety Concerns	Effluent Filter	RISK Eflt. Filter	Treatment Level	RISK Trt. Level	TKN/TN > 60 mg/l	RISK TKN/TN	Distance to shore land (ft)	RISK Distance to shore land (ft)
Risk		*1 = RA/TIC, 4 = WS/TS*		*5 = <1000, 4 = <2,500, 3 =< 5,000, 1 = >5,000*		*5 = >100%, 2 = <100%*		*5 = >100%, 2 = <100%*		*5 = None, 3 = Repair, 1 = Safety issue*		*5 = Filter, 3 = No Filter*		*1 = HSW+, 2= HSW, 3 = C, 4 = A/B*		*5 = < 60, 3 = < 180, 1 = > 180*		*5 = >300, 3 = < 300*
Weighting		*High*		*Moderate*		*Moderate*		*Moderate*		*High*		*Low*		*Moderate*		*Moderate*		*Low*
SITE																		
AE	RA	1	956	5	26%	5	136%	5	Unsafe	1	No	3	HSW	2	217	1	>>300	5
AW	RA	1	1792	3	50%	5	71%	2	Unsafe	1	No	3	HSW	2	256	1	>>300	5
AL	TIC	1	1603	3	22%	5	135%	5	None recorded	5	No	3	HSW	2	115	3	>>300	5
BA	TS	4	ND	5	18%	5	133%	5	None recorded	5	No	3	C	3	67.8	3	>>300	5
BB	TS	4	ND	5	18%	5	200%	5	Potential traffic risk	3	No	3	C	3	82.7	3	>>300	5
BR	RA	1	5421	1	52%	5	55%	2	None recorded	5	No	3	HSW	2	451	1	>>300	5
BU	TS	4	ND	5	32%	5	317%	5	None recorded	5	No	3	C	3	-	5	234	3
CE	TIC	1	2135	3	23%	5	127%	5	None recorded	5	No	3	C	3	183	1	>>300	5
CL	RA	1	1861	3	22%	5	132%	5	None recorded	5	No	3	C	3	209	1	>>300	5
CU	RA	1	2032	3	36%	5	87%	2	None recorded	5	No	3	HSW	2	146	3	>>300	5
DA	WS	4	ND	5	18%	5	200%	5	None recorded	5	No	3	C	3	-	5	>>300	5
DP	RA	1	581	5	6%	5	515%	5	None recorded	5	No	3	C	3	144	3	>>300	5
DL	TS	4	ND	5	14%	5	200%	5	None recorded	5	No	3	C	3	60.5	3	>>300	5
DR	TS	4	ND	5	14%	5	133%	5	Caps broken, lid not at grade	3	No	3	C	3	-	5	>>300	5
DM	RA	1	2335	3	42%	5	76%	2	None recorded	5	No	3	HSW	2	242	1	>>300	5
DR	TIC	1	3813	4	46%	5	64%	2	None recorded	5	No	3	C	3	-	5	85	3
DE	TS	4	ND	5	28%	5	200%	5	None recorded	5	No	3	HSW	2	83.4	3	>>300	5
EN	RA	1	2729	4	24%	5	116%	5	None recorded	5	No	3	HSW	2	170	3	>>300	5
ER	WS	4	NA	5	18%	5	75%	2	None recorded	5	No	3	C	3	-	5	120	3
FL	RA	1	829	5	16%	5	205%	5	None recorded	5	No	3	C	3	77.4	3	158	3
FR	RA	1	606	5	12%	5	275%	5	Hatch lid not attached to riser	3	No	3	HSW	2	196	1	>>300	5
FU	RA	1	5153	1	115%	2	74%	2	None recorded	5	Yes	5	A/B	4	ND	1	>>300	5
GA	RA	1	432	5	8%	5	296%	5	None recorded	5	Yes	5	HSW	1	693	1	>>300	5
GC	RA	1	3084	4	28%	5	102%	5	None recorded	5	No	3	HSW	2	189	1	>300	5
GP	RA	1	394	5	4%	5	762%	5	None recorded	5	No	3	C	3	192/193	1	>>300	5
GF	TS	4	ND	5	18%	5	200%	5	None recorded	5	No	3	C	3	104	3	>>300	5
HL	RA	1	2835	4	68%	5	50%	2	None recorded	5	No	3	HSW	2	150	3	>>300	5
HA	RA	1	2039	3	17%	5	164%	5	None recorded	5	No	3	C	3	-	5	>>300	5
KR	RA	1	671	5	13%	5	191%	5	None recorded	5	Yes	5	HSW	1	731	1	>>300	5
LP	RA	1	897	5	12%	5	243%	5	None recorded	5	No	3	C	3	111	3	184	3
MG	TS	4	ND	5	18%	5	571%	5	Unsafe	1	No	3	C	3	-	5	>>300	5
MA	RA	1	2232	3	15%	5	189%	5	None recorded	5	No	3	HSW	2	191	1	>>300	5
MC	TS	4	ND	5	21%	5	476%	5	None recorded	5	No	3	ND	2	-	5	>>300	5
NM	RA	1	2013	3	13%	5	218%	5	None recorded	5	Yes	5	A/B	4	175	3	>>300	5
NU	TS	4	ND	5	14%	5	227%	5	None recorded	5	No	3	C	3	123	3	>>300	5
NB	TS	4	ND	5	46%	5	133%	5	None recorded	5	No	3	HSW	2	109	3	>>300	5
NO	TS	4	ND	5	18%	5	800%	5	None recorded	5	No	3	C	3	71.5	3	>>300	5
OL	RA	1	1190	3	15%	5	197%	5	None recorded	5	No	3	C	3	-	5	120	3
OW	RA	1	2245	3	32%	5	95%	2	Not at grade lid	3	Yes	5	A/B	4	97.5	3	>>300	5
OD	TS	4	ND	5	18%	5	NA	5	None recorded	5	No	3	C	3	-	5	>>300	5
PR	TS	4	ND	5	11%	5	NA	5	None recorded	5	No	3	NA	3	NA	1	>>300	5
RR	WS	4	ND	5	18%	5	200%	5	None recorded	5	No	3	C	3	79	3	>>300	5
RU	RA	1	1303	3	22%	5	140%	5	None recorded	5	No	3	C	3	-	5	>>300	5
SL	TS	4	ND	5	12%	5	200%	5	None recorded	5	Yes	5	C	3	103	3	>>300	5
ST	TIC	1	3565	4	16%	5	167%	5	None recorded	5	No	3	HSW	2	173	3	>>300	5
SC	WS	4	ND	5	18%	5	200%	5	Mismatched lid on siphon	3	No	3	C	3	130	3	>>300	5
TE	TIC	1	2567	4	22%	5	130%	5	None recorded	5	Yes	5	HSW	2	123	3	>>300	5
WA	TS	4	ND	5	18%	5	200%	5	None recorded	5	No	3	C	3	-	5	>>300	5
WT	RA	1	1587	3	21%	5	143%	5	None recorded	5	Yes	5	C	3	119	3	>>300	5
WI	TS	4	ND	5	18%	5	800%	5	None recorded	5	No	3	C	3	-	5	>>300	5
WO	WS	4	ND	5	35%	5	200%	5	Lock cut off hatch, hinges broken	3	No	3	C	3	-	5	>>300	5
WR	TIC	1	1290	3	10%	5	279%	5	None recorded	5	No	3	HSW	2	177	3	>>300	5

	SOIL TREATMENT - TYPE				SOIL TREATMENT - SIZING						SOIL TREATMENT - PERFORMANCE					
	Distribution Method	RISK Dstrbtn.	Type of Soil Treatment System	RISK Type of STA	% Of Required Sizing	RISK % Of Required Sizing	% Of Required Organic Sizing	RISK % Of Required Organic Sizing	Amount of separation (ft.)	RISK Amount of separation (ft.)	Evidence of Surfacing	RISK Evidence of Surfacing	Ponding	RISK Ponding	Compaction	RISK Compaction
Risk		*2 = Siphon or Gravity, 4 = Pressurized*		*2 = Engineered , 4 = Natural*		*5 = >100%, 2 = <100%*		*4 = >100% or NA, 2 = <100%*		*5 = > 3, 3 = 1 - 3, 2 = < 1*		*4 = None , 2 = Evidence, 1 = Yes*		*2 = Yes , 4 = None recorded*		*4 = No, 2 = Yes*
Weighting		*Moderate*		*Moderate*		*Moderate*		*Moderate*		*High*		*High*		*Moderate*		
SITE																
AE	Siphon	2	Engineered soil beds & cesspools	2	314%	5	172%	4	0.42	2	None recorded	4	Yes	2	None recorded	4
AW	Pressurized	4	Engineered soil beds & cesspools	2	261%	5	155%	4	1.5+ soil survey limit	3	None recorded	4	Yes	2	None recorded	4
AL	Siphons	2	Bed	4	105%	5	88%	2	-3.13	2	None recorded	4	None recorded	4	None recorded	4
BA	Pressurized	4	Bed	4	206%	5	218%	4	-1.00	2	None recorded	4	None recorded (lack	4	None recorded	4
BB	Gravity	2	Trenches	4	691%	5	691%	4	0.33	2	None recorded	4	None recorded (lack	4	None recorded	4
BR	Gravity	2	Trenches	4	113%	5	78%	2	2.00	3	None recorded	4	None recorded	4	None recorded	4
BU	Siphon	2	Engineered soil bed	2	216%	5	203%	4	-3.92	2	Yes	1	None recorded	4	None recorded	4
CE	Pressurized	4	Engineered soil bed	2	216%	5	216%	4	3.5 - soil survey	5	None recorded	4	None recorded	4	None recorded	4
CL	Pressurized	4	Engineered soil bed	2	103%	5	109%	4	0.00	2	In 2010	2	Yes	2	Yes	2
CU	Pressurized	4	Engineered soil bed	2	213%	5	137%	4	3.17	5	None recorded	4	Yes	2	None recorded	4
DA	Gravity	2	Trenches	4	245%	5	245%	4	0.00	2	None recorded	4	Not available	4	None recorded	4
DP	Gravity	2	Trenches	4	284%	5	284%	4	2.67	3	Potentially	2	Not available	4	None recorded	4
DL	Pressurized	4	Engineered soil bed	2	411%	5	411%	4	0.33	2	None recorded	4	None recorded	4	None recorded	4
DR	Gravity	2	Trenches	4	56%	2	20%	2	-2.50	2	Yes	1	Yes	2	None recorded	4
DM	Pressurized	4	Beds	4	185%	5	84%	2	-3.25	2	Yes	1	Yes	2	Yes	2
DR	Siphon	2	Engineered soil bed	2	181%	5	181%	4	2.42	3	No	2	Yes	2	None recorded	4
DE	Pressurized	4	Bed	4	127%	5	109%	4	0.17	2	Yes	1	Yes	2	None recorded	4
EN	Siphon	2	Engineered soil beds and trenches	2	228%	5	129%	4	2.67	3	None recorded	4	None recorded	4	None recorded	4
ER	Gravity	2	Trenches	4	NA	5	NA	4	NA	5	None recorded	4	NA	4	None recorded	4
FL	Pressurized	4	Bottom draining sand filter	2	46%	2	163%	4	-0.17	2	No, but 100% full	2	Yes	2	None recorded	4
FR	Gravity	2	Trenches	4	285%	5	127%	4	1.83	3	None recorded	4	Yes	2	None recorded	4
FU	Pressurized	4	Advantex to Beds	4	67%	2	456%	4	4.50	5	No	2	No	4	None recorded	4
GA	Pressurized	4	Engineered soil bed	2	1999%	5	237%	4	-1.17	2	Yes	1	None recorded	4	None recorded	4
GC	Siphons	2	Trenches	4	350%	5	162%	4	1.83	3	None recorded	4	None recorded	4	Yes, at 13 inches	2
GP	Pressurized	4	Mound	4	396%	5	364%	4	3.17	5	None recorded	4	None recorded	4	None recorded	4
GF	Pressurized	4	Engineered soil bed	2	11%	2	40%	2	2.50	3	None recorded	4	None recorded	4	None recorded	4
HL	Pressurized	4	Engineered soil bed	2	194%	5	119%	4	-0.42	2	None recorded	4	None recorded	4	None recorded	4
HA	Pressurized	4	Bed (trenches)	4	293%	5	275%	4	-1.50	2	Yes	1	Yes	2	None recorded	4
KR	Pressurized	4	Engineered soil bed	2	837%	5	154%	4	-0.83	2	None recorded	4	None recorded	4	None recorded	4
LP	Pumped to gravity	2	Trenches	4	210%	5	209%	4	1.33	3	None recorded	4	None recorded	4	None recorded	4
MG	Gravity	2	Trenches and seepage pit	2	411%	5	411%	4	-1.83	2	None recorded	4	Not available	4	None recorded	4
MA	Pressurized	4	Engineered soil bed	2	561%	5	223%	4	0.25	2	None recorded	4	None recorded	4	None recorded	4
MC	Pressurized	4	Mound	4	1551%	5	1543%	4	3.00	5	None recorded	4	None recorded	4	None recorded	4
NM	Pressurized	4	Advantex to Beds	4	143%	5	5719%	4	-0.58	2	None recorded	4	Yes	2	Compacted at 28 inch	2
NU	Siphon	2	Trenches	4	286%	5	282%	4	-3.00	2	None recorded	4	Yes	2	None recorded	4
NB	Gravity	2	Trenches	4	316%	5	299%	4	2.50	3	None recorded	4	None	4	None recorded	4
NO	Gravity or siphon	2	Bed	4	38%	2	202%	4	-1.33	2	None recorded	4	Yes	2	None recorded	4
OL	Pressurized	4	Beds with chambers	4	417%	5	441%	4	-1.33	2	None recorded	4	None	4	None recorded	4
OW	Pressurized	4	Advantex to trenches	4	101%	5	64%	2	0.83	2	None recorded	4	None recorded	4	None recorded	4
OD	None	4	Holding tank	4	NA	5	NA	4	NA	5	NA	4	NA	4	NA	4
PR	None	4	Holding tank	4	NA	5	NA	4	NA	5	NA	4	NA	4	NA	4
RR	Pressurized	4	Trenches	4	514%	5	483%	4	-3.83	2	None recorded	4	None recorded	4	None recorded	4
RU	Pressurized	4	Advantex, Mounds	4	415%	5	598%	4	3.00	5	No	2	No	4	None recorded	4
SL	Pressurized	4	At-grade	4	1607%	5	1511%	4	0.67	2	None recorded	4	None recorded	4	None recorded	4
ST	Pressurized	4	Bed	4	805%	5	605%	4	0.50	2	None recorded	4	None	4	None recorded	4
SC	Siphon to gravity	2	Trenches	4	736%	5	736%	4	2.00	3	None recorded	4	No	4	Yes	2
TE	Pressurized	4	Trenches	4	128%	5	112%	4	1.42	3	Yes, old system in th	2	No	4	Yes, in old	2
WA	Pressurized	4	Mound	4	1131%	5	1197%	4	3.00	5	None recorded	4	None recorded	4	Potentially, perc test	2
WT	Pressurized	4	Sand Filter, Piranas, Beds	4	490%	5	403%	4	-3.75	2	Yes	1	Yes	2	None recorded	4
WI	None	4	Holding tank	4	NA	5	NA	4	NA	5	ND	2	None recorded	4	None recorded	4
WO	Pressurized	4	Beds	4	216%	5	203%	4	-3.00	2	None recorded	4	None recorded	4	None recorded	4
WR	Pressurized	4	Beds	4	352%	5	344%	4	-1.33	2	Yes	1	Yes	2	None recorded	4

	AQUIFER SENSITIVITY				MAINTENANCE				SUMMARY	
	Overall Aquifer Sensitivity	RISK Overall Aquifer Sensitivity	Best Management Practice	RISK Best Mngt Practice	Vegetation Issues	RISK Veg. Issues	Pumping Appropriate - Sludge & Scum	RISK Pumping Appropriate - Sludge & Scum	% Of Lowest (Ideal) Risk Score	RISK % Of Lowest (Ideal) Risk Score
Risk		*1 = Sensitive, 4 = Non-sensitive*		*2 = No BMP , 4 = BMP*		*2 = Trees , 3 = Issues, 4 = No*		*2 = No or no data , 4 = Yes or no data*		*>90% = 5, >80% = 4, >70% = 3, >60% = 2, <60% = 1*
Weighting		*Moderate*		*Low*		*Low*		*Moderate*		
SITE										
AE	Sensitive	1	Not documented	2	Needs mowing	3	No	2	63.3	2
AW	Sensitive	1	Not documented	2	Needs mowing	3	No	2	61.5	2
AL	Sensitive	1	Not documented	2	No	4	No	2	72.0	3
BA	Sensitive	1	Not documented	2	No	4	Yes	4	86.2	4
BB	Sensitive	1	Not documented	2	Gravel/no vegetation	3	Yes	4	80.4	4
BR	Sensitive	1	Not documented	2	Needs mowing	3	No	2	65.1	2
BU	Non-sensitive	4	Not documented	2	Trees	2	No	2	77.8	3
CE	Non-sensitive	4	Not documented	2	Trees	2	No	2	79.3	3
CL	Sensitive	1	Not documented	2	Needs mowing	3	No	2	65.8	2
CU	Sensitive	1	Not documented	2	Mowing needed	3	ND	2	72.4	3
DA	Sensitive	1	Not documented	2	No	4	Yes	4	86.2	4
DP	Sensitive	1	Not documented	2	No	4	Yes	4	78.2	3
DL	Sensitive	1	Not documented	2	No	4	No	2	81.8	4
DR	Sensitive	1	Not documented	2	Wetland vegetation, not mowed	3	No	2	68.4	2
DM	Non-sensitive	4	Not documented	2	Mowing needed	3	No	2	63.3	2
DR	Sensitive	1	Not documented	2	Mowing needed, remove shrubs	3	Yes, every 6 months needed	4	69.5	2
DE	Non-sensitive	4	Not documented	2	No	4	No	2	79.6	3
EN	Non-sensitive	4	Not documented	2	Needs mowing	3	Yes, every 6 months needed	4	79.3	3
ER	Non-sensitive	4	Not documented	2	Needs mowing	3	No	2	86.2	4
FL	Non-sensitive	4	Not documented	2	No	4	No	2	70.9	3
FR	Sensitive	1	Not documented	2	Mowing needs	3	Yes	4	72.0	3
FU	Sensitive	1	Advantex	4	No	4	Yes	4	70.9	3
GA	Sensitive	1	Not documented	2	Mowing needed, tree removed	3	Yes, every 3 months	4	71.6	3
GC	Sensitive	1	Not documented	2	Grass (too long)	3	No	2	72.4	3
GP	Non-sensitive	4	ATU/Mound	4	Gopher issues, mowed	3	No	2	85.8	4
GF	Sensitive	1	Not documented	2	Sparse vegetation	3	No	2	77.1	3
HL	Non-sensitive	4	Not documented	2	Mowing needed	3	ND	2	74.5	3
HA	Sensitive	1	Not documented	2	Trees	2	Yes, every 6 months needed	4	73.8	3
KR	Sensitive	1	Not documented	2	Mowing needed, tree removed	3	Yes, every 3 months	4	76.0	3
LP	Sensitive	1	Not documented	2	No	4	Yes, every 6 months	4	79.6	3
MG	Sensitive	1	Not documented	2	Mowing needed	3	No	2	75.3	3
MA	Sensitive	1	Not documented	2	Mowing needed	3	Yes, every 3 months	4	73.5	3
MC	Non-sensitive	4	Mound	4	No	4	ND	2	94.2	5
NM	Non-sensitive	4	Advantex	4	No	4	Yes, every 6 months	4	83.3	4
NU	Non-sensitive	4	Not documented	2	No	4	No	2	82.9	4
NB	Sensitive	1	Not documented	2	Yes	3	No	2	81.5	4
NO	Non-sensitive	4	Not documented	2	Mowing needed	3	No	2	78.9	3
OL	Non-sensitive	4	Not documented	2	No	4	No	2	81.5	4
OW	Non-sensitive	4	Advantex	4	No	4	Yes, annually	4	78.5	3
OD	Not applicable	4	Not applicable	4	NA	4	NA	4	97.5	5
PR	Not applicable	4	Not documented	2	NA	4	NA	4	91.6	5
RR	Sensitive	1	Not documented	2	No	4	No	2	84.0	4
RU	Sensitive	1	Advantex	4	No	4	ND	2	82.5	4
SL	Sensitive	1	Not documented	2	No	4	No	2	85.5	4
ST	Sensitive	1	Not documented	2	Needs mowing, gopher issues	3	Yes, annually	4	78.9	3
SC	Sensitive	1	Not documented	2	Trees	2	Yes, annually	4	79.6	3
TE	Non-sensitive	4	Not documented	2	Old, needs mowing, New, vegetation ne	3	No	2	78.5	3
WA	Non-sensitive	4	Mound	4	No	4	ND	2	93.8	5
WT	Sensitive	1	RSF	4	No	4	No	2	73.8	3
WI	Non-sensitive	4	Not documented	2	No	4	ND	2	90.9	5
WO	Non-sensitive	4	Not documented	2	No	4	No	2	86.5	4
WR	Non-sensitive	4	Not documented	2	Yes, needs mowing	3	No	2	72.4	3