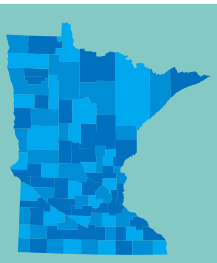
Groundwater

April 2019

Best Management Practices and Data Needs for Groundwater Protection

The MPCA promotes the development of best management practices that prevent, minimize, reduce and eliminate sources of groundwater degradation.

MINNESOTA POLLUTION CONTROL AGENCY



Legislative charge

The Groundwater Protection Act of 1989 (GWPA) requires the Minnesota Pollution Control Agency (MPCA) to develop, promote and monitor the effectiveness of best management practices (BMPs) that prevent, minimize, reduce, and eliminate sources of groundwater degradation. These requirements apply to MPCA programs with activities that may cause or contribute to groundwater pollution for non-agricultural pollutants (https://www.revisor.mn.gov/statutes/cite/103H.001).

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Executive summary

The Groundwater Protection Act of 1989 (GWPA) requires the Minnesota Pollution Control Agency (MPCA) to develop, promote, and monitor the effectiveness of best management practices (BMPs) that prevent, minimize, reduce, and eliminate sources of groundwater degradation. These requirements apply to MPCA programs with activities that may cause or contribute to groundwater pollution for non-agricultural pollutants.

To address the requirements of the GWPA, the MPCA has set goals in its groundwater program and work plans to identify and evaluate groundwater BMP effectiveness. The goals direct the MPCA to: 1) identify groundwater BMPs, 2) highlight BMPs where more data are needed to evaluate their effectiveness, and 3) develop a plan to address data needs that will enhance program groundwater BMPs.

This report provides a review of MPCA programs that identifies 1) groundwater BMPs, and 2) highlights areas where additional data is needed to evaluate the effectiveness of BMPs in preventing groundwater contamination. The report focuses on MPCA programs that typically conduct less groundwater monitoring or have limited information about their program's impacts to groundwater quality. These include the following programs:

- Subsurface Sewage Treatment Systems (SSTS)
- Animal Feedlots
- Biosolids
- Land and Water Quality Permits for land applied industrial wastewaters and by–products
- Stormwater
- Solid Waste Demolition Landfills
- Municipal Inflow and Infiltration (I&I)

A review of the MPCA remediation programs was not included in this effort because these programs routinely collect and analyze an extensive amount of groundwater data to verify that their program practices are effectively protecting groundwater resources with the objective of meeting health-risk based drinking water standards.

Individualized program reviews were conducted by gathering information about groundwater BMPs from program documents that included: fact sheets, permits, policy and rule; and through interviews with program staff to identify program data needs. The interviews with program staff highlighted program data needs that can be used to prioritize data collection efforts to evaluate the effectiveness of program BMPs. The data needs analysis will also serve as a framework to develop plans to evaluate MPCA program groundwater BMPs to address the third goal of the MPCA's strategic plan.

Minnesota Pollution Control Agency groundwater best management practices

The MPCA programs use numerous BMPs to prevent groundwater contamination that are incorporated into their programs' rules, permits, policies, and guidelines. These program BMPs are specifically designed to address the contaminants of concern managed by each of the programs and contain additional requirements that address sensitive groundwater settings, a key requirement of the GWPA.

Examples of BMPs that apply to sensitive groundwater settings include: setback distances for land applied manure, biosolids and industrial by-products (Industrial by-products); locational restrictions for

manure storage and demolition landfills based on groundwater sensitivity; design guidelines for stormwater infiltration in the Minnesota Stormwater Manual; more stringent nitrogen application rates on highly permeable soils for biosolids, and more rigorous design guidelines for SSTS that are based on aquifer sensitivity.

Summaries of program groundwater BMPs are presented within individual program write-ups under the heading "Program practices used to protect groundwater" under the "Program Best Management Practices and Data Needs" section of the report.

Data needs

Several programs have recommended the collection of groundwater quality data to evaluate the impacts of their program BMPs. More specifically, BMP effectiveness could be evaluated from additional groundwater data collection at: mid to large-sized SSTS sites, select animal feedlot drain-tile discharge and manure storage basins, stormwater infiltration sites in sensitive groundwater settings, and at industrial wastewater sprayfield land application sites.

Programs that manage land-applied solid waste do not require the collection of groundwater quality data because their BMPs have been specifically designed to prevent groundwater contamination (biosolids, land-applied manure from feedlots, and industrial by-products). These programs have not recommended groundwater monitoring, as a priority data need. Research suggests that when these program BMPs are properly applied, impacts to groundwater quality are minimal, though there is recognition that more study needs to be done on the possible presence of pharmaceuticals, steroids, and hormones.

Analysis of water quality data was also identified as a need, to assess the impacts and effectiveness of ongoing program BMPs. The Demolition Landfill Program has a need to conduct a statistical analysis of groundwater monitoring data collected over the last eight to ten years at demolition landfills to assess the impacts of program BMPs contained in their Demolition Landfill Guidelines. The Animal Feedlot Program would also benefit from a follow-up sampling and analysis of water quality data collected from larger permitted facilities from a limited number of monitoring wells and tile drainage stations.

An important change noted in this update in 2018 is that most of the programs discussed here have stopped storing basic data in a centralized system at the Agency. Where they once used the now-retired Delta database, they no longer store these data in its replacement, Tempo. Staff are uniform in their hope that data storage will begin within the next few years to rectify this lack, to be available for review and analysis, but no mention is made of specific Agency plans.

An abbreviated list of the program data needs is included in the table below and repeated in Appendix A. More detailed descriptions are provided at the end of each individual program write-up and in the report summary.

Information on the Groundwater Protection Act of 1989 and Minn. Stat. ch. 103H is available at: https://www.revisor.mn.gov/statutes/cite/103H.001. The Degradation Prevention Goal of the law states:

> It is the goal of the state that groundwater be maintained in its natural condition, free from any degradation caused by human activities. It is recognized that for some human activities this degradation prevention goal cannot be practicably achieved. However, where prevention is practicable, it is intended that it be achieved. Where it is not currently practicable, the development of methods and technology that will make prevention practicable is encouraged.

Table 1. Program data needs and recommendations

MPCA Programs	Program data needs and recommendations
Solid Waste Demolition Landfill	• Encourage reuse of demolition materials to reduce reliance on unlined facilities • Provide incentives to owners of unlined landfills to move to facilities that are more protective of degradation through using liners and leachate collection systems • Seek funding for these changes in the State of Minnesota 2018-19 Biennial Budget
Subsurface Sewage Treatment Systems (SSTS)	• Groundwater monitoring at MSTS sites • Assess impacts of smaller ISTS to groundwater monitoring for CECs • Reduce the intentional flushing of unused pharmaceuticals from home and farm
Animal Feedlot	• Follow-up testing and analysis of the drain tile discharge water sampling performed at feedlots, whose permits require testing • Evaluate older manure storage basins lacking double liners in SE Minnesota karst region • Investigate groundwater quality at larger manure storage basins
Land Application of Industrial Wastewaters and IBPs	• Unusual wastes and their environmental fate for land application scenarios are currently (2018) being investigated by the USGS Toxic Substances program • Loading rates at high BOD irrigation sites in Minnesota are much less than similar sites in other states such as MI, which may lead to further study • Site information related to application that used to be entered in the now-retired Delta database is not currently entered in its replacement, Tempo, as of 2018. There will be an attempt to once again capture this information in the future.
Stormwater	• Promote creation of statewide GIS layers to evaluate options to infiltrate stormwater in new development & redevelopment areas in context of vulnerable aquifers • Develop case studies to assess groundwater impacts for stormwater infiltration BMPs (e.g. the Minnesota Stormwater Manual; consider Cl, pathogens, infiltration at brownfields, etc.) • Data collection for stormwater infiltration projects
Biosolids	• No specific recommendations for groundwater monitoring • Biosolids annual reports have been scanned into Tempo, but the data is not in a readily accessible format. New biosolids site approvals and cumulative metals loading data have not been stored electronically since the switch to Tempo. There is a recognized program need to store this data within Tempo. • There is a recognition that the fate of persistent organic compounds (i.e. pharmaceuticals, personal care products, steroids, PFAS, and hormones) in biosolids is important; however, the financial and staff resources necessary to conduct this type of work are beyond the scope of the program's current resources.
Inflow and Infiltration (I&I)	• Limited groundwater impact concerns. Concerns relate to groundwater leaking into wastewater infrastructure. • Investigating leakage to groundwater would be difficult and has not been done in the Municipal Program.

A. Solid Waste Demolition Landfill Program

This program review includes an overview of the best management practices (BMPs) used by the MPCA's Solid Waste Demolition Landfill Program (SWDLP) to prevent groundwater contamination from construction and demolition landfills (C&D landfills). It also presents the nature of groundwater quality impacts, which occur at unlined demolition landfills across the state. Finally, it identifies the steps needed to evaluate groundwater quality data from demolition landfills to better evaluate the effectiveness of program practices in the protection of groundwater resources.

Program BMPs used to protect groundwater

The SWDLP uses a combination of regulatory tools to protect groundwater resources at C&D landfills, including the Demolition Landfill Guidance (DLG), permit requirements, and policies that emulate the mixed municipal solid waste landfill rules. Other regulatory tools used by the SWDLP that indirectly protect groundwater resources include: environmental and technical reviews, facility inspections, operator training, technical assistance, compliance and enforcement, fact sheets, and guidance documents. The DLG and the Landfill Report describe many of the program practices that protect groundwater resources, as described below.

Locational requirements and site evaluations

The DLG states, "The single most effective action that owners/operators of demolition Landfills can take is to locate the demolition Landfills in areas that will inherently protect ground water and surface water

from the risks of contamination. Prohibited locations which must be avoided include active karst topography, flood plains and other areas likely to result in groundwater contamination."

- The Solid Waste Rules prohibit the placement of demolition landfills in areas that would result in groundwater contamination. An existing permitted Landfill that does not meet the location standards above will not be re-permitted.
- Permitting or re-permitting a C&D landfill requires that a site evaluation be conducted to identify potential risks and the need for groundwater monitoring. The site evaluation must verify whether a site meets location standards, has an adequate separation distance between the fill and water table, and provides sufficient information on groundwater flow directions.

Facility classification

The MPCA has developed a three-class system to better manage the potential risks to groundwater from C&D landfills. The three-class system sets different groundwater monitoring and design requirements, and waste acceptance criteria for C&D landfills that are based on waste characteristics and hydrogeologic setting.

- In general, larger C&D landfills have more significant safeguards, such as liners, leachate collection systems, and groundwater monitoring. These landfills are primarily located within the Twin Cities Metropolitan Area. Many smaller C&D landfills are located in rural areas and serve fewer businesses and people and are less likely to have liners or groundwater monitoring; however, operators use more rigorous waste screening practices to control unacceptable wastes that could contaminate the groundwater.
- The DLG sets BMPs for waste screening for the different classes of C&D landfills and defines acceptable waste streams and the requirements for waste stream screening procedures, and Industrial Solid Waste Plans.

Groundwater monitoring

The SWDLP policy states that "all Class II and III Landfills should conduct groundwater monitoring."

- The DLG provides a groundwater monitoring decision matrix to determine whether monitoring is necessary, based on the depth to the water table and the soil type beneath the C&D landfill.
- Decisions to require groundwater monitoring are made upon initial permit issuance or during permit reissuance, which occurs on a 10-year cycle. As noted previously, roughly 65% of all C&D landfills now have some type of groundwater monitoring in place.
- Groundwater monitoring information is reviewed annually and is used to determine if a facility is impacting groundwater quality. Exceedances of groundwater performance standards can lead to permit-required actions to reduce and prevent contaminant impacts. Actions may include: additional monitoring, addition of a less permeable cover atop landfill wastes, or possibly installation of liners beneath the waste to prevent and reduce leaching of contaminants to groundwater.
- In addition to groundwater monitoring requirements, some C&D landfill facilities must also conduct groundwater receptor surveys to identify groundwater users in the vicinity of their facility that may potentially be impacted.

Nature of concern related to groundwater quality

C&D landfills are located in a number of different hydrogeologic settings across the state and vary in size, design and in their contents of construction and demolition debris. C&D landfills may impact

groundwater quality through leaching of contaminants from landfill wastes through the soil to groundwater. The degree to which this occurs is greatly affected by the characteristics of the wastes, hydrogeologic setting, and engineering controls at the landfill. These concerns are presented in greater detail in the report to the Minnesota Legislature on "Management of Industrial Solid Waste and Construction and Demolition Debris in Land Disposal Facilities", January 15, 2009 (Landfill Report), pages 15-17, at the web link http://www.pca.state.mn.us/index.php/view-document.html?gid=41.

To protect groundwater as a source of drinking water the SWDLP applies health-based drinking water limits at C&D landfills and may also apply surface water quality standards for groundwater that may discharge to surface waters of the state. Exceeding these limits triggers permit required actions at the compliance boundary of a C&D landfill, as set forth in Minnesota Solid Waste Rules 7035, subp. 4.

Groundwater quality concerns

Rationale/Background - when the state's 88 unlined C&D landfills were created, it was believed that disposal of standard construction materials such as brick, mortar, wood, metal, etc. would not pose a groundwater threat (Figure 1). As a result, these landfills were not required to be lined or to have leachate collection systems. Over time, construction materials have changed to include more chemicals, adhesives, and plastics – all of which behave differently than wood, metal and brick when subjected to conditions found in landfills. Today, as precipitation percolates through C&D debris and continues to flow out of landfills, the result is frequently contaminated groundwater.

Groundwater monitoring shows that these unlined demolition landfills are contaminating groundwater. Of the state's 88 unlined C&D landfills, 67 have groundwater monitoring on site, and 42 (63%) of those show groundwater contamination that exceeds Minnesota Department of Health (MDH) and U.S. Environmental Protection Agency (EPA) standards. Only four of the monitored sites have shown no contamination at all. Clearly, C&D landfills can generate releases to groundwater, with potential consequences to the environment and public health.

Table 2. Unlined demolition activities

Open permitted unlined demolition activities

MPCA Solid Waste Demolition Landfill Program	No Groundwater Monitoring	Confirmed No Exceedance	Confirmed Intervention Limit Exceedance	Confirmed EPA/MDH Limit Exceedance	Evaluating Groundwater Compliance	Total
Demolition - Class 1	20	3	1	33	16	73
Demolition - Class 2	-	1	1	9	3	14
Demolition - Class 3	-	-	-	-	-	-
Demo - Pre-Guidance	1	-	-	-	-	1
Total	21	4	2	42	19	88

The problem happens by two processes. The first process occurs when the water and organic materials from the landfills enter the ground. This serves to mobilize and concentrate low levels of metals naturally occurring in the soils (i.e. arsenic and manganese), allowing these metals to "flow" into and contaminate the groundwater. The second process occurs when water contaminated by materials in the landfill (i.e. boron and vinyl chloride) seeps through the ground and contaminates groundwater. One or both of these processes may be happening over time in a landfill.

Boron is a major contaminant of concern and is believed to be from flame retardants used to treat sheetrock, lumber and insulation. Nitrates have also been detected in C&D landfill groundwater monitoring systems, but are more likely a result of regional anthropogenic sources and less likely due to wastes contained in the C&D landfills. Testing for volatile organic compounds (VOCs) has shown a limited number of detections at relatively low concentrations at most facilities that include: tetrahydrofuran, vinyl chloride and infrequent detections of Freon and hydrocarbon compounds. More recent testing of groundwater has also identified the presence of per and poly-fluoroalkyl substances (PFAS) at concentrations significantly below groundwater intervention limits for most sites.

MPCA staff have also reviewed C&D landfill leachate data, which provides an indication of what contaminants could potentially enter groundwater systems. Results from this review show that several metal and VOC contaminants are present; however, few of these contaminants have been detected in the groundwater systems at these facilities. This indicates that where facilities have liners they appear to be providing a high degree of protection to groundwater resources.

It is important to note that all significant detections of groundwater contamination are from unlined landfills that pre-date the MPCA's current regulatory regime. Current landfill practices, including more rigorous waste screening procedures, increased use of liners and landfill cover, and groundwater monitoring, all help to reduce and prevent impacts to groundwater resources at C&D landfills. Overall, groundwater-monitoring data from C&D landfills indicates limited impacts to groundwater resources and currently there are no known impacts to private or municipal wells from these facilities.

Program data needs and BMP recommendations

The SWDLP is currently working on a proposal that would address current threats to groundwater posed by construction and demolition (C&D) debris in unlined landfills and expand the reuse of demolition materials to reduce the need for these landfills in the future. The proposal would offer grants and loans to private and public owners of unlined C&D landfills to help divert waste from these landfills and enable a transition to facilities that are more protective of human health and the environment. If funded the following would be allowable uses of the grants or loans:

- To establish or expand programs to recycle/reuse demolition materials, thus reducing the flow of waste into landfills and reducing the threat to groundwater.
- To enhance monitoring for the purpose of better understanding the nature and extent of existing groundwater contamination.
- To incentivize protective actions while the new regulatory system is being created:
  - Cap and close C&D landfills as appropriate to prevent contamination of groundwater.
  - Install liners and leachate collection systems as appropriate at new/expanding facilities.
  - Convert C&D landfills to become C&D transfer stations.

In addition to the above proposal, the MPCA SWDLP must prepare a report that evaluates groundwater quality data from demolition debris land disposal facilities. In evaluating groundwater quality data, comparisons must include at least the following:

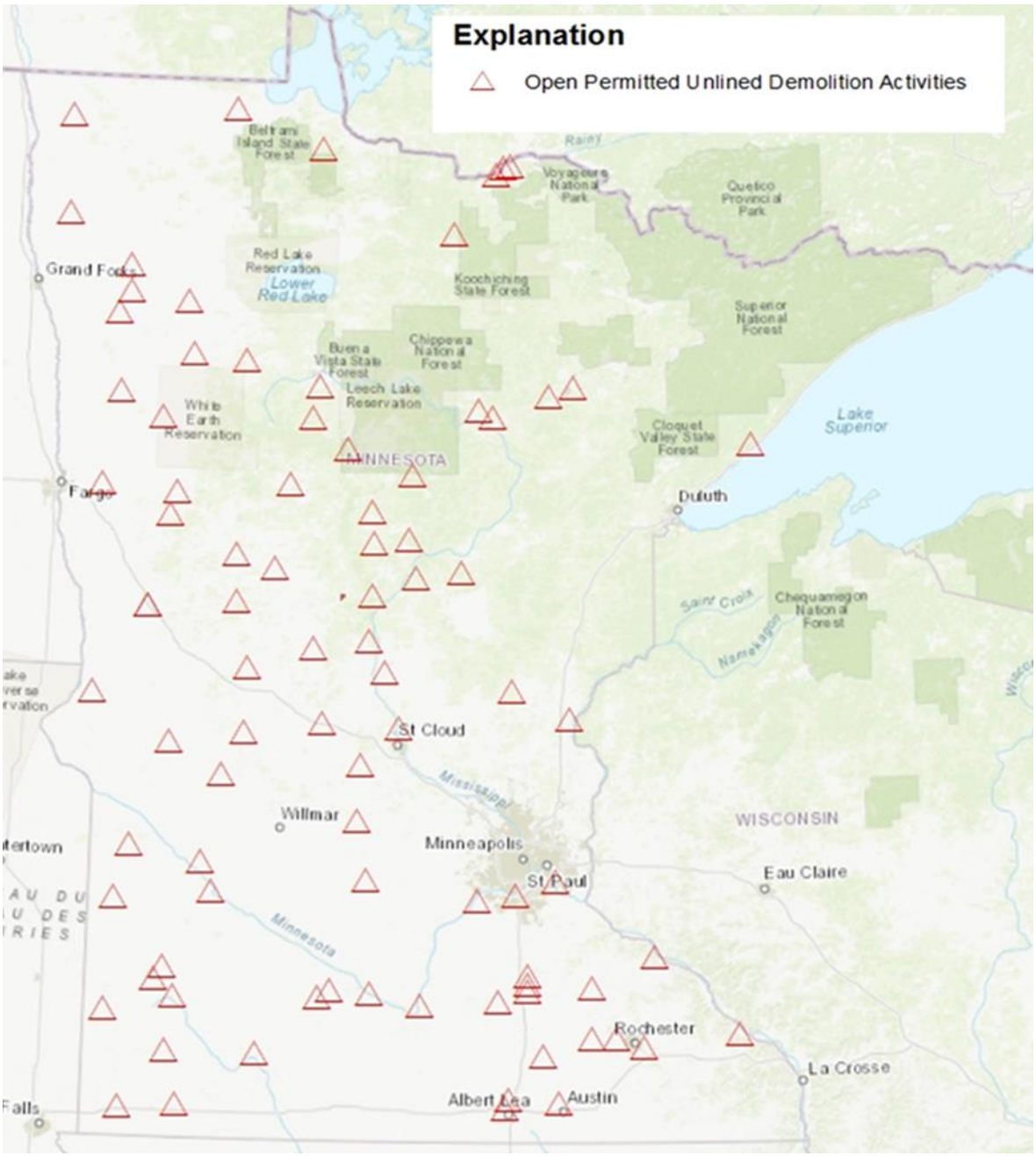
- Adopted health risk limits established in Minn. R. 4717.7500 and Minn. R. 4717.7860.
- Adopted standards, and health advisories & values from both federal and state governments.
- State solid waste intervention limits.

The report must also examine at least:

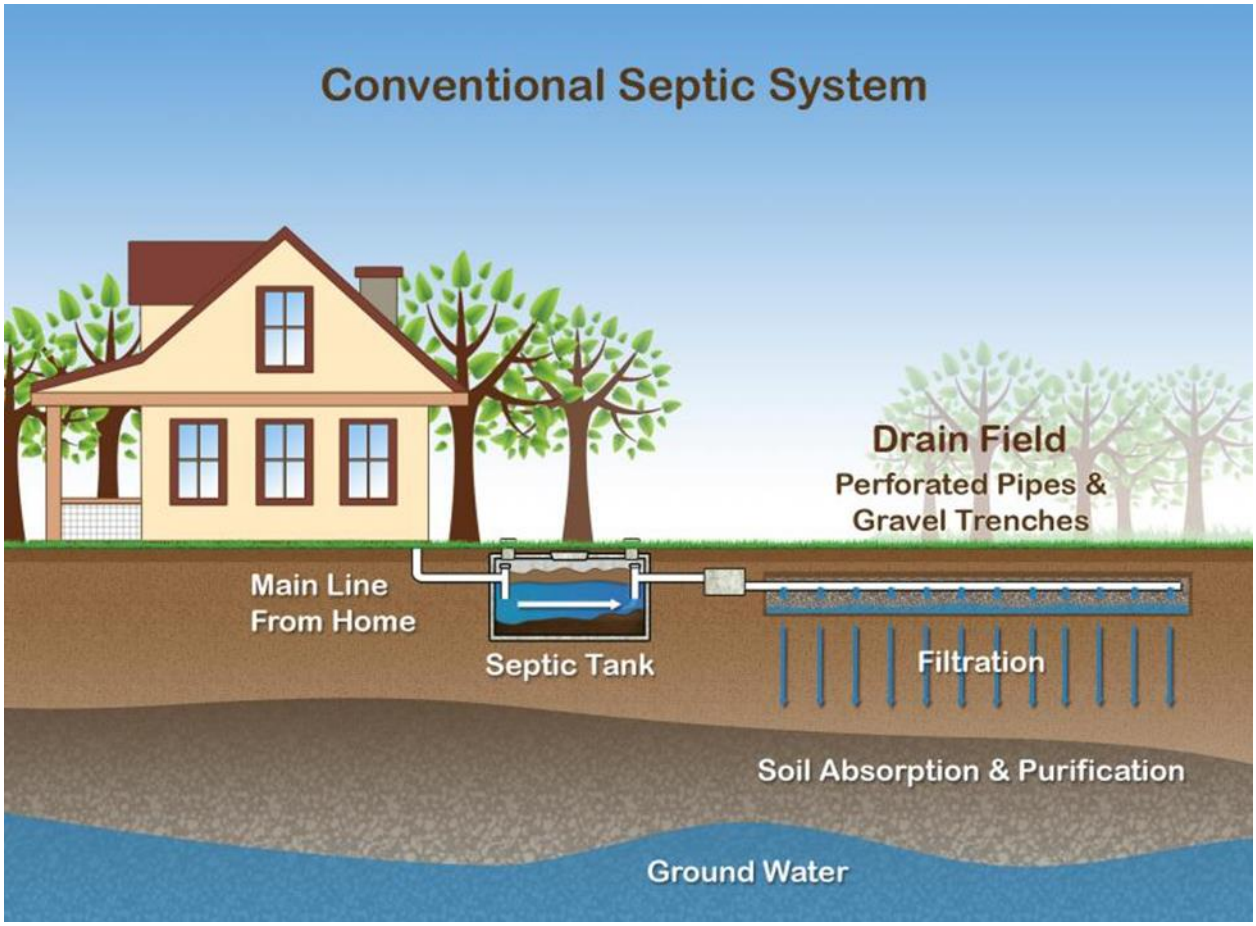
- The role oxidation-reduction reactions have in groundwater chemistry at permitted demolition debris land disposal facilities and compare the role oxidation-reduction reactions have in general to other regulated facilities such as septic systems, surface impoundments, and lined land disposal facilities.
- Compare concentrations to groundwater quality data from other local, regional, and statewide wells, including domestic wells, not associated with landfills.

The findings from this report will be used by the MPCA SWDLP to further evaluate the effectiveness of program BMPs that prevent, minimize, reduce and eliminate sources of groundwater degradation from unlined demolition landfills.

Figure 1. Open permitted unlined demolition activities



B. Subsurface Sewage Treatment Systems



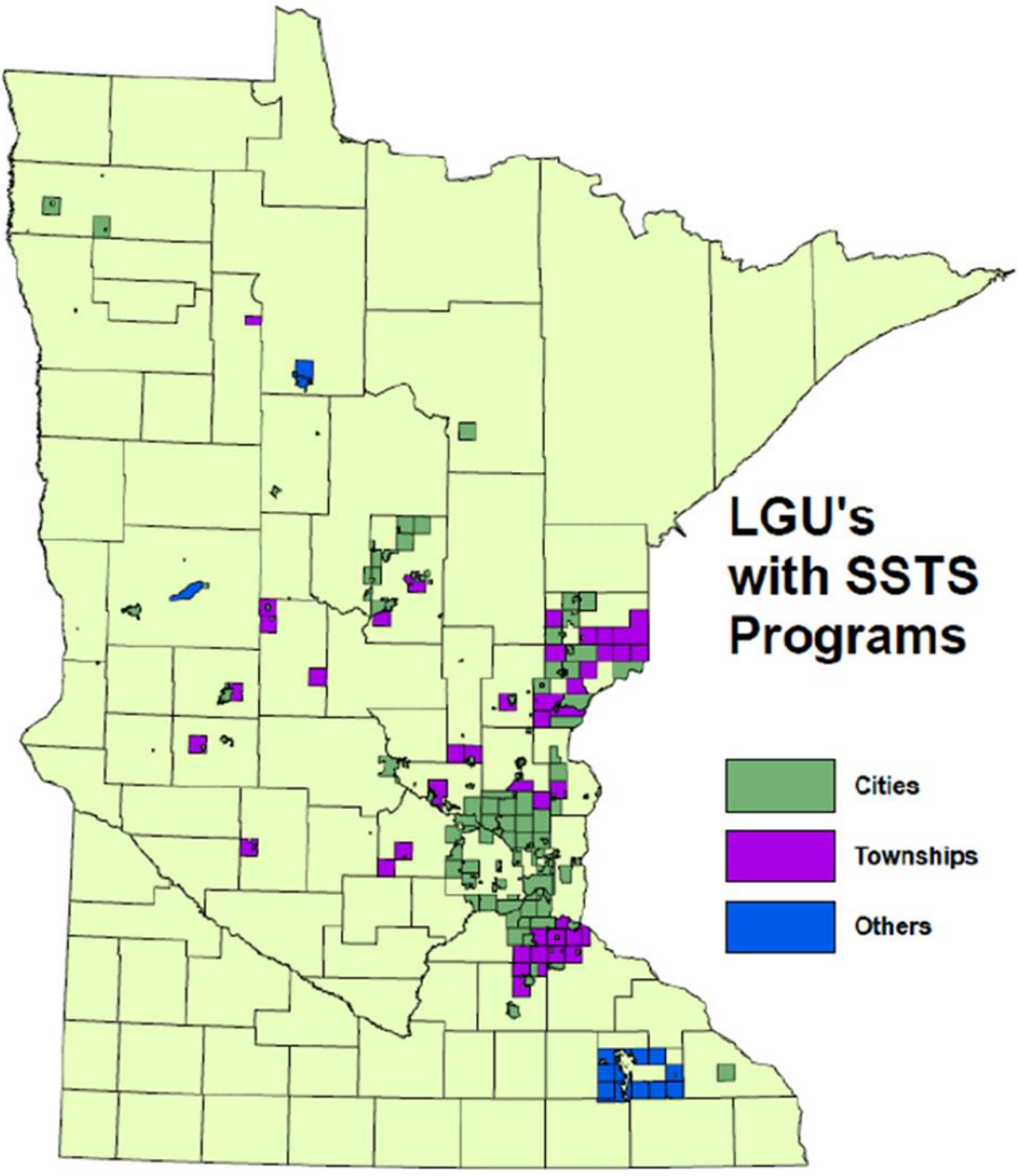
This program review identifies program practices implemented by the MPCA's Subsurface Sewage Treatment Systems (SSTS) program to prevent the contamination of groundwater. It also identifies program areas where additional data are needed to better evaluate the effectiveness of SSTS program practices to protect groundwater resources and makes recommendations to address some of these data gaps.

Overview

The SSTS program oversees the treatment of sewage discharge to SSTS in accordance with state statute (Minn. Stat. 115.55) and rules (Minn. R. ch. 7080-7083). Subsurface or soil-based treatment systems treat approximately one quarter of Minnesota's domestic wastewater (sewage). In 2017, 211 Local Government Units (LGU) reported 537,354 SSTSs in Minnesota. There were 10,906 construction permits issued for both new or replacement systems and 770 SSTS repairs for a grand total of 11,676 SSTS related permits. Over a period of 16 years, from 2002 to 2017, LGUs reported that over 187,766 construction permits were issued. A map showing locations of known SSTS programs is shown in Figure 2. Roughly 98% of these systems are smaller individual sewage treatment systems (ISTS) serving flows of 2,500 gallons per day (gpd) or less. The remaining 2% include mid-sized sewage treatment systems (MSTS) serving flows between 2,501 and 10,000 gpd, and large sewage treatment systems (LSTS) serving flows of 10,000 gpd or greater. Individual sewage treatment systems and MSTS are regulated by local units of government (i.e. city, township, or county). All counties except Ramsey

oversee SSTS programs. Minnesota rules require the MPCA to regulate LSTS due to the greater volume of wastewater treated and their associated potential for environmental and health risks. Overall,

Figure 2. Location of county, city, township and other known SSTS programs in 2017



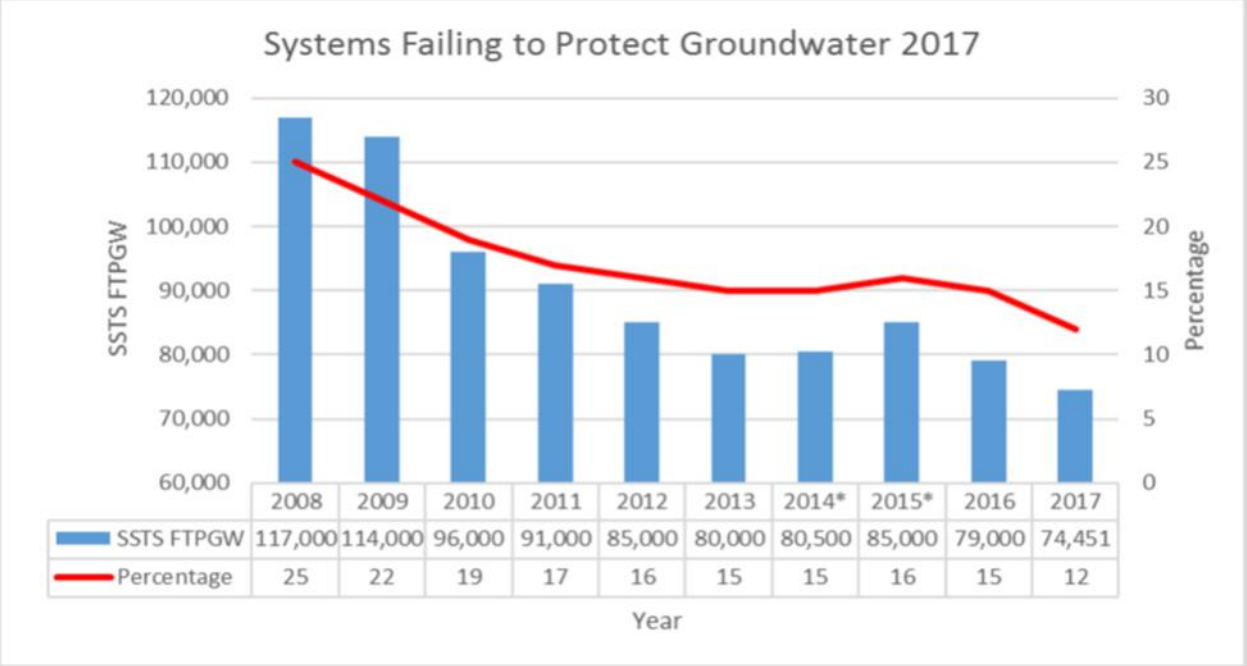
groundwater protection increases based on SSTS size and proximity to vulnerable aquifers. Larger systems have additional monitoring requirements, permit conditions, and BMPs applied to their location, design, installation, use and maintenance.

Nature of concern related to groundwater

Subsurface Sewage Treatment Systems discharge sewage into the ground, where it is treated before mixing with groundwater and surface waters. The wastewater in SSTS contains organic matter and solids, pathogenic organisms (bacteria, viruses, and parasites), nutrients, and some chemicals. A properly operating SSTS will convert a large percentage of the total nitrogen in the sewage to nitrate. Once the nitrate-laden effluent reaches the groundwater, concerns arise about use of that groundwater as a drinking water supply.

LGUs were asked to provide their best estimates of SSTS compliance information as part of the MPCA 2017 SSTS Annual Report, including total number of SSTS in their jurisdiction, the number estimated in compliance, the number estimated to be an imminent threat to public health and safety, and the number estimated to be failing to protect groundwater. The percent of compliant SSTS has increased from 75% in 2008 to 82% in 2017, and the estimated number of systems failing to protect groundwater decreased over the same time period from 117,000 (25%) to 74,451 (12%) systems in 2017; a decrease of 42,549 systems (Figure 3).

Figure 3. The estimated number of systems failing to protect groundwater (FTPGW).



Existing SSTS compliance inspections

Groundwater quality depends not just on the regulations controlling SSTS systems, but also on compliance inspections, to ensure that the SSTS systems are functioning as planned. Out of the total 537,354 SSTS reported in Minnesota in 2017, approximately 2.8% of the existing septic systems were reported to have been inspected in the prior year. Inspections are an important part of addressing existing systems that pose an environmental or human health risk. Local governments include inspection triggers, such as at the time of property transfer or when a building permit is sought, in their ordinances to create a mechanism for verifying system conformance and correcting nonconforming systems within the timeframes specified through state statute or local ordinance.

There were 15,250 compliance inspections of existing systems reported by local SSTS programs representing a 2.7% increase from 2016 (14,847).

Contaminants of concern

Nitrate/nitrogen is the main concern for septic system impacts to groundwater. Nitrates, once formed, will move with groundwater and will likely not denitrify, except in some favorable soil and groundwater conditions. Pathogens and phosphorus generally adsorb to the soil and are treated adequately by these systems. Pathogens are usually attenuated in soil treatment systems; there are a few cases of bacterial and viral transport in groundwater. Phosphorus typically precipitates in the unsaturated zone or is adsorbed in the aquifer close to drain fields; this is less so in older systems where phosphorus saturation can occur.

In addition to pathogen and nutrient concerns noted above, contaminants of emerging concern, such as pharmaceuticals, personal care products, and endocrine active compounds are present in septic effluents. Though the SSTS program has limited capacity to assess the presence of many of these compounds, and has typically made their focus the control and prevention of nitrate/nitrogen and pathogens from entering the groundwater, progress has been recently made on pharmaceuticals and groundwater.

Pharmaceuticals

Pharmaceuticals wind up in STSS via excretion from normal use by people (i.e. because not all of the drug is fully metabolized in the body) and through improper disposal of unused medications by flushing, both at homes and at care facilities.

Pharmaceuticals are commonly detected in Minnesota surface water, groundwater and sediment. The concentrations detected are low relative to other contaminants, but they can have potential negative impacts on the environment, aquatic species, and human health. It is extremely difficult and costly to remove these compounds from wastewater and drinking water once they are present. Preventing entry to the environment is the best way to address potential impacts of pharmaceuticals. Two approaches to doing this are: 1) minimizing input to SSTS and 2) promoting education and support for care providers, pharmacists, and prescribing practitioners about the pharmaceutical “footprint”.

The MPCA, the U.S. Drug Enforcement Agency (DEA) and the Minnesota Board of Pharmacy worked together to develop the regulatory framework that has allowed over 300 pharmacies and law enforcement agencies to begin voluntary collection of unused medications. There are several independent and chain operated pharmacies that began collection within the past two years after the DEA and state regulations were revised. Sites continue to come online with very few discontinuing collection.

Through this system, over 600,000 pounds of unused drugs were collected in Minnesota between 2007 and 2017. The amount of unused drugs collected annually grew tremendously between 2013 and 2017, with the total for 2017 at over 175,000 pounds.

Voluntary collection of unused pharmaceuticals will increase with further with expansion of the collection network and outreach and education to the general public, doctors, and pharmacies. As of 2018, there were only two counties in Minnesota without a local collection option, but the MPCA is working on a grant to help bring collection to those counties as well as other currently underserved areas.

Manufacturers, health care facilities of all types (including long-term care facilities), and animal health facilities may flush waste medications if allowed by their local treatment plants. Because flushing involves no cost, it is still used by many of these operations.

Pollution prevention efforts for medications at this point in time mainly means reducing the overuse of medications, which will reduce what is directly excreted and released into the environment. The changes in prescribing recommendations for antibiotics, and for opioids and other controlled substances, should reduce the amount of medications released into the environment from excretion.

This is especially true looking at the "preventive" use of antibiotics in livestock. This is being studied at the federal level, as well as in Minnesota chiefly through the Department of Health's One Health Antibiotic Stewardship Collaborative. The European Union has banned "off label" use of antibiotics and hormones in livestock, which presumably reduced the use of the drugs and the resulting discharge into the environment. Livestock in the US consume roughly 70% of the antibiotics produced for use. You can view the work efforts and components of the collaborative here: http://www.health.state.mn.us/onehealthabx/.

Manufacturers are putting some effort into more effective drug delivery systems, which may reduce the amount of medication released through excretion, but those efforts will take years to produce measurable results.

Other program practices used to protect groundwater

As noted previously, the SSTS program applies Minn. R. ch.7080 through 7083 to oversee the treatment and dispersal of sewage discharge to subsurface treatment systems. These rules include a large number of requirements for the proper location, design, installation, use and maintenance of SSTS systems to protect our state's water resources from the discharge of treated sewage to the groundwater, that include the following:

- Nitrogen BMPs for MSTS and LSTS based on system size and the sensitivity of the aquifer.
- Registration of treatment products for nitrogen and phosphorus reduction.
- Identifying imminent threats to public health and safety from uncontrolled surface discharges.
- A plan to strengthen local county programs to continue to reduce the percentage of failing SSTS, which have fallen in nine years from 39% to 12%, with a goal to eventually get the percentage of failing systems below five.
- Design guidelines for larger ISTS and MSTS that require the assessment of soil and groundwater conditions so that systems are protective of groundwater resources. Guidelines include:
  - Groundwater sensitivity and mounding assessments.
  - Nitrogen modeling and nitrogen BMPs to reduce total nitrogen, and nitrogen limits.
  - Determining whether a site is located in a Drinking Water Supply Management Area.
  - Vertical separation distances to groundwater.
  - System design criteria based on the above factors.
- A groundwater nitrate nitrogen policy that provides a technical basis for permitting decisions as well as a means to ensure the best, reasonable protection of groundwater resources.
- Well testing (nitrates), point of sale requirement (not a state requirement).
- Education, certification, and training.
- Compliance and enforcement.

Program data needs and recommendations

- Mid-sized sewage treatment systems – The SSTS program would greatly benefit from groundwater monitoring data collected at MSTS sites to verify whether these systems are meeting groundwater nitrogen limits set in design guidance. In addition, monitoring of groundwater mounding is needed to evaluate system performance and to compare these results to predictions from numerical (MODFLOW) and analytical (Kahn & Hantush) groundwater models. This type of research is needed in both sand, gravel, and finer textured glacial till soils that occur across the state. Assessment of the predictive ability of groundwater mounding models in different geologic settings will help support program decisions regarding system performance and ultimately lead to reduced review times and site assessment work.
- Individual sewage treatment systems – The assessment of impacts to groundwater from smaller ISTS is also needed because of their large numbers. There is little to no groundwater monitoring conducted for these types of systems, and many were installed prior to the enactment of minimum statewide standards for ISTS in 1996.
- Monitoring for contaminants of emerging concern – As noted previously, the SSTS program does not have the capacity to test for contaminants of emerging concern (CECs) including endocrine active compounds. It is known that sewage effluent contains CECs; however, their occurrence has not been investigated for SSTS in Minnesota.
- Pharmaceuticals - work needs to continue to cut down on the flushing of unused drugs into treatment systems of all types, by including more collection facilities in the effort, both for human and livestock use (and overuse).
- Land application of solids removed from SSTS systems – monitoring could be added to track the possible migration of contaminants into groundwater.

Based on discussions with program staff, the most immediate data needs, with respect to groundwater protection concerns, are for MSTS as described in the first bullet above. Next would most likely be groundwater data from ISTS sites; however, a number of homes and businesses have straight pipe discharges of sewage effluent to surface waters, which represents an even greater immediate concern to surface water resources. Currently, the SSTS program has limited capacity to investigate the above listed data gaps and any work in these areas would need to be conducted with local partners and stakeholders outside of the program.

C. Animal Feedlot Program

This program review identifies some of the program practices and BMPs used by the MPCA's Animal Feedlot Program (Feedlot Program) to prevent the contamination of groundwater resources. It also identifies program areas where additional data is needed to better evaluate the effectiveness of feedlot program practices to protect groundwater resources and makes recommendations to address some of these data gaps.

Overview

The Feedlot Program regulates the land application and storage of animal manure for over 25,000 registered feedlots in Minnesota in accordance with Minn. R. ch.7020. In addition, there are approximately 5,000 to 10,000 smaller, unregistered feedlots across the state. Overall, there are more feedlot sites than can be evaluated on an individual basis, and therefore, there is limited monitoring of their impacts on groundwater quality, with the exception of a few of the larger facilities.

Feedlots are located in agricultural areas across Minnesota with the greatest number occurring in the southern and central portions of the state. Feedlots vary in size, as measured by the number of animals they manage (animal units), and in the quantity of manure they land apply or store in manure storage basins. In general, larger feedlots have more rules and regulations they must follow to protect groundwater resources.

Nature of concern related to groundwater

Groundwater can be contaminated by nutrients (primarily nitrate-nitrogen) and microbial pathogens from animal manure. Animal manure contains significant quantities of nitrogen and if not properly managed, can lead to nitrate contamination of groundwater. The main concern regarding feedlot contaminant impacts to groundwater systems is through the application of manure to the land and its storage in manure storage basins. The land application of manure, if not conducted properly, can overload the soil/crop system and lead to leaching of contaminants to the groundwater. In addition, the design, construction, and maintenance of manure storage basins and their location relative to vulnerable groundwater settings play big roles in whether manure storage systems are likely to affect groundwater quality.

Many feedlots are located in areas of the state with vulnerable aquifers where groundwater quality is highly susceptible to contamination from land surface activities. Nitrate contamination of groundwater has been shown to be a problem in areas having coarse-textured soils with shallow groundwater and solution weathered bedrock. Pathogens can also move directly to groundwater through cracks in the soil, especially near old wells, sinkholes, quarries, and areas having shallow soils over fractured bedrock.

Contaminants of concern

As stated above, nitrate-nitrogen and pathogens have been identified as the contaminants of greatest concern from feedlots that may impact groundwater quality. Groundwater studies of manure storage systems by the MPCA have also identified high concentrations of ammonia, organic nitrogen, phosphorus, organic carbon, potassium, chloride, manganese, and iron in groundwater plumes downgradient of manure storage areas. In these same studies, high nitrate concentrations were measured where sites were underlain with a thick unsaturated zone, indicating the conversion of organic nitrogen and ammonia most likely resulted in the higher nitrate concentrations. In general, MPCA studies showed the greatest impacts to groundwater quality occurred at sites lacking a constructed liner for their manure storage basins.

Moreover, as was mentioned in the previous section on Surface Sewage Treatment Systems, the use (and overuse) of antibiotics as a preventive measure in the treatment of livestock must be considered a likely source of the contamination of groundwater. This possible misuse of antibiotics is being studied at the federal level, as well as in Minnesota chiefly through the Department of Health's One Health Antibiotic Stewardship Collaborative. The European Union has banned "off label" use of antibiotics and hormones in livestock. Off label use is the practice of proscribing drugs for an unapproved purpose, a practice that boosts antibiotic use in livestock. Livestock in the US consume roughly 70% of the antibiotics produced for use. More information available at: http://www.health.state.mn.us/onehealthabx/.

Program practices used to protect groundwater

The Feedlot Program protects groundwater quality primarily through the application of Minn. R. ch. 7020, in addition to a mix of BMPs, program policies, fact sheets, and guidelines that contain specific requirements and recommendations for water quality protection. Some examples of Feedlot Program practices that protect groundwater quality, and how they do so, are listed below.

- Manure management plans are considered one of the primary program practices that protect groundwater quality. Manure management plans regulate the rate and timing of the land

application of manure to prevent overloading the soil/crop system with excess nitrogen and phosphorus, reducing the potential for nitrogen leaching to groundwater.

- Feedlot general permit conditions place additional constraints on manure applications in areas with vulnerable aquifers (sand and gravel aquifers) and restrict applications in the winter for concentrated animal feedlot operations.
- Rules for liquid manure storage basins (7020.2100) set the liner design standards and location restrictions for feedlots to prevent leakage of liquid manure to underlying soils and groundwater.
- Feedlot water quality discharge standards (7020.2003) require that manure, its runoff and process wastewaters are prohibited from flowing into a sinkhole, fractured bedrock, well, surface tile intake, mine or quarry. Feedlots and manure storage areas must comply with Minn. R. ch. 7050 effluent limit standards.
- Location restrictions and expansion limitations (7020.2005) apply to new animal feedlots or manure storage areas within a shoreland, a floodplain, 300 feet of a sinkhole, 100 feet of a private well, or 1,000 feet of a community water supply well, or other wells serving schools or day care centers.
- Groundwater monitoring is required as laid out in a program policy memorandum from June 2008 - "MPCA Feedlot Program Ground Water Monitoring at New Liquid Manure Storage Areas".
- Guidelines for the land application of manure, "Applying Manure in Sensitive Areas" developed by the MPCA and Natural Resources Conservation Service (NRCS), provides feedlot operators with a user-friendly overview of state requirements and recommended program practices to protect water quality.

Program data needs and recommendations

Feedlot Program staff identified several areas where additional data would be helpful in determining the effects of feedlot impacts on groundwater quality, as follows:

- **Obtain Water quality data from perimeter drain tile discharge at manure storage basins** - Provide professional evaluation follow-up on testing results of drain tile discharge water for drain systems that MPCA has required of permittees around manure storage basins. There are a large number, perhaps thousands, of perimeter tile drainage systems around concrete or earthen manure storage basins. However, there are only around a dozen feedlot sites statewide that have permit conditions outlining the sampling of drain tile discharge on a routine basis. One challenge to obtain regular samples comes from the seasonal fluctuations in perimeter drain tile flow. At many times the groundwater is not saturated enough to allow the drain tile to flow readily enough to obtain a sample. The drain systems are set around the base of the storage basins to lower the water table beneath the basin and maintain a separation distance of four feet between the bottom of the basin and the underlying water table. The drain tiles typically discharge to county ditches, which flow to surface waters of the state. The quality of water from the drain tiles is representative of the groundwater beneath the manure storage basins and would indicate if there is contaminant leakage from the basins to the groundwater.
- **Evaluate manure storage basins in southeast Minnesota karst region** – In southeastern Minnesota, a number of manure storage basins were built in the mid-1990s, prior to when manure storage basins were required to have double liners. Basins or lagoons built without double liners have a greater potential for catastrophic failure in karst settings. Feedlot staff have conducted some visual inspections of these facilities; however, it would be good to evaluate the condition of the older storage basins (>15 years old) more rigorously. This evaluation could

determine the locations of older basins, depth to bedrock, proximity to springs, sinkholes, streams, and include any soil data or construction information available on these structures from the NRCS, Soil and Water Conservation District, Joint Powers Boards, etc. A pilot study could be conducted for a county where good geologic information is available from county geologic atlases, along with groundwater data and hydrogeologic studies, and where cooperation from local government units is likely. Such counties could include Wabasha, Fillmore, or Olmsted Counties. MPCA groundwater studies from 2001 for these types of structures could supplement this type of analysis, and MPCA could review old-field log books from sample collection efforts.

- **Investigate groundwater quality at larger manure storage basins** – Conduct focused investigations at manure storage basins that pose a greater risk to groundwater quality. Newly constructed basin capacities continue to grow in size each year, with some basin volumes in the 20-30 million-gallon range, per cell. Use information from MPCA Groundwater Monitoring and Assessment Program studies, a comprehensive literature review, and experiences from other states to prioritize site investigations. Collect samples of soil and groundwater with a geoprobe at basins with the following characteristics: unlined basins and or earthen basins; liquid storage greater than 5 million gallons; locations in hydrogeologically sensitive areas of the state with either sand/gravel or fractured bedrock beneath the basin; locations in areas that supply drinking water to wells or springs; and where the uppermost water bearing unit is an aquifer, located in a vulnerable drinking water supply management area, and with liner design seepage rates of 1/56”/day vs. 1/560”/day).

  Preventive antibiotics and hormones – The use of antibiotics as a preventive measure in the treatment of livestock must be considered a likely source of the contamination of groundwater.

D. Land Application Sites for Industrial Wastewater and Industrial by-products

This program review identifies program practices implemented by the MPCA Water Quality Permits Program to prevent the contamination of groundwater from the land application of industrial wastewaters and industrial by-products (IBP). It also identifies whether additional data is needed to better evaluate the effectiveness of program practices to protect groundwater resources and discusses other areas of potential concern.

Overview

The Water Quality Permits Program oversees the permitting and regulation of the land application of industrial wastewaters and industrial by-products, primarily generated by the food, beverage and agricultural processing industry. The land application of industrial wastewaters is regulated primarily through National Pollutant Discharge Elimination System (NPDES) and State Disposal System (SDS) permits. These permits set limits on the land application of nutrient-rich process wastewaters for its beneficial use as a fertilizer on agricultural fields. There are currently 25 facilities with NPDES/SDS permits that land apply industrial wastewaters, located mainly in southern and central Minnesota. At most, of these facilities industrial wastewaters are applied by spray irrigation to fields planted to a forage crop during the growing season. These facilities have annual application rates that range between several million gallons up to 100 million gallons for larger facilities. The regulations in the

NPDES/SDS permits emphasize groundwater protection through good crop and irrigation management and set requirements for land application activities with the goal to protect both groundwater and surface water.

The land application of industrial by-products is most often regulated by the MPCA SDS general permit (MNG960000) for wastes generated from the food and beverage processing industry. Under the general permit, industrial byproducts may be land applied for their beneficial use as a fertilizer and soil amendment to agricultural lands. Industrial by-products include materials such as: liquid or dewatered wastewater treatment sludges, wash water from small food preparation, whey from cheese processing, sweet corn silage, ethanol by-products, and materials with similar characteristics. Approximately 80 industrial facilities are covered under this general permit. A gross estimate of land applied industrial by-products in 2012 indicates 65 million gallons and an additional 77 wet tons of industrial by-products were land applied, which is typical of most years.

A majority of industrial by-product management requirements were adopted from the biosolids rules (Minn. R. ch. 7041) into the general industrial by-product permit. The permit requirements for both industrial wastewater and industrial by-products have stated goals to protect water quality in accordance with Minn. Stat. chs. 115 and 116, and Minn. R. chs. 7001, 7050, 7060, and the U.S. Clean Water Act.

Nature of concern related to groundwater quality

Industrial wastewaters and industrial by-products are considered to be high strength organic wastes that may contain nutrients, salts, organic matter, and, to a lesser degree, pathogens. Potential impacts to groundwater quality can occur from their over-application or improperly timed applications, which can exceed the capacity of the soil/crop treatment zone to assimilate the nitrogen they contain, leading to nitrate contamination of the groundwater. In addition, salts in these materials can build up in soils and shallow groundwater leading to contamination of groundwater with chlorides.

Industrial wastewaters are applied through spray irrigation to the same fields continuously for many years. These types of applications have shown impacts to shallow groundwater in the form of nitrate-nitrogen and chlorides at some application sites. Most land application sites receiving high strength industrial wastewaters are required to monitor the condition of the wastewater received, along with the groundwater, tile line discharge, and soils and crops as a part of their permit requirements.

A number of industrial spray sites show elevated nitrate and chloride concentrations in the shallow water table adjacent to the application fields. Concentrations of nitrates or chlorides in excess of permit limits requires actions on the part of the facility to remedy these conditions that include increased monitoring, reductions in applications, or entirely eliminating applications to a field. In general, groundwater contamination at most facilities has shown decreasing trends in recent years and continues to be monitored. There are currently no known cases of groundwater contamination, in excess of drinking water standards, in private or public water supply wells that are directly linked to industrial spray activities in Minnesota.

In contrast to industrial wastewaters, most industrial by-products are surface applied or injected into soils and are routinely applied to different fields or different areas of a field from year to year. Conducting groundwater monitoring at industrial by-product application sites was considered in the development of the industrial byproduct general permit; however, because of the characteristics of food, beverage, and agricultural industrial by-products and the numerous conservative management practices required in the general permit, they are considered to pose a limited environment risk to

groundwater if managed properly. For these reasons, industrial by-product land application sites are not required to have groundwater monitoring systems in place.

Contaminants of concern

As noted above, the contaminants of concern in industrial wastewaters and industrial by-products include: nutrients (nitrogen and phosphorus primarily), salts, organic matter, and may contain pathogens. The risk from pathogen contamination in these materials is considered minimal because these materials are generated from food grade by-products. Overall, nutrients, organic matter, and pathogens are considered to be adequately treated where land application is conducted properly and should not create groundwater contaminant problems.

However, the Water Quality Permits Program is routinely faced with permitting decisions regarding the land application of "unusual industrial by-products" that do not fit the definition or characteristics of food and beverage industrial by-products. The industrial by-product general permit is designed to address by-products from the food and beverage industry and may not have appropriate requirements that are protective of human health and the environment for "unusual industrial by-products". Individual permits are required when the by-product falls outside the agriculture and food and beverage universe and monitoring and management requirements need more specificity than provided in the general permit. The program currently has a need to better understand the fate and transport of constituents contained in "unusual industrial by-products" to avoid contamination of groundwater resources and determine levels where these contaminant pose a risk to human health and the environment. Examples of unusual industrial by-products include petroleum compounds in wash waters, constituents of personal care products discharged by beauty shops, and wastes generated from various manufacturing facilities located outside of sewer service areas.

Program practices used to protect groundwater

As noted above, the Water Quality Permits Program regulates the land application of both industrial wastewaters and industrial by-products through NPDES and SDS permits. The permits set limits and conditions on the locations, quantities and characteristics of land applied industrial wastewaters and industrial by-products that are designed to prevent groundwater contamination.

Historically, program policy has required that land applied industrial wastewaters and industrial by-products must provide a beneficial use as a fertilizer or soil amendment and not be land applied solely for the purpose of waste disposal. However, if land application of some of the unusual wastes is approved, the policy on beneficial use may need to be changed. A number of the permit requirements provide specific protection of groundwater and several provide indirect protection of groundwater resources through management practices that prevent releases of pollutants to the environment, as follows:

- Industrial wastewater facilities that spray irrigate high strength effluent, which receives limited treatment, are required to conduct groundwater monitoring around their spray fields. In addition, these facilities are required to conduct rigorous environmental monitoring throughout the irrigation season that includes monitoring of: tile line discharges, the received wastewater effluent, cooling water, county ditches, soils, crops, and occasionally offsite private wells.
- The permits for industrial wastewater application sites include intervention limits in groundwater for nitrate-nitrogen that are one-quarter of the drinking water standard for nitrate of 10 mg/l. In addition, the industrial wastewater permit sets a total chloride intervention limit

at the secondary drinking water standard of 250 mg/l. An exceedance of either of these limits requires actions by the permittee to prevent these exceedances.

- Industrial wastewater facilities must have a Type V certified operator responsible for the day-to-day operations of the wastewater treatment disposal system.
- Industrial wastewater facilities must prepare a Sprayfield Management Plan that includes details of monitoring, irrigation scheduling, loading rates, soil moisture monitoring, runoff collection, drain tile discharge or collection, and crop management practices.
- Tile drainage systems beneath land application sites are also monitored and have limits set for ammonia-nitrogen and biological oxygen demand. Monitoring data from the tile line discharge is representative of the water quality that may be infiltrating to groundwater.
- Industrial by-products must be completely characterized before a permit can be issued for industrial by-product land application. Industrial by-products must not exceed specific concentration limits for metals, dioxin, and PCBs, and cannot be a hazardous waste.
- The industrial by-product general permit requires that a Type IV certified operator oversee the land application of industrial by-products and ensure they are properly applied. Industrial by-product application sites must also be reviewed by the Type IV operator and their soils tested.
- Land-applied industrial by-products are subject to a number of limitations and restrictions that protect groundwater resources that include:
    - Hydraulic loading limits based on soil texture.
    - Separation distances from drinking water wells, and sinkholes.
    - No industrial by-product applications on fallow ground for the cropping year.
    - Limits on nitrogen applications.
    - Additional restrictions on Industrial by-products that contain pathogens.

The industrial by-product program has implemented an Unusual Waste Review that includes a multi-program task group to determine the proper management of unusual wastes, such as vehicle carwash wastewaters. These wastes may contain constituents such as PFAS that are not typically found in industrial by-products that could impact groundwater quality and must be addressed accordingly. The State of New Jersey is currently investigating the threat posed by PFAS compounds used in carwashes due to the connection of many of the facilities to large septic systems, and the resulting discharge of this contamination to groundwater.

Program data needs

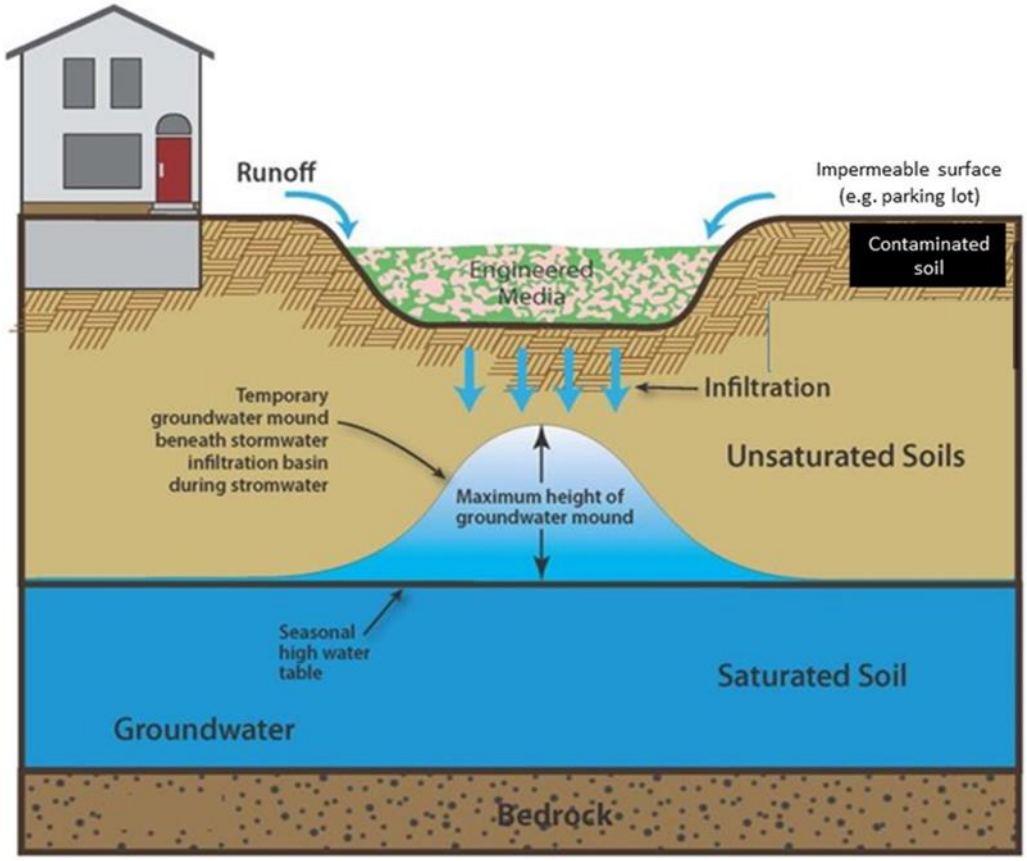
- **Groundwater evaluations -** As risk data becomes available on emerging chemicals of concern, MPCA staff may need to review chemical additives used in land application activities and it may be necessary to review the decision to land apply certain waste types. The Agency is still determining how to proceed with possible groundwater contamination with arsenic, iron, and manganese at high biological chemical demand (BOD) irrigation sites. Preliminary review shows that loading rates are much less in Minnesota than problem sites in other states such as Michigan. If the Agency does decide to review the application of waste for arsenic, iron, and manganese at industrial wastewaters and industrial by-products sites, then it should also consider expanding the review to the animal feedlot and biosolids programs, as similar contamination opportunities apply to all three programs.
- **Unusual wastes** - the Water Quality Permits Program is routinely faced with permitting decisions regarding the land application of unusual wastes that do not fit the definition or characteristics of typical food and beverage industrial by-products or fit neatly into any other land application program at the MPCA. Program staff from water quality, solid waste, and

hazardous waste meet when these types of waste management issues require new approaches. Both carwash wastewater and wastewaters and solids from holding tanks and trap wastes have been addressed in guidance documents. The program requires information on the fate and transport and toxic effects of contaminant compounds contained in unusual wastes in order to develop scientifically based application requirements.

Examples of unusual wastes include constituents of personal care products discharged by beauty shops (personal care products), and wash water wastes generated from various manufacturing facilities located outside sewer service areas. The issue of unusual wastes and their environmental fate for land application scenarios is currently (2018) being investigated by the US Geological Survey's Toxic Substances Hydrology Program. The group has a current study looking at wastewater discharges from food, beverage, and feedstock processing plants. The project team has sampled wastewater discharges from the plants to characterize the chemical signatures. They will likely look at effects from land application in a future, as yet unfunded study.

- **Data review and reporting** - data related to industrial by-product land application activities were once entered into the MPCA's now-retired Delta permit database; however, with the implementation of Tempo, that no longer occurs. The goal is to have facilities enter data, currently required to be reported in the Annual Report, directly into e-Services similar to what facilities are doing for wastewater Discharge Monitoring Reports (DMRs). It is anticipated that this will not occur for a few years. Data for spray irrigation facilities are entered into Tempo through DMRs.

E. Stormwater Program



Stormwater Program

This program review identifies program practices implemented by the MPCA's Stormwater Program (SWP) that reduce and prevent the degradation of groundwater from stormwater runoff. This review identifies data needs for better evaluating the effectiveness of SWP practices to protect groundwater resources and provides recommendations for addressing these data needs.

Overview

The MPCA's SWP regulates the discharge of stormwater and snowmelt runoff from municipal separate storm sewer systems (MS4), construction activities, and industrial facilities, mainly through the administration of NPDES/SDS permits. The SWP program oversees the permitting of approximately 250 municipal systems, 2,000 construction stormwater sites, and 2,500 industrial facilities, in any given year. The SWP administers general permits (and in some cases, individual permits) that incorporate state (Minn. R. ch. 7090) and federal Clean Water Act requirements to reduce the amount of sediment and pollution in stormwater runoff that enters surface and groundwater.

Management of urban stormwater runoff utilizes volume control practices (e.g., infiltrate, evaporate or reuse), filtration practices (e.g., rain gardens, sand filters), rate control and sedimentation practices (e.g., stormwater ponds), and new pollutant removal technologies (e.g., chemically enhanced treatments such as iron enriched sand filters). On a national scale, the EPA has strongly encouraged federal facilities and

states to adopt low impact development (LID) practices, primarily for infiltration-based BMPs, and Better Site Design practices that protect forest and stream corridors.

In 2009, the Legislature directed the MPCA to develop performance and design standards or other tools to enable and promote the implementation of low-impact development and other stormwater management techniques. (Minn. Stat. 115.03, subd. 5c). That language defines low impact development as "an approach to stormwater management that mimics a site's natural hydrology as the landscape is developed. Using low-impact development approach, stormwater is managed on-site and the rate and volume of predevelopment stormwater reaching receiving waters is unchanged. The calculation of predevelopment hydrology is based on native soil and vegetation."

Working off the principles of low impact development, a diverse group of stakeholders from the public and private sectors and the Minnesota Stormwater Steering Committee worked with the MPCA to develop a Minimal Impact Design Standards (MIDS) package. This included: 1) volume performance goals, 2) a method to determine credits for those goals, 3) a user-friendly calculator to input site conditions and credits, 4) design specifications for a variety of LID practices, and 5) an ordinance package to help developers and communities implement MIDS.

Nature of concern related to groundwater

Several BMPs infiltrate treated stormwater into the soil, where it can recharge groundwater aquifers. The management of stormwater runoff is increasingly relying upon these infiltration practices.

Several field and laboratory studies conducted over the past 10 years provide information on the fate of pollutants in water as the water goes through infiltration practices. Trojan et al. (2018) provide an extensive review of groundwater impacts from stormwater infiltration practices. While recent studies provide considerable information to better guide the use of infiltration practices, several information gaps remain, including the following:

- Because soils have finite retention capacities, we need a greater understanding of the processes and timing of pollutant breakthrough.
- Pollutant transport and retention in underground infiltration systems is poorly understood.
- We need a greater understanding of chloride dynamics in urban runoff and resulting fate and transport of chloride in infiltration systems.
- We need additional monitoring for organic pollutants (e.g., hydrocarbons, pesticides) and pathogens in the region beneath infiltration systems.

We have a poor understanding of the hydrology of infiltration practices, specifically understanding and quantifying the fate of infiltrated water.

Contaminants of concern

Stormwater runoff, including snowmelt, contains pollutants such as nutrients, pathogens, heavy metals, solids, organic compounds such as oil and pesticides, and chlorides. Properly constructed and maintained BMPs are effective at attenuating most pollutants. The following conditions or pollutants represent a potential risk to groundwater from infiltrated stormwater runoff.

- Chloride is mobile and will not be retained by stormwater BMPs.
- Pathogens are also mobile in infiltration systems constructed in highly permeable soils with low organic matter content.

- Stormwater hotspots are locations where activities have the potential to produce high levels of pollutants in runoff.

Program practices used to protect groundwater

The SWP incorporates required stormwater practices into permits; provides guidance, tools, and outreach on stormwater management; and conducts and supports stormwater research efforts. Examples of these include the following:

- Stormwater permits regulate the discharge of stormwater and snowmelt runoff through administration of a general permit, and in some cases, individual permits, for MS4, construction activities, and industrial facilities. Permit requirements include performance goals (e.g., infiltrating 1 inch of runoff from new impervious surfaces for post-construction), BMPs (e.g., the 6 Minimum Control Measures), development of stormwater pollution prevention plans and programs (SWPPPs), and annually reporting progress toward meeting Total Maximum Daily Load requirements.
- The Minnesota Stormwater Manual is an innovative, online, interactive and user-friendly tool that provides guidance on BMP design, construction, operation, maintenance, and assessment. Specifically, the manual contains two sections addressing stormwater infiltration and infiltration practices. The manual includes information and guidance on tools, such as model ordinances and water quality models, and was developed using a wiki application to allow for easy editing and powerful search abilities. Included in the manual is information on MIDS, including a link to the calculator, guidance and examples for using the calculator, and a MIDS ordinance package. Information on stormwater infiltration and infiltration practices can be found in the stormwater manual wiki, available at: https://stormwater.pca.state.mn.us/index.php?title=Main_Page.
- The SWP is currently conducting research on pollutant fate in infiltration systems and infiltration characteristics of swales. The SWP regularly collaborates with the University of Minnesota and others conducting stormwater research.
- The SWP regularly provides outreach through webinars, newsletters, presentations, and meetings with stakeholders.

Table 3. Summary of typical risk of groundwater (GW) contamination by pollutant, increasing groundwater risk, and management strategies for reducing risk

Pollutant	Risk of GW contamination from infiltration practices	Conditions when pollutant may represent a risk to GW or surface water receiving groundwater inputs	Management strategies for sites where conditions may represent a risk
Nitrate	Low-moderate	Nitrogen fertilizer used historically, and where turf is being established; use of media with organic nitrogen that can convert to nitrate	Pretreatment to remove organic Nitrogen; reducing infiltration rates by using finer texture material; relocating high Nitrogen practices away from drinking water receptors
Chloride	High	Areas receiving applications of chloride-based deicers	Reducing chloride deicer application. Encouraging infiltration may reduce peak concentrations in surface waters, but overall loading remains unchanged
Phosphorus	Low	Infiltration practices having a high concentration of organic matter discharging to shallow GW near surface receiving waters	Ensure concentration does not exceed 30 mg-P/kg-soil; construct layer at bottom of the practice to attenuate phosphorus using elemental iron
Toxic metals	Low	Practices with low adsorption capacity; low pH media; large inputs of chloride; receiving high concentration of metals in runoff	Replace top few inches of soil or media in the infiltration practice; test soil to ensure proper pH; limit chloride loads to the practice
Pathogens	Low-moderate	Practices with low adsorption capacity (e.g. low organic content) & rapid infiltration rates; areas with high concentration of bacteria (like Enteroviruses)	Utilize infiltration practices having greater concentrations of organic matter; avoid underground infiltration in very coarse soils if bacteria concentrations are high
Organic chemicals	Low-medium (varies by chemical)	Practices having low adsorption capacity (often low organic content) & rapid infiltration rates; nearby large terrestrial sources of soluble contaminants	Add organic matter to soil or media
Temperature	Low-moderate	Infiltration practices with very rapid infiltration rates and located adjacent to temperature-sensitive receiving waters	Locate practices representing a risk away from temperature-sensitive waters or slow infiltration rates by adding organic matter or fine-textured material

Program data needs

- Promote the creation of statewide GIS data layers to evaluate options to infiltrate stormwater in new development and redevelopment areas in relation to wellhead protection zones, extremely vulnerable aquifers (e.g. sand/gravel outwashes over bedrock), depth to shallow groundwater, and hydrologic soil groups (A, B, C, and D).
- Incorporate research and case studies of groundwater impacts from stormwater infiltration practices into guidance (e.g., the Minnesota Stormwater Manual). This involves collaboration with outside partners, such as municipalities, watershed districts, and other state agencies. Specific focus areas include:
  - Obtaining a better understanding of the fate of chloride and pathogens in infiltration systems.
  - Obtaining a better understanding of infiltration volumes and fate of infiltrated water.
  - Assessing changes in shallow groundwater that relate to potential issues for buried utilities and structure basement flooding (e.g. groundwater mounding potential).
  - Identifying locations of BMPs relative to wellhead protection areas and their emergency response areas for source water protection.
  - Evaluating failed infiltration projects to determine causes.
  - Obtaining a better understanding of infiltration at Brownfield sites.
- Improve data collection and management for stormwater infiltration projects. Components of this effort could include:
  - Advancement of standardized data collection protocols through development of recommendations and guidelines for sample collection and analysis.
  - Collection of monitoring data for input to a common database that allows for access by outside stakeholders.
  - Data interpretation and reporting.

F. Biosolids Program

This program review identifies program practices implemented by the MPCA Biosolids Program (MBP) to prevent the contamination of groundwater. It also identifies whether additional data are needed to better evaluate the effectiveness of biosolids program practices to protect groundwater resources and notes other areas of potential concern related to the land application of biosolids and groundwater quality.

Overview

The MBP oversees the land application and storage of municipal sewage sludge or biosolids for beneficial use as a soil amendment in accordance with Minn. R. ch. 7041. Biosolids are a nutrient-rich solid, semisolid, or liquid organic material that results from the treatment of domestic wastewater (sewage sludge) by municipal treatment plants. Biosolids are land applied to improve the fertility of cropland and forestland, as well as to restore and revegetate land impacted by the mining of iron and taconite (Western Lakes Superior Sanitary District and other facilities).

In Minnesota, there are approximately 280 facilities generating biosolids on a regular basis; this number has not changed substantially over the last 10 years. The total biosolids produced in 2016 was approximately 148,825 dry tons; 21% was land applied, 61% was incinerated, and 18% was landfilled.

Table 4. Biosolids in Minnesota in 2016

Method	Amount	Percent	# of Facilities
Incinerated	90,873 Dry tons	61%	3
Land Applied	30,951 Dry tons	21%	137
Land filled	27,001 Dry tons	18%	18

On a tonnage basis, the majority of Minnesota biosolids are incinerated in St. Paul and Eagan, while a larger number of municipal wastewater treatment facilities land apply their biosolids. There are a few facilities like Grand Rapids that landfill their biosolids on a continual basis. In 2016, biosolids (class B)

were land applied on 16,733 acres, approximately 1,800 fewer acres than in 2009. A majority of biosolids are applied to agricultural fields planted to field corn and soybeans. The total acreage of land where biosolids are applied in the state represents less than 0.001% of the approximately 23,000,000 acres used as cropland in Minnesota, in any given year.

Nature of concern related to groundwater

Biosolids contain nutrients (nitrogen and phosphorus), pathogens, trace metals and trace amounts of persistent organic compounds. They are routinely applied to agricultural lands as a soil amendment. If biosolids are improperly applied, some pollutants such as nitrogen could potentially leach past the soil/crop treatment zone and negatively impact groundwater quality.

The primary concern with the improper land application of biosolids to groundwater quality is from nitrate/nitrogen impacts, and to a lesser degree, pathogens. However, the conservative management requirements for land-applied biosolids make the likelihood of impacting groundwater quality negligible. The MPCA requires that all land-applied biosolids be processed and tested before use and be low in potential contaminants and treated to reduce the levels of pathogens and odor.

The conservative management of land-applied biosolids, and the relatively small acreage they are applied to, suggests a limited risk to groundwater quality, as long as they are managed in accordance with the BMPs set forth in Minn. R. ch. 7041.

Contaminants of concern

The contaminants of concern in biosolids include: nutrients (nitrogen and phosphorus primarily), trace metals, pathogens, and trace amounts of persistent organic compounds. The nitrogen content of the biosolids typically drives their application rates which are set to meet the agronomic needs of crops grown on the land they are applied. Setting the biosolids application rates to meet agronomic cropping needs helps avoid over application that could lead to nitrate impacts to groundwater quality. The phosphorus content of biosolids is usually not considered to be a threat to groundwater quality because phosphorus adsorbs to soil and typically will not leach to groundwater in appreciable quantities. Pathogens are treated in biosolids prior to land application and receive further treatment in the soil when land applied, and trace metals are tracked and regulated to prevent their excess accumulation at biosolid application sites. Nutrients, pathogens, and trace metals are regulated by MBP requirements and should not create groundwater contaminant problems if BMPs are followed.

Persistent organic compounds that include pharmaceuticals, personal care products, steroids, and hormones show high affinities for organic carbon in biosolids and preferentially accumulate in them (Kumar et al., 2017), as can be seen in the results of the Environmental Protection Agency's (EPA) Targeted National Sewage Sludge Survey of 2009. In addition, PFAS has also been detected in biosolids, biosolids amended soils, and in the environment adjacent to biosolids, application sites (Lindstrom et al., 2011; Blaine et al., 2013; Sepulvado et al., 2011; Higgins, 2017).

In general, organic contaminants tend to accumulate in biosolids in the part per billion to part per million-concentration range (Kumar et al., 2017). The relative risk of organic contaminants in land-applied biosolids is currently being debated by the water quality professionals who treat the wastewater and manage biosolids, toxicologists who set contaminant limits for food and water, and research scientists who are studying the presence of these contaminants in food crops, soils receiving biosolids applications and nearby surface water and groundwater. Ultimately, the EPA will be need to provide some regulatory direction or guidance for biosolids management, considering these contaminants,

which has been provided for nutrients, metals and pathogens, under the current biosolids regulations in 40 CFR part 503 (see https://www.epa.gov/biosolids/select-biosolids-regulatory-processes).

Persistent organic chemicals are not specifically addressed within the scope of the MBP and the MBP relies on the EPA to provide regulatory guidance for biosolids management as set forth under 40 CFR part 503. The current MPCA biosolids rules (Minn. R. ch. 7041) incorporate all of the 40 CFR Part 503 requirements for land applying public and private biosolids. In the event the EPA promulgates new requirements for biosolids related to persistent organic compounds, it is reasonable to assume these requirements will be incorporated into MBP BMPs.

Program practices used to protect groundwater

The MBP applies Minn. R. ch. 7041 to biosolids land application operations in Minnesota. Minn. R. ch. 7041 includes all of EPA's 40 CFR Part 503 requirements for land applying public and private biosolids. Together these rules:

- Regulate the pathogen and vector attraction treatment standards and chemical monitoring of biosolids that are land applied.
- Establish criteria for the permitting, land application site approval, storage, pollutant limits, management practices and limitations, recordkeeping and reporting of biosolids that are land applied in Minnesota.

Biosolids land application must follow minimum design requirements. A number of these requirements provide specific protection of groundwater and several provide indirect protection of groundwater resources through management practices that prevent releases of pollutants to the environment, as follows:

- Stricter management practices are required for highly permeable soils that receive biosolids. Nitrogen application rates must comply with agronomic application rate requirements set in federal rule. The agronomic rate is the sludge application rate, which is designed to 1) provide the amount of nitrogen needed by the food crop, feed crop, fiber crop, or vegetation grown on the land, and 2) to minimize the amount of nitrogen in the biosolids that passes below the root zone to the groundwater.
- Biosolids rules require a minimum separation distance to bedrock and the seasonal high water table of three to five feet to allow for soil conditions, which are necessary to treat the biosolids, as well as provide a good growing environment for crops.
- Biosolids may not be applied within 1000 feet of a public water supply well or within 200 feet of private wells to avoid possible direct contamination of a well or water supply.
- Biosolids applications are prohibited on fallow land because there is no crop growing which will remove the nitrogen supplied by the biosolids.
- A crop must be growing on the site if biosolids are applied in June, July, and August so that any nitrogen applied is taken up by the crop rather than potentially lost to groundwater.
- Biosolids application is not allowed on cropland when the soil phosphorus test is greater than 200 part per million unless a federal Natural Resources Conservation Service conservation plan is in place.

Program data needs and recommendations

The MBP deals with data from about 280 facilities and thousands of land application sites associated with these facilities. Since June of 2015, site approval information and annual report data has not been

entered into an official MPCA database. As of early 2019, all Biosolids annual reports have been scanned into Tempo; however, the data is not currently entered in a manner that facilitates use of the data. In addition, in approximately 2013, MPCA staff discontinued entering in metal loading rates into the now-retired Delta database. Site approval information and annual report data exists since the program started in 1982; while all of the information is in paper form, only some information is in electronic form, making it challenging to easily access data when needed.

Several years ago, concerns were raised that biosolids may have been a source of groundwater contamination in Lynden Township south of St. Cloud. Several area wells in close proximity to the City of St. Cloud's biosolids land application sites were found to have elevated concentrations of metals. A follow-up analysis of biosolids loading data and additional well analysis was needed to reach the conclusion that biosolids were not the source of any groundwater contamination and the original testing of these wells was in question.

- The MBP needs to have all of its biosolids land application locational information and metals loading data entered into the MPCA's Tempo database or another database, to allow for ready access and data analysis. This is necessary to address data request concerns related to groundwater quality concerns, as identified in Lynden Township, and from a program management standpoint to better track nutrient and metals concerns related to biosolids land application activities.
- There is a program interest to better understand the fate of and human health risks associated with persistent organic compounds likely to be present in biosolids (pharmaceuticals, personal care products, steroids, and hormones). However, the financial and staff resources necessary to conduct this type of work are beyond the scope of the program's resources. Currently, the testing of persistent organics in biosolids is being conducted by the EPA. It is reasonable to expect the Biosolids Program will stay current with EPA's research in this area and look for results from any risk analysis or development of pollutant limitations resulting from EPA's work.

Blaine, A.C., Rich, C.D., Hundal, L.S., Lau, C., Mills, M.M., Harris K.M., Higgins, C. 2013. Uptake of Perfluoroalkyl acids into Edible Crops via Land Applied Biosolids: Field and Greenhouse Studies. Environ. Sci. Technol., 47: 14062-14069.

Higgins, C.P. Accumulation of Perfluoroalkyl Acids in Food Crops. Colorado School of Mines. April 19th, 2017 presentation.

Kumar, K., Lakhwinder, S. H., Bastian, R.K., and Davis, B. Land Application of Biosolids: Human Health Risk Assessment Related to Micro-constituents. Water Environment Federation, 2017.

Lindstrom B.A., Strynar, M.J., Delinsky, A.S., Nakayama, S. F., McMillan, L., Libelo, E.L., Neill, M., Thomas, L. Application of WWTP Biosolids and Resulting Perfluorinated Compound Contamination of Surface and Well Water in Decatur, Alabama, USA. 2011. Environ. Sci. Technol., 2011, 45, 8015-8021.

Sepulvado, J.G.; Blaine, A.C., Hundal, L.S.; Higgins, C.P. Occurrence and fate of perfluorochemicals in soil following the land application of municipal biosolids. Environ. Sci. Technol. 2011, 45 (19), 8106-8112.

G. Inflow and Infiltration

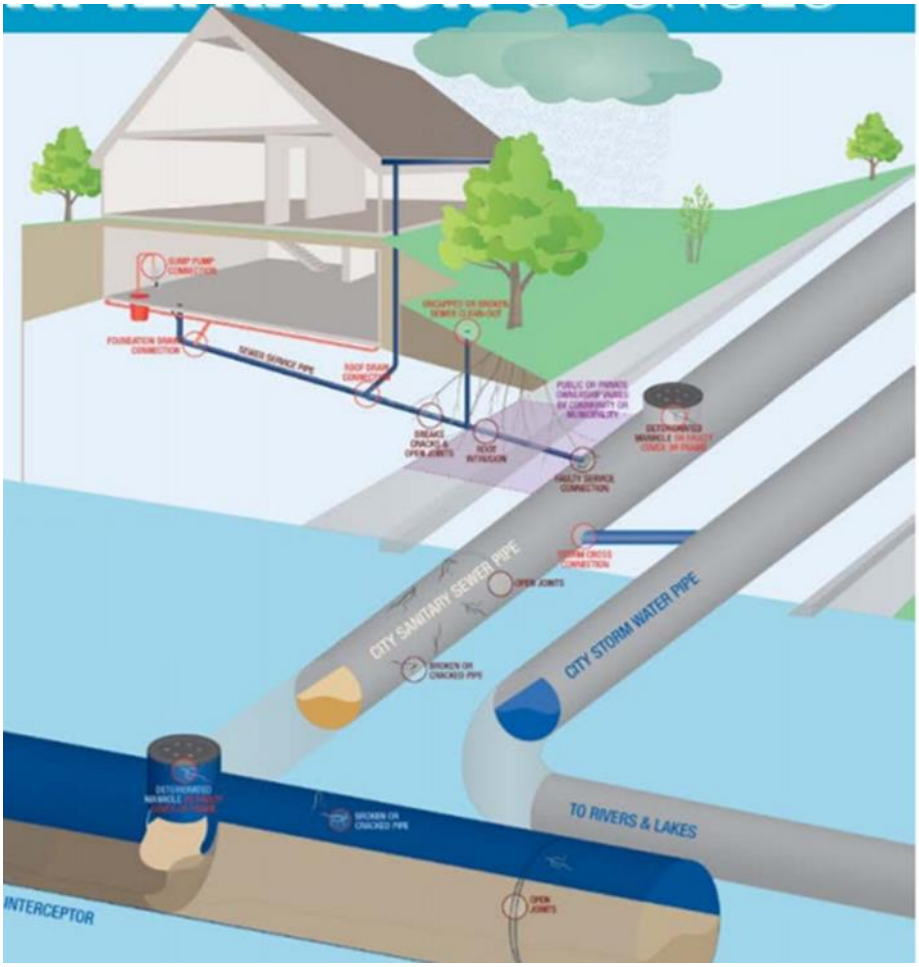


Figure credit: Metropolitan Council

Nature of concern related to groundwater

The concern has been raised that leakage from municipal wastewater piping systems or city sewers may be contributing to groundwater pollution and should be addressed within the scope of a review of MPCA groundwater protection practices. Basic definitions of inflow and infiltration (I&I): inflow is a plumbing choice (e.g. a storm drain or gutter connected to a sewage system); while infiltration is a leakage due to wear or breakage, where water is forced into pipe by external positive pressure. City sewers are known to have problems with I&I, or excess water entering sewer systems from groundwater and stormwater through holes, cracks, joints and faulty connections. However, the reverse process of wastewater leaking out of sewer pipes or exfiltration may also affect groundwater quality. The following comments were gathered from conversations with MPCA staff in the Municipal Wastewater Section.

There are thousands of miles of city sewer piping and infrastructure in various conditions throughout the state; however, there are no known volumes of wastes that can realistically be estimated as impacting groundwater from systems that do leak. Inflow and infiltration could be occurring anywhere there are city sewer systems, so it is probable this would be occurring within wellhead protection areas and vulnerable aquifers. There is no list of sites where I&I impacts to groundwater are being investigated or targeted for investigation.

I&I is recognized as a concern from the wastewater engineering perspective when groundwater leaking into old or broken sewer pipes increases the volume of water going to the publicly owned treatment works (POTW). There is a wastewater infrastructure-funding program that funds sewer rehabilitation projects where I&I may be a problem. These projects are ranked on the Clean Water Project Priority List and are overseen by the Minnesota Public Facilities Authority and other state agencies, including the MPCA. Rehabilitation projects fix leaky sewer problems, and new sewer systems are tested for sewers for leakage when they are installed. Sewer rehabilitations use materials that are less likely to leak than materials used in the past and sanitary sewer piping is separated from stormwater piping systems.

The main contaminants in sewage include bacteria measured as fecal coliform, biological oxygen demand (BOD), nitrogen, phosphorus, and numerous other parameters from improper disposal of household wastes and industrial wastes that could contain contaminants of emerging concern (CECs).

The MPCA staff noted the biggest potential impacts to groundwater from city sewers would likely be from a complete pipe failure; however, that would likely result in a sewer back up or overflow and would be identified. In addition, dry weather flow into the POTW can also be used to determine if significant leakage is occurring. If there is less flow volume than predicted by user inputs, the piping system probably leaks into the surrounding soils and groundwater.

Overall, the ability to locate and assess the impacts of leaking sewer pipes to groundwater would be very difficult to assess and monitor without exact locations of leakage. Leakage can flow along the pipe trench within the gravel sub base most pipes are laid in and enter soils or groundwater in a different area from that of the leakage. Methods such as dye tracing or video logs of piping could be used to locate leakage that may affect groundwater; however, as stated previously there is no list of sites that are being monitored or investigated for leakage impacts to groundwater.

Summary and next steps

A review of MPCA program documents and interviews with program staff indicate that several MPCA programs require groundwater quality monitoring data to verify whether their groundwater BMPs are protective of groundwater resources. More specifically, this includes groundwater monitoring of mid-sized septic systems (MSTS sites), select animal feedlot manure storage basins, stormwater infiltration sites, and enhanced monitoring at specific industrial wastewater land application sites.

In addition, analysis of existing groundwater quality data sets was also identified as a need to assess the impacts of program BMPs. The Demolition Landfill Program has a pressing need to conduct a statistical data analysis of groundwater monitoring data collected over the last eight to ten years from demolition landfills to assess the impacts of program BMPs contained in their Demolition Landfill Guidelines. The Animal Feedlot Program would also benefit from an analysis of a water quality database collected from larger permitted facilities collected from monitoring wells and tile drainage discharge stations.

Furthermore, program staff has identified a need to collect and store data in a database that allows for meaningful analysis and data sharing. Formerly, the bulk of data generated by the Solid Waste Demolition Landfill program and for the land application of industrial wastewaters and industrial by-products was stored in the now-retired Delta database. Once a decision is made concerning the restarting of the loading of this information into a MPCA database, data generated from the monitoring of stormwater infiltration sites should also be collected, assessed and made available to outside parties.

Summaries of the MPCA program data needs are provided in Appendix A in table form and more detailed descriptions are found at the end of each program write-up under the "Program BMPs and Data Needs Findings" section of the report.

Work plans

The next step in this process is to develop work plans to address program data needs that will enhance program groundwater BMPs. Developing work plans must be conducted with program staff, and management and will need to consider a number of factors. Some of these factors include available funding, staff resources, program readiness, scope or length of project, material costs, and whether the BMP evaluation should be conducted solely by the MPCA staff or jointly with outside stakeholders, consultants, responsible parties, other government entities, or contracted out entirely.

Several programs are moving forward with their priority data needs collection; however, these are limited by staffing resources. Both the Demolition Landfill and Stormwater Programs have taken initial steps to collect data for their priority needs, and the SSTS program and Industrial Waste land application programs have set their priority data needs and are looking for resources and outside partners to initiate data collection.

Appendix A

Table 1. Program data needs and recommendations

MPCA Programs	Program data needs and recommendations
Solid Waste Demolition Landfill	• Encourage reuse of demolition materials to reduce reliance on unlined facilities • Provide incentives to owners of unlined landfills to move to facilities that are more protective of degradation through using liners and leachate collection systems • Seek funding for these changes in the State of Minnesota 2018-19 Biennial Budget
Subsurface Sewage Treatment Systems (SSTS)	• Groundwater monitoring at MSTS sites • Assess impacts of smaller ISTS to groundwater monitoring for CECs • Reduce the intentional flushing of unused pharmaceuticals from home and farm
Animal Feedlot	• Follow-up testing and analysis of the drain tile discharge water sampling performed at feedlots, whose permits require testing • Evaluate older manure storage basins lacking double liners in SE Minnesota karst region • Investigate groundwater quality at larger manure storage basins
Land Application of Industrial Wastewaters and IBPs	• Unusual wastes and their environmental fate for land application scenarios are currently (2018) being investigated by the USGS Toxic Substances program • Loading rates at high BOD irrigation sites in Minnesota are much less than similar sites in other states such as MI, which may lead to further study • Site information related to application that used to be entered in the now-retired Delta database is not currently entered in its replacement, Tempo, as of 2018. There will be an attempt to once again capture this information in the future.
Stormwater	• Promote creation of statewide GIS layers to evaluate options to infiltrate stormwater in new development & redevelopment areas in context of vulnerable aquifers • Develop case studies to assess groundwater impacts for stormwater infiltration BMPs (e.g. the Minnesota Stormwater Manual; consider Cl, pathogens, infiltration at brownfields, etc.) • Data collection for stormwater infiltration projects
Biosolids	• No specific recommendations for groundwater monitoring • Biosolids annual reports have been scanned into Tempo, but the data is not in a readily accessible format. New biosolids site approvals and cumulative metals loading data have not been stored electronically since the switch to Tempo. There is a recognized program need to store this data within Tempo. • There is a recognition that the fate of persistent organic compounds (i.e. pharmaceuticals, personal care products, steroids, PFAS, and hormones) in biosolids is important; however, the financial and staff resources necessary to conduct this type of work are beyond the scope of the program's current resources.
Inflow and Infiltration (I&I)	• Limited groundwater impact concerns. Concerns relate to groundwater leaking into wastewater infrastructure. • Investigating leakage to groundwater would be difficult and has not been done in the Municipal Program.