



Guidance for Leachate Recirculation at Municipal Solid Waste Landfills

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Contents

Introduction	1
History	1
Benefits	2
Goals	2
Design	3
Operation	4
Landfill gas management	5
Monitoring	5
Physical monitoring parameters	6
Leachate monitoring parameters	6
Gas monitoring parameters	7
Reporting	8
Closure	9
Long-term care	9
Contact information ...	9

Introduction

This Guidance has been developed to meet three goals:

1. Provide municipal solid waste landfill (MSWLF) owners with the minimum standards to implement leachate recirculation as a tool in managing leachate on-site and minimizing the long-term impact of the disposed waste to human health and the environment.
2. Encourage the control of greenhouse gas (GHG) emissions at MSWLFs.
3. Encourage the production of energy from landfill gas as an alternative renewable energy source.

It is the intention of the Minnesota Pollution Control Agency (MPCA) to approve leachate recirculation through permit reissuance or major permit modification at MSWLFs that meet the minimum guidelines outlined herein. This guidance supersedes any previous policy or guidance on leachate recirculation.

History

In 2006, almost 1.5 million tons of waste generated in Minnesota was landfilled at 21 permitted MSWLFs within the state. These 21 landfills were developed in accordance with Minnesota's solid waste management rules and play a necessary role in the integrated waste hierarchy. The rules, promulgated in 1988, are based on the concept of "dry entombment", minimizing the contact of the waste with precipitation. This concept was intended to reduce

leachate generation, and thus, potential groundwater quality impacts.

Of the waste in landfills at Minnesota MSWLFs in 2006, approximately 77 percent went to facilities that currently have active gas collection systems (Burnsville, Clay, Crow Wing, East Central, Elk River, Pine Bend, and Spruce Ridge). Also in 2006, 43 percent of the waste stream went to facilities that recirculate their leachate (Crow Wing, East Central, Elk River, Lyon, Morrison, and Spruce Ridge).



Current MSWLF design and operation does not promote the degradation of disposed organic wastes within a reasonable timeframe. Non-degraded waste can potentially cause future environmental and/or economic impacts if the leachate and landfill gas (LFG) control systems fail. The costs of these impacts would be borne by future generations. The MPCA believes that MSWLF design and operation practices should enhance organic waste degradation, limit dependence on off-site facilities for leachate treatment and disposal, provide a renewable "green"

energy source, and promote stabilization of landfills. Leachate recirculation is one tool to achieve these objectives.

Benefits

The MPCA identified leachate recirculation as an alternative leachate management option in 1991 (Leachate Disposal and Treatment Options, March 1991) and further promoted leachate recirculation in Environmental Policy No. 4: Alternative Leachate Management, April 9, 2001. Under Environmental Policy No. 4, six landfills have implemented demonstration or pilot projects on a site-specific basis. Most have experienced the following benefits:

- leachate treatment within the waste
- increased LFG generation rate, augmenting energy recovery potential
- increased waste settlement, leading to recoverable and ultimately more efficient use of landfill airspace
- accelerated waste degradation as evidenced by improved leachate quality and reduced organic fraction in waste samples
- avoidance of leachate transport to distant Publicly Owned Treatment Works (POTWs)

The MPCA recognizes the advantage of providing on-site treatment of leachate and reducing MSWLFs dependence on POTWs. In addition, the potential benefit of generating, capturing, and utilizing landfill gas from facilities that recirculate leachate may help the state achieve its goals of increasing the production of renewable energy and reduce the intensity of greenhouse gas emissions.

Goals

The MPCA's 2008 Strategic Plan includes the following goals:

- Goal A3b) Reduce greenhouse gas emissions in Minnesota by 15 percent from 2005 levels by January 1, 2015, and by 30 percent by January 1, 2025, as set in the *Next Generation Energy Act of 2007*.
- Goal L1a) By January 1, 2025, achieve a total reduction of 75 million metric tons of greenhouse gas attributed to changes in waste generation, materials conservation, and resource management practices.

At the request of the Governor and the Minnesota Legislature, the Minnesota Climate Change Advisory Group published a Climate Mitigation Action Plan in April 2008 that contained many recommendations to state agencies and the Legislature. Highlighted in its policy document on the Agriculture, Forestry, and Waste Sector is the importance of capturing and burning methane that would otherwise escape from landfills and, where practical, to use the landfill gas as a substitute for fossil fuel. The MPCA believes that a well-run leachate recirculation system can result in effective gas management which in turn can promote renewable energy from landfill gas.

In the short-term, the MPCA will be phasing out the existing pilot projects. Each landfill in the pilot project will be requested to provide any remaining data gaps. Pilot studies will need to be terminated before a landfill may be authorized for long-term leachate recirculation. Landfills currently participating in pilot studies, as well as other MSWLFs wishing to recirculate leachate long-term, shall demonstrate compliance with this Guidance.

In addition to the benefits of on-site management of leachate identified above, the MPCA believes that, on a long-term basis, MSWLFs may benefit from leachate recirculation and has identified the following goals that leachate recirculation may help MSWLFs achieve:

- Use leachate to assist in breaking down, or perpetually confining toxic materials within the permitted facility boundary.
- Maximize the functional capacity of the permitted airspace for waste disposal.
- Manage waste so that the organics are broken down within the revenue life of the landfill.
- Control greenhouse gas (GHG) emissions at or below current emission levels, where practical.
- Achieve efficient capture of gas for beneficial use or energy production from landfilled waste, where practical.

The MPCA will evaluate this Guidance with respect to the goals in the Strategic Plan every five years. This Guidance may be modified in the future if necessary to achieve the State's goals.

Potential concerns of leachate recirculation that have occurred and has been identified in the literature, shall be addressed and monitored through the standards that follow.

A permittee wishing to implement recirculation shall submit a plan that details how the design, operation, monitoring, and reporting will be performed. The following guidance should be considered as the minimum standards for leachate recirculation at landfills in Minnesota.

Design

MPCA staff shall review the design of proposed long-term leachate recirculation systems to ensure that they meet the following minimum requirements:

- Only leachate and LFG condensate generated from the landfill may be recirculated.
- Leachate recirculation can only occur over a liner and leachate collection systems that meet the rule requirements of Minn. R. 7035.2815, subp. 7(E) that includes a composite liner system incorporating a geomembrane. An alternate liner system may be proposed pursuant to Minn. R. 7035.2815, subp. 7(K).
- The permittee shall demonstrate using the HELP model or other MPCA approved method that leachate head is maintained below 12 inches once leachate recirculation is initiated.
- Due to the potential for leachate seeps, distribution systems shall not be installed within 50 linear feet of exterior side slopes.
- Due to higher moisture content as a result of recirculation, slope stability shall be determined on liner, intermediate waste, and cover interfaces with the design providing for a factor of safety greater than 1.5 for saturated conditions.
- Measurement systems shall be provided to measure leachate head, recirculation flow into the landfill, and leachate collected from the landfill.

Other design considerations shall be presented for MPCA staff review, including:

- An evaluation of the need for additional off-liner storage to provide complete on-site treatment of leachate shall be submitted for MPCA review.
- The need for augmented leachate treatment shall be evaluated.
- All systems shall be designed to minimize odor emissions and meet existing LFG control regulations.

- All distribution techniques shall be designed to accommodate the expected waste settlement.
- Systems shall be designed to operate in all weather conditions when leachate recirculation will take place.
- The permittee shall propose the method and location of leachate head monitoring for MPCA review.
- A minimum of 20 feet of waste is recommended over new areas before the installation of leachate recirculation systems; this may be adjusted based on site-specific conditions.
- Alternate temporary caps may be proposed to enhance LFG collection and reduce emissions while allowing waste to settle. The temporary cap shall be designed to prevent threats to human health and the environment.
- Permeable caps may be considered provided they demonstrate effectiveness in reducing GHG emissions, and allowing LFG collection if an active gas system is in place while allowing the infiltration of precipitation.
- The facility shall be permitted for the maximum fill grade expected during operations. All design and stability calculations shall be based on the maximum fill grade and be consistent with other MPCA rules and policies (e.g. Landfill Slope Guidance, May 28, 2002). Permittees may propose operating procedures to periodically fill back in over settled areas to the maximum fill grades, or may choose to fill to the maximum fill grade and then allow the waste to settle to a permanent final grade. Refilling of the settled areas may trigger Certificate of Need (CON) considerations since CON is based on gate receipts. However, CON issues shall be resolved with the MPCA during permitting.
- Regardless of the method chosen, permittees shall maintain positive drainage off the temporary and final cover systems.
- Construction of final caps may be delayed until settlement is achieved (less than one percent overall settlement in a one year period) and/or the permittee decides that no further waste will be placed.

- Leachate shall be distributed throughout the waste mass as much as practical. Methods could include horizontal distribution, and/or vertical distribution. The permittee shall propose a leachate recirculation method to be used and provide designs and procedures to recirculate leachate such that leachate recirculation will not cause an increased threat to human health and the environment.

Surface or working face application

- Wetting of the working face may be considered to promote compaction, litter control, and uniform distribution of liquid throughout the waste mass.
- Surface application of leachate shall not result in ponding or surface runoff of leachate.
- The system shall be designed to distribute the leachate in a manner that results in absorption of leachate into the waste mass.
- Ambient monitoring will be required to estimate the level of GHG emissions.
- To protect the public and employees from exposure to the leachate, a site-specific Health Risk Assessment shall be completed and the results submitted to the MPCA for review.

Horizontal distribution systems

- Shall be designed to distribute liquid equally along its length.
- Incorporate permeable bedding to rapidly dissipate leachate into the waste mass and maintain its integrity through the operating life.
- Maintain pumping pressures, rates, and rest/load intervals to prevent surface seeps and promote even liquid distribution.

Vertical distribution systems

- Shall be separate systems from those used for leachate collection or gas collection unless specifically designed as dual-purpose wells.
- Have well or injection point spacing based on leachate flow rates, waste mass permeability, and waste pore pressure.
- Distribute liquid uniformly within the zone of influence of each well or injection point, and to prevent surface seeps.

- Be designed so that the leachate does not short circuit directly into the leachate collection system.

Operation

MSWLF operation with leachate recirculation shall be consistent with the goal of degrading the organic waste fraction within a reasonable timeframe without causing



increased threat to human health and the environment. To that end, MPCA staff will review operations manuals to ensure that the following minimum operational requirements shall be met:

- The MSWLF shall have a designated leachate system operator responsible for the leachate recirculation program. A training program for this individual and other staff shall be identified in the plan.
- Daily cover or alternate daily cover (ADC) shall completely and adequately cover the waste until the next business day.
- An inspection and maintenance plan shall be prepared that identifies methods, schedules, and responsible parties that will verify that operation and monitoring equipment for the leachate recirculation system are functional.
- Waste and cover soil placement shall be completed to minimize horizontal leachate flow to the landfill perimeter (i.e., seep potential). The following methods shall be included in the operations manual, if applicable:
 - removal or scarification of low permeability daily and intermediate cover between waste lifts
 - removal of internal haul roads with fill progression

- use of higher permeability daily and intermediate cover, and ADC
- careful placement of low permeability industrial, construction and demolition debris, and contaminated soil wastes

As with any MSWLF, a landfill implementing leachate recirculation is required to plan for and respond to related contingency events such as elevated leachate head, seeps, odors, equipment failure, slope instability, and emergencies. Problems shall be repaired within two weeks of discovery. If a longer time period is needed, prior approval shall be obtained from the MPCA.

The landfill's contingency action plan shall be amended to address potential contingencies associated with leachate recirculation. Contingency actions shall include suspension of recirculation in cells with seeps or elevated leachate head or excessive odors, and repair or replacement of watered-out gas wells. Financial assurance calculations shall include costs for the increased potential and the occurrence of unique contingency events associated with leachate recirculation identified.

Landfill gas management

When it comes to landfill gas management, landfills fall into the following categories:

- facilities with active LFG collection operating under the New Source Performance Standards (NSPS)
- facilities which have voluntarily installed an active LFG system, although not required under NSPS
- facilities that do not have a design capacity that triggers the LFG active control requirements of the NSPS and have not installed an active gas collection system

As documented in the literature and verified at several of the pilot projects, leachate recirculation increases the LFG generation rate when compared to conventional dry tomb landfilling. LFG emissions contain constituents that have been linked to climate change and can also result in odor nuisance complaints.

The MPCA will evaluate the need for landfill gas management controls on a site by site basis during the permitting process.

In order to measure progress toward state goals (L1a and A3b), the permittee shall annually present an evaluation

on the feasibility of managing LFG in a manner that would limit LFG emissions at or below the quantity that would have been produced in a dry landfill condition. If cost is given as the reason that this level of LFG control is infeasible, then an analysis of the cost to install and operate such a system shall be given.

Facilities that install an active gas collection system or convert an existing active system with a flare to a gas-to-energy system must check in with the MPCA Air Quality permitting staff to determine applicable air permitting requirements.



Facilities with active gas collection systems shall develop a procedure for determining whether a gas well has been watered-out (minimum monthly monitoring), and a method for evaluation or remediation of the gas well. (Note: Some gas wells may be abandoned or otherwise disconnected from the gas collection system and the vacuum enhanced in adjacent wells to compensate for the watered-out well.)

Monitoring

The goals of monitoring at leachate recirculation facilities are to provide information for operational control and to evaluate system performance and overall effectiveness. It is also important to collect data that is comparable from facility to facility for overall program objectives. For these reasons, monitoring requirements shall be standardized as much as practical considering that different projects may have different goals. Monitoring procedures can be generally organized into physical parameters, leachate parameters, and gas parameters. As part of each leachate recirculation plan,

the permittee shall propose methods to monitor leachate recirculation. The following media and parameters shall be included in the monitoring plan:

Physical monitoring parameters

The minimum physical monitoring parameters for evaluation of the performance and operation of recirculation landfills include:

Parameter	Frequency	Units
Mass of landfilled waste	Daily	Tons
Leachate head on the liner	Weekly ⁽¹⁾	Feet
Leachate generation rate	Monthly	Gallons
Leachate recirculated	Daily	Gallons
Precipitation ⁽²⁾	Daily	Inches
Incoming waste moisture content ⁽³⁾	Annually	% (M/M)
Water balance ⁽⁴⁾	Annually	% (M/M)
Settlement	Annually	Feet (surveyed)

Notes:

(1) Measured daily, however, it is suggested that a weekly average is reported.

(2) Used for preparation of the water balance reported annually. Use of data from nearby weather stations is permissible.

(3) Default Value is 20 percent or site specific data can be used based upon four independent samples.

(4) EPA document EPA-456/R-03-007, Method A or approved alternate.

Leachate head is required to document compliance with the MPCA rules and U.S. Environmental Protection Agency (EPA) regulations that require all Subtitle D landfills to maintain less than 12 inches of head on the liner system. If leachate head exceeds 12 inches on the liner, the MPCA shall be notified within 24 hours. The permittee shall propose to the MPCA the methods, locations, and frequency of leachate head monitoring. Typically, leachate head on liner is monitored daily or continuously and reported as a weekly average.

The mass of landfilled waste, leachate generation rate, leachate recirculated, initial waste moisture, and precipitation are required for the preparation of a water balance for the facility. The water balance calculations can be used to determine the moisture content within the recirculation area. While methods are also available for measuring moisture levels in-situ, none of the methods currently available can provide accurate measurements of the gravimetric moisture content of the landfilled

waste. Water balance methods shall be proposed for MPCA approval.

Settlement is useful in determining the status of waste stabilization and efficiency (as determined by waste density) of recirculation and landfill operations. However, settlement plates can be difficult to maintain and survey in active landfill operations. Therefore, the MPCA shall only require the use of settlement plates at existing pilot study projects until they complete their study. At a minimum, settlement shall be measured by using the required annual surveys.

Leachate monitoring parameters

The leachate parameters that are generally-accepted as the most useful for evaluating waste stabilization and leachate recirculation operational efficiency include:

Parameter	Frequency	Units
pH	Quarterly	Standard
Chemical Oxygen Demand (COD)	Quarterly	mg/l
Biochemical Oxygen Demand (BOD)	Quarterly	mg/l
Ammonia	Quarterly	mg/l
Nitrate + Nitrite	Quarterly	mg/l
TDS	Quarterly	mg/l
Alkalinity	Spring/Fall	mg/l
VOCs (MDH 465E)	Spring/Fall	ug/l
Iron	Spring/Fall	ug/l
Arsenic	Spring/Fall	ug/l
Cadmium	Spring/Fall	ug/l
Chromium	Spring/Fall	ug/l
Lead	Spring/Fall	ug/l
Mercury	Spring/Fall	ug/l
Zinc	Spring/Fall	ug/l

The parameters to be monitored quarterly constitute the primary leachate recirculation parameters used for both operational control and long term performance monitoring. The key parameters to assess stabilization progress include pH, COD, BOD, and nitrogen forms.

The other parameters included are important for determining the degree of metals sequestration occurring within the landfill as a result of recirculation.

Examination of data from the pilot project suggests that a semi annual frequency is sufficient to capture the long-term trends in these secondary parameters. These

parameters will be monitored in addition to any other leachate monitoring criteria provided in the facility permit that may include additional sampling parameters for leachate that is taken off-site for disposal, or treated on-site by methods other than leachate recirculation. The



permittee is responsible for sampling and analyzing the leachate as required in the permit and based on the leachate treatment option being used.

Note: If the facility also land applies or hauls its leachate to a wastewater treatment facility, it must also continue to conduct leachate monitoring in accordance with the approval/permit for these other leachate treatment options.

Gas monitoring parameters

Gas monitoring procedures are identified separately for facilities with operating active gas extraction systems and those without active gas extraction systems.

Ambient monitoring shall be done quarterly (four times per year) at all facilities using the surface scan serpentine route/method regardless of whether the facility triggers the NSPS requirements. Sampling shall be done by personnel trained in NSPS monitoring procedures. A portable monitoring device shall be used to determine the methane concentrations. Background concentrations should first be determined by moving the detector probe inlet upwind and downwind of the landfill at the facility compliance boundary. The sampler would then walk the serpentine path over the landfill surface with the detector probe positioned between 2 to 4 inches off the ground. The serpentine path shall follow a pattern of parallel lines approximately 100 feet apart over the landfill surface. Steep slopes or dangerous areas may be avoided. The serpentine path should be established in a manner that prohibits crossing back and

forth over recirculating and non-recirculating areas of the landfill. The meter should be on continuously, with the sampler recording the range of values detected during the scan. A separate range for recirculating and non-recirculating areas shall be reported. Any values of methane over 500 ppm shall be flagged, investigated, repaired, and retested in accordance with NSPS procedures. Monitoring shall be performed during typical meteorological conditions (dry site with no rain for at least a 72 hour period). Average wind speed will be measured and recorded throughout the sample event. Monitoring shall be terminated at average wind speeds in excess of 5 miles per hour (mph) or gusts greater than 10 mph.

On an annual basis, each landfill shall evaluate its total potential for greenhouse gas emissions. The results of this evaluation shall be submitted with the annual report.

When estimating greenhouse gas emissions for an active extraction system, a collection efficiency of 75 percent shall be used, unless a higher efficiency can be substantiated.

Facilities with active gas extraction systems:

The minimum landfill gas parameters appropriate for recirculation landfills operating active gas systems include:

Parameter	Frequency	Units
Total gas production ⁽¹⁾	Quarterly	CFM
Individual well production ⁽¹⁾	Quarterly	CFM
Methane ⁽²⁾ @ blower	Quarterly	(%V/V)
Oxygen ⁽²⁾ @ blower	Quarterly	(%V/V)
Temperature ⁽²⁾ @ blower	Quarterly	° F
Surface scan ⁽³⁾	Quarterly	PPM CH4

Notes:

(1) Orifice plate/pitot tube/mass flow meter (cfm)

(2) Measured via Portable Gas analyzer (% V/V)

(3) NSPS requirements for serpentine scan using PID/FID measuring ppm CH4. Maximum and minimum range of values reported.

Permittee may request from the MPCA a reduction in frequency of testing if surface scans indicate no readings above 500 ppm for four consecutive quarters.



Facilities without active gas extraction systems:

For recirculation landfills operating without active gas systems, monitoring shall occur at the passive gas vent and/or leachate cleanouts as specified in the facility's approved monitoring plan. The minimum landfill gas parameters appropriate for these facilities include:

Parameter	Frequency	Units
Methane ⁽¹⁾	Quarterly	(%V/V)
Oxygen ⁽¹⁾	Quarterly	(%V/V)
Temperature ⁽¹⁾	Quarterly	° F
Surface scan ⁽²⁾	Quarterly	PPM CH4

Notes:

(1) Measured via Portable Gas analyzer (% V/V)

(2) NSPS requirements for serpentine scan using a portable gas analyzer measuring ppm CH4. Maximum and minimum range of values reported. Permittee may request from the MPCA a reduction in frequency of testing if surface scans indicate no readings above 500 ppm for four consecutive quarters.

These readings shall be measured in addition to any measurements outlined in the facility's LFG system operation plan.

Reporting

Facilities shall submit operating, gas monitoring, and leachate monitoring information in the facility's annual report due February 1st of the following year in accordance with Minn. R. 7035.2585. A report presenting and evaluating the leachate recirculation program shall be submitted as part of the Annual Facility Report.

The annual leachate recirculating report shall include:

- a statement of compliance with design and operation criteria in the leachate recirculation system plan

- description of expansions or modifications to the leachate recirculation system conducted in the operating year (these need MPCA review and approval prior to implementation)
- description of the recirculation operation during the previous year, including methods used, frequency of dosing, and observations
- a summary of the volume of leachate collected, recirculated, and disposed off-site or by other means
- the results of head on liner measurements
- water balance evaluation
- settlement achieved and an estimate of airspace gained and utilized
- problems encountered and contingency actions taken
- monitoring results for leachate
- quantification of landfill gas parameters
- estimate of LFG generation for a dry landfill based on actual waste receipts
- itemization of the cost to control excess LFG generated due to wet landfill conditions
- summary of LFG data and discussion of GHG emission reductions achieved
- an assessment of waste stability in the recirculation cells
- an assessment of the leachate results and discussion on trends
- the summary of inspections conducted
- a log of any odor or other complaints received during the year and how they were addressed
- a log of leachate seeps identified and how they were addressed
- any permit specific reporting requirements
- all data collected from monitoring
- summary of potential greenhouse gas emissions

Closure

Closure of a leachate recirculation area shall be conducted according to Minnesota Rules for solid waste landfill closure. Each facility shall identify its schedule/plan for closure of the leachate recirculation cells in its Closure Plan. The Closure Plan shall address the use of temporary and permanent final cover systems; a schedule for constructing the permanent final cover system; a plan for refilling over settled areas in the recirculation cells, if desired, or otherwise addressing settlement; and the decommissioning of the leachate recirculation system.

A temporary cover system shall be designed and constructed to contain or reject at least 90 percent of the precipitation falling on the system. A temporary cover system comprised of soils or amended soils shall be at least 24 inches thick and include at least a 6 inch layer of topsoil or organic-rich soil to reduce greenhouse gas emissions through the cap. A temporary cover system shall be graded to a minimum 3 percent slope. Slopes greater than 20 percent shall be in compliance with the MPCA's Landfill Slope Guidance dated May 28, 2002.

Facilities that use a temporary cover system shall remain in a "closure phase" until such time as a permanent final cover system has been installed. Facilities shall adjust their closure cost estimates to not only include the cost of final cover construction in all areas that have not had a permanent final cover system installed, but also include any operation and maintenance costs associated with remaining in the closure phase.

Leachate recirculation may continue into the post-closure care period until waste stabilizes. Using industry-identified methods as described by Reinhart and Townsend, waste is considered stabilized when:

- leachate COD is less than 1,000 mg/l and BOD is less than 100 mg/l with a BOD:COD ratio less than 0.1, **and**
- gas production drops to 5 percent of its peak value.

When leachate recirculation facilities shall be decommissioned, it must be done in a manner that shall not impact installation or operation of closure features such as synthetic caps.

Long-term care

The post-closure care period shall commence on the date that the MPCA approves the construction certification report for the permanent final cover system. Post closure care shall be conducted according to Minnesota Rules. Each facility shall identify in its Post-Closure Care Plan whether the leachate recirculation system will continue to operate during the post-closure care period. The Post-Closure Care Plan shall also identify a management plan for the cessation of leachate recirculation which may require off-site disposal of high ammonia leachate. Cost estimates shall be adjusted to reflect the ongoing management of leachate via recirculation and the cost for ultimate disposal of leachate once recirculation ceases.

Contact information

For more information on leachate recirculation at MSWLFs, contact the MPCA at 651-296-6300 or 800-657-3864 and ask for the solid waste engineer assigned to the region in which your facility is located.