Minnesota Pollution Control Agency

land application of Biosolids

a manual for Minnesota

July 2014

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Produced by

Donna Portner of the Minnesota Pollution Control Agency's (MPCA) Training, Certification and Outreach Unit revised, reorganized and reformatted the draft manual to create the final version of *Land Application of Biosolids.* Jorja DuFresne, MPCA Biosolids Coordinator, and Steve Stark, formerly of the Metropolitan Council Environmental Services and currently of the MPCA, contributed their vast biosolids knowledge and experience to the manual. Please direct program questions to:

Biosolids Program Coordinator
Minnesota Pollution Control Agency
520 Lafayette Road North
St. Paul, Minnesota 55155-4194
651-296-6300 or 1-800-657-3864

Thanks to

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Revisions

Revised July 2014 by MPCA staff Jorja DuFresne and Steve Duerre with assistance from Nancy Ellefson.

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Definitions of terms used in this manual

Agricultural land. *Agricultural land* means land on which a food crop, feed crop, cover crop, or fiber crop is grown as well as land managed for the production of hay, pastureland for grazing of livestock, or rangeland.

Agronomic rate. *Agronomic rate* means the biosolids application rate (dry weight basis) designed to:

A. provide the amount of nitrogen which can be utilized by the food crop, feed crop, fiber crop, cover crop, or vegetation grown on the land; and
B. minimize the amount of nitrogen in the biosolids that passes below the root zone of the crop or vegetation grown on the land to the groundwater.

Annual pollutant loading rate. *Annual pollutant loading rate* means the maximum amount of a pollutant that can be applied to a unit area of land during a 365-day period.

Apply biosolids or biosolids applied to the land. *Apply biosolids* or *biosolids applied to the land* means applying biosolids by spraying or spreading biosolids on the surface of the land, injecting biosolids below the surface of the land or incorporating biosolids into the soil for beneficial use.

Available nitrogen. *Available nitrogen* means nitrogen that is present in inorganic forms and the amount of organic nitrogen that can be mineralized to plant available forms.

Beneficial use. *Beneficial use* means any application of biosolids to the land to improve soil physical and chemical properties by supplying nutrients, organic matter, and other components of this material.

Biosolids. *Biosolids* means sewage sludge that is acceptable and beneficial for recycling on land as a soil conditioner and nutrient source.

Bulk biosolids or sewage sludge. *Bulk biosolids or sewage sludge* means biosolids that are not sold or given away in a bag or other container for application to the land.

Cave. *Cave* means any naturally formed, subterranean open area or chamber, or series of chambers.

Cover crop. *Cover crop* means a small grain or other close growing vegetation not grown for harvest such as vegetation growing on land set aside for conservation purposes.

Cropping year. *Cropping year* means a year beginning on September 1 of the year prior to the growing season and ending August 31 the year the crop is harvested. For example, the 1999 cropping year began September 1, 1998, and ended August 31, 1999.

Cumulative pollutant loading rate. *Cumulative pollutant loading rate* means the maximum amount of an inorganic pollutant that can be applied to an area of land.

Dewatered biosolids. *Dewatered biosolids* means any biosolids with a total solids content of 20 percent or greater or which can be transported and handled as a solid material.

Disposal Facility. *Disposal Facility* means a waste facility that is designed or operated for the purpose of disposing of waste on or in the land and has a permit, stipulation agreement, or other written approval from the MPCA.

Domestic septage. *Domestic septage* means either liquid or solid material removed from a septic tank, cesspool, portable toilet, Type III marine sanitation device, or similar treatment works that receives only domestic sewage. Domestic septage does not include liquid or solid material removed from a septic tank, cesspool, or similar treatment works that receives either commercial wastewater or industrial wastewater (wastewater generated in a commercial or industrial process) and does not include grease removed from a grease trap at a restaurant.

Domestic sewage. *Domestic sewage* means waste and wastewater from humans or household operations that is discharged to or otherwise enters a treatment works.

Dry weight basis. *Dry weight basis* means calculated on the basis of having been dried at 105 degrees Celsius until reaching a constant mass, or essentially 100 percent solids content.

EPA. *EPA* means the United States Environmental Protection Agency.

Exceptional quality biosolids. *Exceptional quality biosolids* means biosolids which have been prepared to meet one of the Class A pathogen reduction requirements in part 7041.1300, subpart 2; the pollutant concentrations in part 7041.1100, subpart 4, item C; and one of the vector attraction reduction requirements in part 7041.1400, subpart 2, items A to H.

Feed crops. *Feed crops* means crops produced primarily for consumption by animals.

Food crops. *Food crops* means crops consumed by humans. These include, but are not limited to, fruits, vegetables, and tobacco.

Forest. *Forest* means a tract of land thick with trees and underbrush.

Groundwater. *Groundwater* means water below the land surface in the saturated zone.

Highly permeable soils. *Highly permeable soils* means soils whose soil leaching potentials are rated as severe, poor filter for soil pesticide loss, by the Natural Resources Conservation Service using the procedure found in part 620, Soil Interpretation Rating Guides of the United States Department of Agriculture—Natural Resources Conservation Service National Soil Survey Handbook.

Inspector. *Inspector* means any individual who has governmental authority to routinely review waste disposal facilities to determine compliance with applicable statutes, rules, permits, ordinances or standards. *Inspector* does not include county board members, MPCA board members, or other individuals employed, appointed or elected who are not directly involved in routine review of a waste disposal facility. *Inspector* may include individuals who are employed as environmental health specialists or sanitarians, technicians, zoning administrators, county solid waste officers, pollution control specialists, engineers, soil scientists and hydrologists.

Land application site. *Land application site* means an area of land that receives application of biosolids for beneficial use.

Long-term storage. *Long-term storage* means the storage of dewatered bulk biosolids for a period greater than 30 days but not exceeding seven months at a land application site.

Material derived from biosolids. *Material derived from biosolids* means biosolids received from a treatment works whose quality is changed either through treatment or mixing with a nonhazardous material prior to being applied to the land.

Mine. *Mine* means an excavation for minerals.

NPDES permit. *NPDES permit* means a National Pollutant Discharge Elimination System permit issued by the MPCA that authorizes under certain conditions the discharge of pollutants to surface waters of the state. Combined NPDES/SDS permits issued by the MPCA will be considered NPDES permits under this chapter.

Operator. *Operator* means any individual responsible for conducting work at a waste disposal facility. *Operator* does not include office personnel, laborers, transporters, corporate directors, elected officials, or other individuals in managerial roles unless such individuals are directly involved in on-site supervision or operation of a waste disposal facility. *Operator* does not include private individuals who store or landspread biosolids on property owned or farmed by that individual. *Operator* includes facility managers, supervisors and equipment operators.

Natural Resources Conservation Service. *Natural Resources Conservation Service* means the Natural Resources Conservation Service of the United States Department of Agriculture, formerly known as the Soil Conservation Service.

Other container. *Other container* means either an open or closed receptacle. This includes, but is not limited to, a bucket, box, carton, or vehicle or trailer with a load capacity of one metric ton (2205 pounds) or less.

Pathogens. *Pathogens* means organisms that are capable of producing an infection or disease in a susceptible host.

Perched water condition. *Perched water condition* means the soil is saturated with water in one or more layers within 200 centimeters (78.7 inches) of the mineral soil surface and has one or more unsaturated layers, with an upper boundary above 200 centimeters (78.7 inches) in depth, below the saturated layer. The zone of saturation, i.e., the water table, is perched on top of a relatively impermeable layer. The Natural Resources Conservation Service also classifies this as "epi-saturation."

Person who prepares biosolids. *Person who prepares biosolids* means the person who generates biosolids during the treatment of domestic sewage in a treatment works or the person who derives a material from biosolids.

pH. *pH* means the logarithm of the reciprocal of the hydrogen ion concentration measured at 25 degrees Celsius or measured at another temperature and then converted to an equivalent value at 25 degrees Celsius.

Pollutant. *Pollutant* means an organic substance, an inorganic substance, a combination of organic and inorganic substances, or a pathogenic organism that, after discharge and upon exposure, ingestion, inhalation, or assimilation into an organism either directly from the environment or indirectly by ingestion through the food chain, could, on the basis of information available to the administrator of EPA, cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions including malfunction in reproduction, or physical deformations in either organisms or offspring of the organisms.

Pollutant limit. *Pollutant limit* means a numerical value that describes the amount of a pollutant allowed per unit amount of biosolids, such as milligrams per kilogram of total solids, or the amount of a pollutant that can be applied to a unit area of land, such as pounds per acre.

Public contact site. *Public contact site* means land with a high potential for contact by the public. This includes, but is not limited to, public parks, ball fields, cemeteries, and golf courses.

Quarry. *Quarry* means a surficial mine used to obtain building stone, limestone, gravel, or sand.

Realistic yield goal. *Realistic yield goal* means the most recent five-year average of crop yields, excluding the worst year, or the most recent three- to five-year average yield increased by ten percent or if the crop has never been grown, the realistic yield goal based on soil productivity and level of management as determined by the county Natural Resources Conservation Service, county extension agent, or a crop consultant.

Reclamation site. *Reclamation site* means drastically disturbed land that is reclaimed using biosolids. This includes, but is not limited to, strip mines and construction sites.

Residential development. *Residential development* means ten or more places of habitation concentrated within ten acres of land. The term also includes schools, churches, hospitals, nursing homes, businesses, offices, and apartment buildings or complexes having ten or more living units.

SDS permit. *SDS permit* means a State Disposal System permit issued by the MPCA that authorizes under certain conditions the subsurface disposal or on-land disposal of pollutants and the operation of a disposal system.

Seasonal high water table. *Seasonal high water table* means the highest level the water table reaches during a given year. Methods of determining the seasonal high water table are given in part 7041.3400, subpart 3.

Sewage sludge. *Sewage sludge* means solid, semisolid, or liquid residue generated during the treatment of domestic sewage in a treatment works. Sewage sludge includes but is not limited to, scum or solids removed in primary, secondary, or advanced wastewater treatment processes and a material derived from sewage sludge. Sewage sludge does not include ash generated during the firing of sewage sludge in a sewage sludge incinerator or grit and screenings generated during preliminary treatment of domestic sewage in a treatment works. Sewage sludge that is acceptable and beneficial for recycling on land as a soil conditioner and nutrient source is also known as biosolids.

Short-term storage. *Short-term storage* means the storage of dewatered bulk biosolids for a period of less than 30 days at a land application site.

Sinkhole. *Sinkhole* means a closed depression in an area of Karst topography that is formed either by solution of surficial limestone or by collapse of underlying caves.

Soil horizon. *Soil horizon* means a layer of soil that is approximately parallel to the soil surface and has some set of properties that have been produced by soil-forming processes, and has some properties that are not like those of the layers above and beneath it. These properties include color, structure, texture, consistency, and bulk density.

Soil texture. *Soil texture* means the relative portion of the soil separates sand, silt, and clay. It can be measured using methods described in part 7041.3400, subpart 1. Coarse texture is United States Department of Agriculture textural classifications sand, loamy sand, and sandy loam. Medium texture is United States Department of Agriculture classifications loam, silt, silt loam, and sandy clay loam. Fine texture is United States Department of Agriculture classifications clay loam, silty clay loam, sandy clay, silty clay, and clay.

Specific oxygen uptake rate (SOUR). *Specific oxygen uptake rate (SOUR)* means the mass of oxygen consumed per unit time per unit mass of total solids (dry weight basis) in the biosolids.

Surface waters. *Surface waters* means waters of the state including streams, lakes, ponds, marshes, watercourses, waterways, springs, reservoirs, and all other bodies or accumulations of water, natural or artificial, public or private, which are contained within, flow through, or border upon the state.

Total solids. *Total solids* means the materials in biosolids that remain as residue when the biosolids are dried at 103 to 105 degrees Celsius.

Treatment works. *Treatment works* means either a federally owned, publicly owned, or privately owned device or system used to treat, recycle, or reclaim either domestic sewage or a combination of domestic sewage and industrial waste of a liquid nature. This includes a septage treatment or septage storage facility that receives domestic septage from multiple sources. For the purpose of Minnesota biosolids regulations, a treatment works does not include septic tanks unless they are part of a wastewater treatment facility operated by a municipality or sanitary district that is required by the MPCA to have a NPDES or SDS permit.

Type IV certified operator or inspector. *Type IV certified operator or inspector* means a person certified according to chapter 7048 for the land application of biosolids or the inspection of biosolids land application sites.

Unstabilized solids. *Unstabilized solids* means organic materials in biosolids that have not been treated in either an aerobic or anaerobic biosolids treatment process.

Vector attraction. *Vector attraction* means the characteristic of biosolids that attracts rodents, flies, mosquitoes, or other organisms capable of transporting infectious agents.

Volatile solids. *Volatile solids* means the amount of the total solids in biosolids lost when biosolids are combusted at 550 degrees Celsius in the presence of excess air.

Wetland. *Wetland* means those areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. Constructed wetlands designed for wastewater treatment are not waters of the state. Wetlands must:

A. have a predominance of hydric soils;
B. be inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support a prevalence of hydrophytic vegetation typically adapted for life in a saturated soil condition; and
C. under normal circumstances, support a prevalence of such vegetation.

History of biosolids regulations

1979: 40 CFR, Part 257

The U.S. Environmental Protection Agency (EPA) adopted the first comprehensive regulation governing the use and disposal of biosolids on September 21, 1979. This regulation was 40 CFR Part 257. It primarily regulated biosolids treatment, soil pH, soil cation exchange capacity, cadmium loadings and PCB concentrations. Biosolids treatment was one of two types:

- Processes to significantly reduce pathogens (PSRP)
- Processes to further reduce pathogens (PFRP)

1982: MN Rules Chapter 7040

The State of Minnesota has regulated the management of biosolids since 1982. On May 18, 1982, the Sewage Sludge Management Rules (MN Rules Chapter 7040) were promulgated. The biosolids operations regulated by these rules were only those of municipalities or political subdivisions. Private or other governmental (state and federal) biosolids producers were not regulated by these rules. The rules regulated the following regarding biosolids at landspreading sites and facilities: pathogen reduction, analysis, storage, record-keeping and application. All land application areas required approval by the Minnesota Pollution Control Agency (MPCA) prior to land application.

Landspreading facilities were application areas that were owned, leased or rented by the political subdivision that generated the biosolids. Landspreading facilities were required to have a permit from the MPCA to operate. Landspreading sites were privately owned application areas, generally owned by farmers. A Letter of Approval, instead of a permit, was required to operate landspreading sites. Requirements for facilities and sites were different. Both facilities and sites were approved for five years, and the approval could be renewed.

1982: MN Rules Chapter 7048

In 1982, the State of Minnesota adopted MN Rules Chapter 7048 for certifying Types I through V waste disposal facility operators and inspectors. These rules establish criteria for skill, knowledge and experience necessary for certification. Biosolids operators, inspectors and those who apply other industrial by-products and solids wastes to land are classified as Type IV. These individuals must meet all of these conditions:

- Must have a high school diploma or equivalent
- Receive training from the MPCA
- Have at least six months of experience (operators) or have inspected ten facilities (inspectors)
- Have received a passing score on an MPCA exam
- To maintain certification, Type IV operators and inspectors must receive at least nine contact hours of additional training every three years.

The MPCA has trained and certified more than 1,000 Type IV operators and inspectors since 1982. Along with their other duties, these individuals are responsible for the safe and beneficial recycling of biosolids by approximately 200 wastewater treatment facilities in Minnesota. In addition, they manage residual by-products from some industries. MPCA's biosolids regulatory and operator training and certification programs have been used as models around the country.

1993: 40 CFR Part 503

The next major regulation for the use and disposal of biosolids was 40 CFR Part 503, promulgated by the EPA on February 19, 1993. This regulation replaces 40 CFR Part 257. Biosolids generated by all public and private treatment works, as well as domestic septage, are covered by 40 CFR Part 503. Industrial by-products are ***not*** regulated by 40 CFR Part 503.

40 CFR Part 503 is the most comprehensive and scientifically supported regulation ever written by the EPA. It contains requirements for all major methods of using and disposing of biosolids, including land application, incineration and surface disposal (that is, landfilling and using lagoons). For land application, 40 CFR Part 503 provides general requirements, pollutant limits, management practices, operational standards, monitoring frequencies, recordkeeping and reporting criteria for those who prepare and apply biosolids.

1997: MN Rules Chapter 7041

Because EPA adopted 40 CFR Part 503, the MPCA felt that it would be in the regulated community's best interest to repeal MN Rules Chapter 7040 and draft a new rule to incorporate parts of 40 CFR Part 503. By doing this, biosolids land application operations in Minnesota would only have to follow one rule. Consequently, MN Rules Chapter 7041 was adopted on May 19, 1997.

Minnesota Rules Chapter 7041 is comprehensive. It combines new requirements, previous Chapter 7040 requirements, and all 40 CFR Part 503 requirements for land applying public and private biosolids. MN Rules Chapter 7041does the following:

Provides requirements for the land application of biosolids and septage produced by a municipality or political subdivision

- Regulates the pathogen and vector attraction treatment standards and chemical monitoring of biosolids that are to be land applied
- Establishes 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
- **Does not** establish regulatory criteria for domestic septage from private individual septic tanks or industrial by-products that are applied to land.
- **Does not** regulate surface disposal, incineration or landfilling of biosolids, unlike 40 CFR Part 503

Notable differences between MN Rules Chapter 7041 (1997) and the previous MN Rules Chapter 7040 (1982) are:

1 The *landspreading facility* category of land no longer exists. All requirements for recycling biosolids on land are the same regardless of land ownership.

2 Sites are approved indefinitely, whereas in the past, a site had to be reapproved every five years. Sites would only have to be reapproved if the site acreage changed.

3 Chapter 7041 has a new classification for biosolids called *exceptional quality* or *EQ*. EQ biosolids are those that are pathogen-free, have low odor potential (vector attraction) and have low metal concentrations. The concept for this category of biosolids is to emphasize the regulation of its processing and quality. If the biosolids meet these processing and quality requirements, using this product can be more or less unrestricted, similar to using other high quality soil amendments and fertilizers.

4 As in Chapter 7040, Chapter 7041 limits the cumulative amount of trace metals that can be applied to land. However, the limits have changed in Chapter 7041 to coincide with 40 CFR Part 503 and soil cation exchange capacity is no longer used to determine cumulative loading limit categories. Additional metals are also regulated.

5 Chapter 7041 limits the maximum concentration of trace metals in biosolids above which land application is not allowed (i.e., ceiling limits). Chapter 7040 did not have such a limit.

6 A new category of soil types — highly permeable soils — may receive biosolids under Chapter 7041. These coarse-textured, highly permeable soils can now receive the benefit of an organic soil amendment and a slow-release nitrogen supply, under certain restrictive management conditions.

7 Chapter 7041 has reduced the minimum soil pH to 5.5 for sites receiving biosolids. The new soil pH limit applies to all land under Chapter 7041, whereas the minimum pH requirement of 6.5 under previous Chapter 7040 applied only to land used for food-chain crops.

8 An applier can now apply biosolids to non-agricultural land, such as a reclamation site (see 7041.0800 subpart 5) without necessarily meeting all the land application criteria for agricultural sites (e.g., slopes, soils, setbacks).

Type IV operators and inspectors, as well as those who prepare and apply biosolids, should become familiar with the rules — this manual does not address every aspect of the rules. See Appendix A for a copy of MN Rules Chapter 7041.

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Chapter

1

Achieving

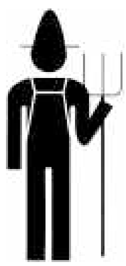
Good Public Relations

As one can imagine, biosolids recycling programs have been plagued with negative criticism and poor public acceptance since day one. We believe this is partially true because Americans are offended by human waste. This conditioning was initiated at an early age and remains with us. The average citizen does not realize that biosolids is no more human waste than gasoline is crude oil. In addition to the human waste stigma, many people believe that industries are unregulated and that sewers are a convenient repository for all kinds of toxic industrial waste.

Most people in the biosolids recycling industry realize that it makes no difference how well we know the rules and regulations or how good our compliance is with these rules if our recycling program isn't well accepted by the public. With poor public acceptance, we cannot entice landowners to enroll in biosolids recycling programs. In addition, we constantly react to hostile neighbors, public officials and even environmental organizations when the public has this mindset. Establishing and maintaining an acceptable public image is half of the responsibilities for those of us who run a successful biosolids recycling program. The other half is knowing and following rules and regulations.

There are two aspects to public relations, and they are intertwined. One aspect is to gain acceptance from potential biosolids users, generally farmers. The other aspect is to satisfy the concerns of the public, which includes the farmers' neighbors, township boards and county officers. This chapter provides suggestions on how to address concerns of all involved.

How to find cooperative landowners



In Minnesota, biosolids are recycled on agricultural land, forest land and reclamation sites. By far the most common biosolids users in Minnesota are farmers. Consequently, this section will concentrate on enticing farmers to use biosolids.

1 **Learn the agricultural benefits of biosolids.** Before you make any contacts with farmers, we recommend that you prepare a table that lists the pounds per acre and monetary value of the nitrogen, phosphorus and potassium that your typical biosolids application provides. You may also want to include in this list some of the micronutrients (for example, copper and zinc) and lime, if applicable. Table 1 is an example of such a list.

Table 1

Financial value of biosolids

Nutrient	Amount applied	Cost*	Benefit/acre
nitrogen	100 lbs/acre	$0.25/lb	$25.00
phosphorus	150 lbs/acre	$0.20/lb	$30.00
potassium	30 lbs/acre	$0.15/lb	$ 4.50
copper	5 lbs/acre	$2.00/lb	$10.00
zinc	4 lbs/acre	$1.25/lb	$5.00
lime	2 tons/acre	$10/ton	$20.00
Total value			$94.50

**Local fertilizer suppliers can give current costs.*

In addition to the nutrient value, it is important to stress that much of the nitrogen applied is in the organic form, which is slow-release. This form of nitrogen feeds the crop throughout the growing season and supplies nitrogen for several years to come. Also, other nutrients are supplied, such as sulfur, iron, magnesium, manganese, and calcium. Don't forget to talk about the organic matter provided by the biosolids application. Organic matter is extremely important in maintaining soil tilth, improving water-holding capacity, reducing runoff, and preventing erosion.

2 **Develop a brochure or information sheet.** Several biosolids facilities in Minnesota have produced their own brochures. Something as simple as an 8.5 x 11 inch color sheet folded into three sections is usually adequate. Keep the language simple and upbeat, do not use jargon or unfamiliar acronyms, dwell on the positives and not the negatives, and do not try to cram too much information into the brochure.

Once you have calculated the nutrient value of a typical application of biosolids as explained in the previous section, you have a terrific start on an educational brochure or information sheet. Besides the nutrient value of your biosolids, this informational piece can include one or more of the additional ideas below:

- ❑ Description of your biosolids treatment process which stresses pathogen destruction and reduction in odor potential.
- ❑ Description of your application equipment and whether you surface-apply or inject biosolids. Injection is a big plus to the farmer because not only does he receive the nutrients from the biosolids but he also gets a tillage operation.
- ❑ Description of your pretreatment program that stresses industrial regulation, which results in reducing metal concentrations in your biosolids.
- ❑ List of farmers and their telephone numbers who have used your biosolids and have agreed to act as references.
- ❑ Analysis of metals in your biosolids compared to analysis in soil, other fertilizers or the EPA "Clean Limits." Alternately, you may want to compare your annual metal loading to the cumulative loading limits and stress that it would take X years of continuous application to meet a limit.
- ❑ You may want to summarize the MPCA rules, including setbacks, slopes, soils criteria, allowable crop types, waiting periods and approval process.
- ❑ Remember to include your facility's name, address, and telephone number.

3 **Ask agricultural extension for help**. The Minnesota Cooperative Extension Service has been very valuable to biosolids programs over the years. The agricultural extension service can put you in touch with potential cooperating farmers. Also, the extension service can help you organize farmer field days and demonstration plots (discussed next).

4 **Advertise roadside demonstration plots**. We have all seen seed variety trial plots as we travel down rural roads and highways. These plots:

- **Educate** farmers as to which crop varieties do best in their area, and
- **Advertise** the name of seed companies.

Biosolids operators can use the same technique to educate the public and advertise their local biosolids program. Plots can be set up at low cost with the assistance of agricultural extension or a local crop consultant together with a cooperating landowner. We suggest you:

- ❑ Make sure the plots are adjacent to well-traveled roads.
- ❑ Display attractive informational signs.
- ❑ Always have a control (no fertilizer, no biosolids) plot. Sometimes agricultural extension is more cooperative if you offer to pay them to collect yield information at the end of the season.
- ❑ If you compare biosolids to fertilizer plots, make sure you have a sign showing cost per acre of fertilizer for both plots.

5 **Take part in Farmer Field Days.** Other techniques used in agriculture to educate and promote interest are *Farmer Field Days* and summer farm tours. These types of activities are usually organized by the agricultural extension service or by local agribusinesses. Probably the easiest way to take part in one of these activities is to request to be included through the agricultural extension service. If a tour is taking place, one of the stops could be one of your demonstration plots or a field that is receiving or has received biosolids. You can be either a speaker or, if you have a set of demonstration plots, a sponsor.

Sometimes an entire field day can be devoted to your demonstration plots. If you choose to do this, we recommend that you have on hand a land application machine, brochures and refreshments. We also recommend that you line up several speakers. Possible speakers include:

- ❑ Yourself
- ❑ The county extension agent
- ❑ Natural Resource Conservation Service (NRCS) staff
- ❑ University of Minnesota (U of M) staff
- ❑ MPCA staff
- ❑ Central States biosolids spokesperson
- ❑ Cooperating farmers

If you do not have demonstration plots, you may want to sponsor a tour of a wastewater treatment plant and focus on biosolids recycling.

If you are organizing a farmer field day or plant tour, you will need to advertise it. We suggest you:

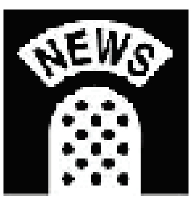
- ❑ Develop a mailing list of farmers — get help from agricultural extension service
- ❑ Place newspaper advertisements
- ❑ Place radio announcements
- ❑ Invite local media to your event. Before the event, you may want to discuss with the media what you are trying to accomplish. You can even write a short press release for them to publish or announce as a news item.

How your program can gain public acceptance

In this section, the *public* refers to neighbors to land application sites and can include farmers, township board members, local environmental groups and county officials (i.e. planning and zoning officers and environmental managers). Public acceptance goes hand in hand with public education. In other words, once someone is educated or informed of biosolids recycling, that person's acceptance of the practice usually comes naturally. However, there are always some that are persuaded more by an emotional and sensational argument than by scientific facts. What was it that Jack Nicholson shouted in the movie, *A Few Good Men*? —"You can't handle the truth!" Some people just don't want to believe, regardless of facts, that biosolids recycling is beneficial.

One can establish public acceptance in many ways. Many of the items discussed in the previous section regarding obtaining farmer cooperators can be used for educating the public. The following paragraphs offer a few more suggestions:

Press releases and media invitations



The local media, whether newspaper or radio, are always looking for interesting items to write or broadcast. Biosolids managers have periodically contacted the local media and asked if they would be interested in doing a story. Many times they are. It is suggested that you couch your request with a positive tone. Discuss with the reporter the benefits to the farmer and to the city. Make a big deal that this is just another way of recycling — just like cans, bottles and newspaper recycling.

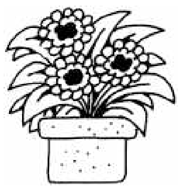
Sometimes the local media is extremely busy and short staffed, in which case we recommend that you write the press release. Many times the press release is copied verbatim in the newspaper as a regular news story. Send along some pictures of your spreading equipment in action with the press release. Always include your name and phone number for further information.

Public presentations and exhibits

Many opportunities occur throughout the year that lend themselves to educating the public about biosolids recycling. Some of these include:

- ❑ City or county fairs
- ❑ Environmental events (Earth Day Celebrations)
- ❑ School science fairs
- ❑ Classroom presentations
- ❑ Wastewater treatment plant tours
- ❑ City/Farm Days, etc.

The events suggested above offer opportunities where you can set the stage. You may want to borrow the *Biosolids Recycling Display* from the Minnesota Section of the Central States Water Environment Association (CSWEA)/Minnesota Wastewater Operators Association (MWOA) Joint Biosolids Committee. This lighted, table top display contains many informative pictures, pamphlets and a video pertaining to biosolids recycling. The only cost for the display is shipping.



Another idea is to have samples of crops grown with your biosolids, such as ears of corn or miniature wheat sheaths. If you prepare ahead of time, one could dry some Class B biosolids in a drying oven to pasteurize it, and then use it to grow flowers to put on display. The same biosolids could be used in classroom presentations where the students plant flowers in pots containing the biosolids. If you do not want to go through the mess of making a batch of pasteurized biosolids you can use Milorganite. Milorganite is available at most nurseries and garden centers.

Creativity is the key. The more appealing you can make the display, the more attention it will attract. If the event is outside, you might want to consider cleaning up the spreader and putting that on display. Why not drive the spreader with an informative sign on it during the city parade?

Public information meetings

Generally, public information meetings are given when there is a conflict. However, this is not to say that a public information meeting should not be conducted when things are going smooth. In fact, many biosolids managers make it a matter of routine to meet with and provide information to the public whenever they move into an area where they have not worked before. It is also recommended that you visit with the township board where you do your land application. The board may request that you provide a presentation at an upcoming meeting.

If you are not comfortable in giving a presentation at a public information meeting there are other options. Requesting the *Biosolids Recycling Display* or the *Biosolids Recycling Video* (see *Resources* at the end of this chapter) may help you. Perhaps someone from the MPCA, U of M or agriculture extension service can help you. You could also ask the regional Water Environment Federation (WEF) biosolids spokesperson for help. At the township level, a formal presentation is not normally necessary. Experience has shown that people simply want some questions answered.

Biosolids recycling messages

Whether you write a press release, conduct a public information meeting or exhibit a display at a public event, there are four main messages you should try to get across. These are:

message 1 Biosolids recycling is beneficial. The product supplies macro- and micro-nutrients, organic matter, and sometimes lime. The nutrients are slow-release that "spoon-feed" the crops throughout several growing seasons. The nitrogen in biosolids is less likely to leach to ground water compared to commercial forms of nitrogen fertilizer.

Biosolids application to land is also beneficial because it is a form of recycling. Instead of the normal glass, metal, and paper recycling, biosolids application recycles nutrients. Since nutrients are the Number One cause of ground and surface water pollution, the recycling of nutrients should lessen these problems by reducing the total quantity of nutrients put into the environment. Biosolids recycling also promotes sustainable agriculture and replenishes that which is taken out of the soil.

message 2 Biosolids recycling is not something new. In Minnesota, biosolids application has been conducted since the early 1940s. The City of Milwaukee, Wisconsin has dried and bagged biosolids for over 60 years. Their product, called Milorganite, can be bought in almost any garden center or nursery. Almost every golf course in the nation has used Milorganite.

message 3 Biosolids recycling is common. More than 98% of the mechanical wastewater treatment plants in Minnesota practice biosolids recycling. This amounts to more than 200 Minnesota cities and sanitary districts. Nationwide, biosolids recycling is the most common method of biosolids management.

message 4 Biosolids recycling is safe. The EPA regulations on biosolids recycling are supported by more than 20 years of study and research and are the most comprehensive regulations ever promulgated by that agency. In Minnesota, the University of Minnesota has investigated the continuous use of biosolids to the same parcel of land for more than 20 years. The research has concluded that applying biosolids to land is safe, if properly managed, and crop yields consistently meet or exceed those of commercial fertilizers.

Martha Prothro, former Deputy Administrator for Water, EPA, is quoted as saying, "In fact, in all the years that properly treated biosolids have been applied to the land, we have been unable to find one documented case of illness or disease that resulted."

The safety of biosolids recycling is further enhanced by strict enforcement of industries connected to our sewers through pretreatment programs. In addition, the frequent monitoring of biosolids ensures that only a quality product is recycled on land.

Suggested *Do's* and *Don'ts* for public acceptance

1. Be proactive! Do not wait for a conflict to start a public acceptance campaign — by then it's too late. The only public acceptance campaigns that really work start when everything is going along fine.

2. In real estate, it's "Location, Location, Location." In biosolids recycling, it's "Perception, Perception, Perception." Or as someone has said, "Perception is reality." Be the first to mold the public's perception of biosolids recycling. Do not let someone else be the first to educate the public on biosolids recycling. This someone else is usually a misguided and misinformed individual that portrays biosolids recycling in a negative light. Be proactive!

3. Stop using the word *sludge*. Use the word *biosolids*, or better yet, come up with a name for your biosolids.

4. Stop using the words *dump* and *dispose*. Use words like *land apply*, *beneficial use* and *recycle*.

5. Accentuate the positives — nutrients, organic matter, recycling. Do not dwell on, but be fully aware of and acknowledge the negatives like metals and pathogens. It is best to bring up these issues first and address them quickly and simply.

6. Keep it Short and Simple — *KISS*." Short, concise answers are usually the best. Do not use jargon, fancy words or acronyms. National evening news broadcasts report at a seventh grade (12 year old) level. So should you.

7. You do not have to give complete detail; however you must be honest. If you do not know the answer, don't create one. Tell the person that you will find the answer and get back to him or her.

Dealing with conflict

Conflicts over the recycling of biosolids often arise, especially in locations where biosolids have not been recycled in the past. Sometimes people have legitimate complaints, such as odors, traffic, runoff, etc. You know what to do about these problems. However, often it's gossip or the fear of the unknown that starts a campaign against biosolids recycling. We must remember that the public is constantly bombarded with sensationalist news stories about contamination by something dumped on the land.

In Minnesota, several counties and townships have completely prohibited biosolids recycling. Others only allow biosolids generated within their borders to be applied to land within their jurisdiction. Still others allow biosolids recycling, but have ordinances that make it difficult or impossible with which to comply.

As mentioned earlier, a little proactive biosolids recycling education can circumvent the fear of the unknown. However, let's assume that a full-fledged conflict has arisen over your biosolids recycling program. What can you do?

- ❑ First, remember that it is very difficult to get people to change their minds, at least publicly, at this point. This is especially true for those who initiated the conflict in the first place. If possible, address their concerns by compromising on issues. This way both parties win.

- ❑ Often at public meetings, one or two very vocal or hostile individuals show up — try to isolate these people and talk with them separately. During the meeting, address the concerns of the average attendee.
- ❑ Ask experts for help. Call the MPCA or the regional WEF biosolids spokesperson for help.
- ❑ Communicate with small groups. Small group settings are a little more comfortable and less likely to get out of hand.
- ❑ Be prepared. Find out what the issues are ahead of time and determine the best answers. In Appendix B are fact sheets prepared by the Rocky Mountain Water Environment Association that address most of the common concerns associated with biosolids recycling.
- ❑ Suggest that an advisory committee be formed. This committee’s charge would be to research biosolids recycling and report back to the group (i.e., township, county, etc.). The advisory committee should be made up of local environmental/agricultural representatives, such as the regional MPCA, Department of Natural Resources, extension service and NRCS. Also, try to get the "hostile" individual on the committee. Often, this person will now see the problem as his problem and become an advocate rather than an opponent.
- ❑ Go slowly with townships or counties that have banned biosolids recycling. Be satisfied if you can get your foot in the door. Suggest that you develop a single demonstration site. This demonstration site could be operated with the agriculture extension service and the advisory committee suggested previously. The purpose of the site is "to prove yourself and your program," as well as the benefits and safety of biosolids recycling.
- ❑ When the biosolids are to be applied to the demonstration site, invite all of the concerned citizens and officials to the event. Make it similar to a Farmer Field Day (discussed previously). If necessary, have the agriculture extension service or other unbiased agency collect soil, water and yield samples at the demonstration site before biosolids application and then again after harvest. Discuss the results of the demonstration with the governing body, and assuming things were successful, request that you be allowed to apply biosolids on a few more sites. A slow progression from one demonstration site the first year, then maybe two or three sites the second year, and finally *carte blanche* the third or fourth year has worked for other biosolids managers. Townships and counties are sometimes afraid of handing over what they perceive as total control too quickly.

Resources

Pamphlets

Biosolids Recycling: Beneficial Technology for a Better Environment (EPA 832-R-94-009), U.S. Environmental Protection Agency

Biosolids Recycling (HP 1403), Water Environment Federation

Biosolids Recycling: Beneficial Technology for a Better Environment (HS 1404), Water Environment Federation

Put Biosolids Recycling to Work in Your Classroom (HS 1505), Water Environment Federation

Biosolids Information Kits (ZM7406), Water Environment Federation

Video

Biosolids Recycling Video (ZV4400), Water Environment Federation

Books

Biosolids Public Acceptance Digest (P06101), Water Environment Federation

Beneficial Use Programs for Biosolids Management (P04117), Water Environment Federation

Document Long-Term Experience of Biosolids Land Application Programs (D0015), Water Environment Federation

Chapter

2 How Land Treatment Works

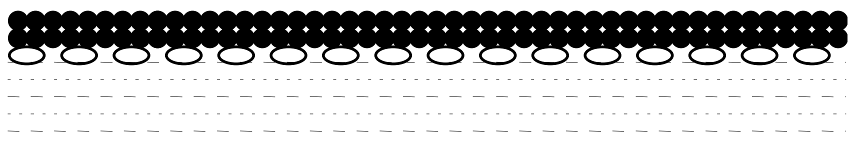
Soils, plants, microorganisms and other physical, chemical and biological elements of the environment form the treatment system for biosolids. The components of concern in biosolids are nitrogen, phosphorus, trace metals, pathogens and persistent organic compounds. As in a wastewater treatment plant, physical, chemical and biological processes break down these components.

Soil as a medium for physical processes

Soil acts as a filter for biosolids much the same way a bar screen filters wastewater in a wastewater treatment. Such filters remove the large wastewater contaminates, while small particles are allowed to pass through the filter. The soil is like a screen in that it physically filters particles and contaminates from land-applied biosolids.

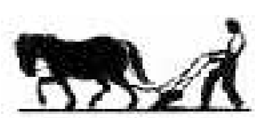
When biosolids are applied to the land, solid materials such as organic matter and certain pathogens (for example, helminth eggs) are filtered from the biosolids. As a result, these solids stay near the surface of the soil where other treatment processes can then occur.

Soil acts as a physical filter



Soil must have the appropriate texture and structure to physically filter biosolids well. Soil with a fine texture filters biosolids better than soil with a coarse texture.

The physical soil environment is a major factor in the die-off of pathogens in land-applied biosolids. Temperature extremes, moisture content of the soil and sunlight all help destroy pathogens. This is how it works. Most pathogens are attached to particles of organic matter in biosolids. When biosolids are applied to the land, the soil's texture and structure physically filter the particles of organic matter. Because of this filtering, the organic matter particles remain at or near the soil surface. The soil surface is where soil temperature and moisture content fluctuate to the extremes, and the UV rays from sunlight help kill pathogens.



If one considers a plowed black field, it is not hard to imagine how hot the surface can become on a sunny day. In addition, the first few inches of soil can become extremely dry in a short time. Conversely, in the winter, surface soils can become extremely cold. These temperature extremes and periodic dryness contribute to the die-off of pathogens from land-applied biosolids.

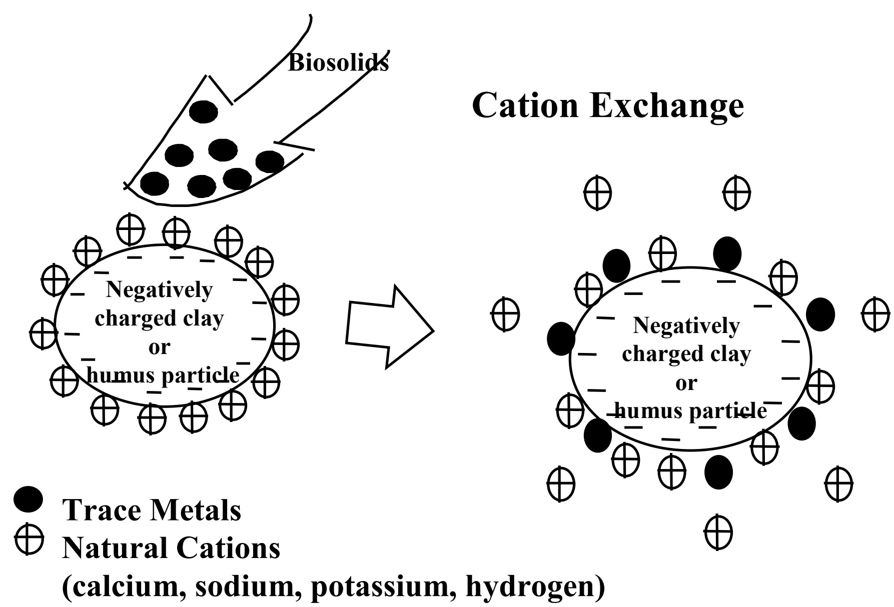
Soil as a medium for chemical processes

The soil system provides the medium upon which contaminates of biosolids are treated by chemical processes. There are several chemical processes that occur to filter out inorganic chemicals, persistent organic compounds and pathogens in biosolids. These processes are:

- Ion exchange
- Adsorption
- Precipitation
- Complexation.

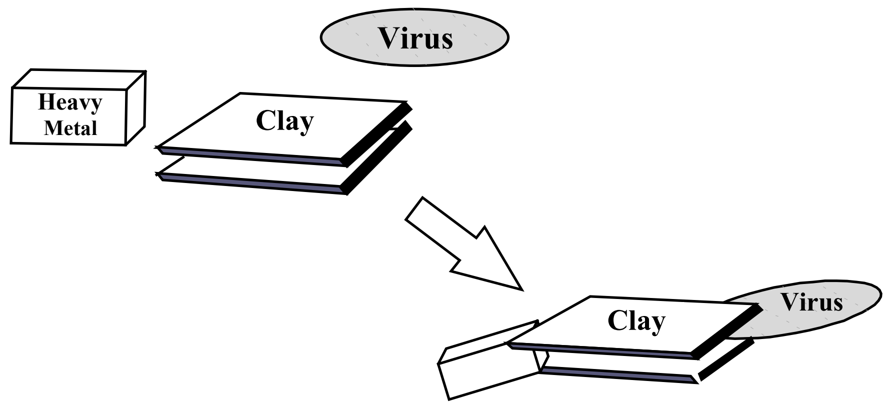
Ion exchange

Ion exchange is the transfer of dissolved ions between soil water and soil particles. The same process occurs in a water softener.



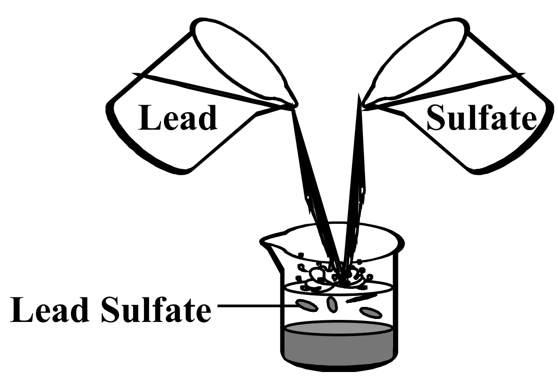
Adsorption

Adsorption is a non-reversible process where ions are bonded to soil minerals by chemical reactions. This process also occurs in a charcoal filter or activated carbon filter. Viruses are also adsorbed onto soil particles.



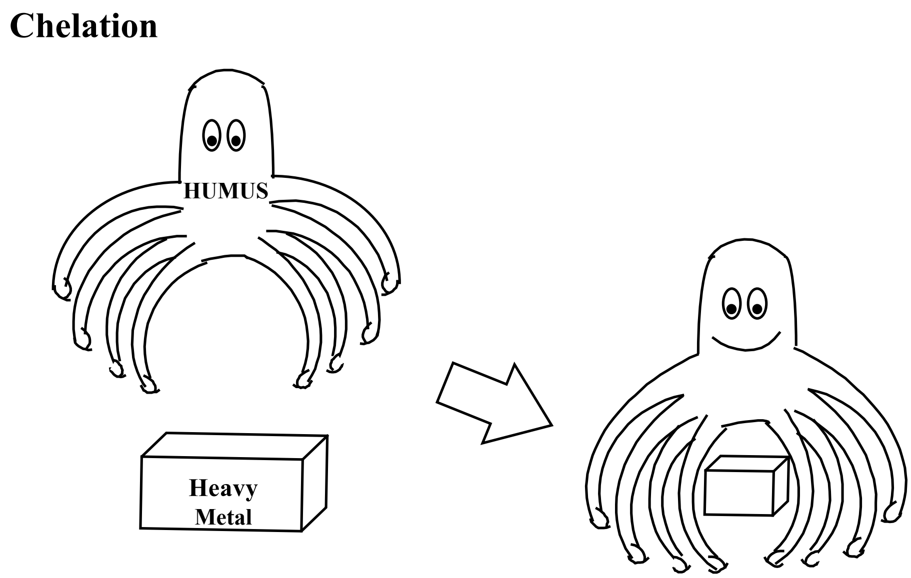
Precipitation

Precipitation is the formation of an insoluble solid from two or more soluble ions or compounds. An example in the wastewater industry is the addition of alum to wastewater to remove phosphate by precipitation. In soils, many compounds are present that can precipitate out contaminates such as trace metals. Soil minerals such as sulfates, sulfides, carbonates, phosphates and hydroxides can form relatively insoluble compounds with land-applied trace metals. The new compounds thus formed become part of the soil matrix.



Complexation or chelation

Complexation or chelation is the interaction of metals with reactive sites on soil humus. Soil humus is a very complex mixture of natural organic compounds. Humus is essentially the end-product of organic matter decomposition and is resistant to further break down. In this process, a metal ion binds with a humus compound to form a relatively insoluble complex. This complex is relatively resistant to decomposition and re-release of the metal into solution as an ion.



A soils' ability to act as a chemical filter depends on the soil texture, pH, organic matter (humus) content and presence of clay or hydrous oxides. Fine textured soils with a pH greater than 6.5 provide the most suitable chemical filter. The soil cation exchange capacity (CEC) is an index of a soils' ability to retain trace metals. At one time, CEC was used to determine the allowable amount of metal addition to a site.

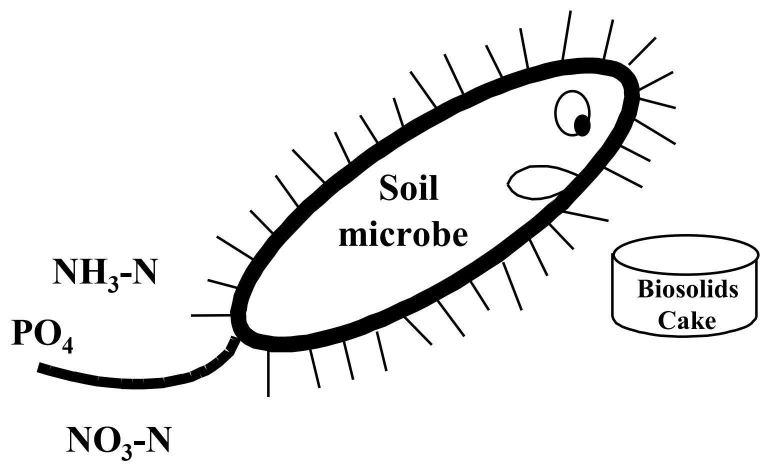
Soil as a medium for biological processes

The soil contains many living organisms that decompose or alter material placed on or in the soil. An estimated 8000 pounds of microorganisms per acre live in the top six inches of soil. These microorganisms act to alter components in biosolids by:

- Mineralization
- Immobilization
- Elimination

Mineralization

Mineralization is converting an element from an organic form to an inorganic form. An example of mineralization is the conversion of organic nitrogen in biosolids to ammonia and nitrate, which are inorganic.

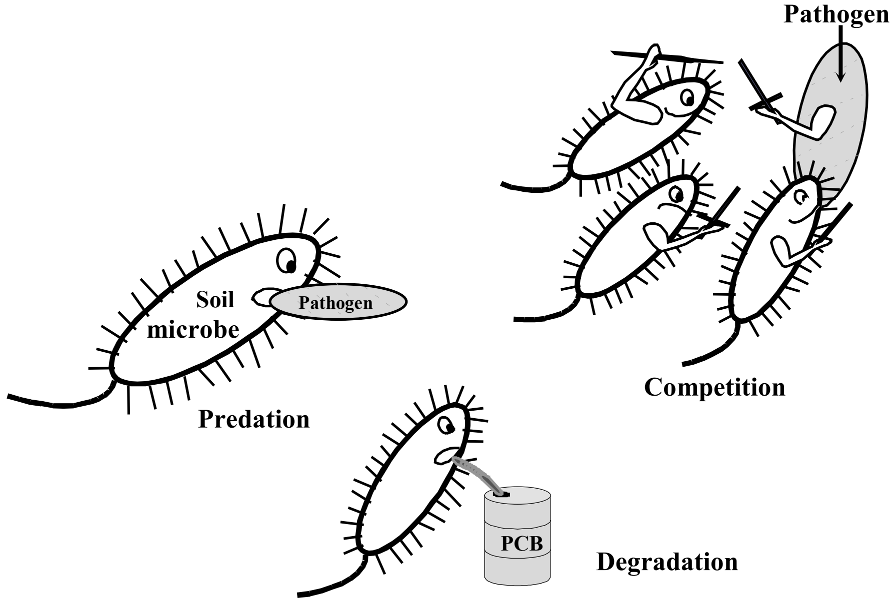


Immobilization

Immobilization is converting elements from an inorganic form to an organic form (plant or microbial tissue). Crop uptake of nutrients is an example of immobilization.

Elimination

Elimination is destroying or altering pathogens or organic compounds by soil microorganisms by predation, competition and degradation.



What happens to the components of concern in biosolids in the land treatment system?

Nitrogen is:

- Mineralized — converted from an organic state, such as protein, to an inorganic state such as nitrate
- Immobilized — converted from nitrate or ammonia to plant or microbial tissue (inorganic to organic)
- Volatilized — ammonia nitrogen in land-applied biosolids can be volatilized into the atmosphere during and soon after application.
- Denitrified — converted from nitrate to gaseous nitrogen forms that volatilize

Phosphorus is:

- Precipitated by soil minerals
- Adsorbed by clays and hydrous oxides
- Taken up by plants
- Immobilized or mineralized by soil microorganisms

Trace metals are:

- Used by plants as essential elements in plant growth
- Held by complexation with soil humus
- Adsorbed by clays and soil minerals
- Precipitated by soil minerals

Pathogens are:

- Consumed by soil microorganisms
- Adsorbed by clays
- Die from hot, cold, wet or dry soil conditions
- Trapped by soil organic matter
- Destroyed by ultraviolet sunlight exposure

Persistent organic compounds are:

- Broken down by soil microorganisms and ultraviolet light
- Chemically decomposed
- Adsorbed by clays and soil organic matter
- Volatilized

Summary

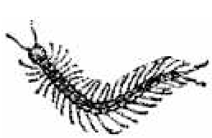
Some soil and crop types will perform as treatment systems for biosolids better than others. Each system has a different treatment capacity. Operators must evaluate that capacity before making management decisions. The following chapters tell you how to evaluate a site to determine if it's suitable as a land treatment system.

Chapter 3

Reducing Pathogens

Pathogens are organisms that can produce an infection or disease in a susceptible host. For disease to occur, the disease-causing organism must find a susceptible host. The spread of disease is like a chain — disease is prevented if a link in the chain is eliminated or broken. Biosolids regulations address each link in the chain below.

= **Disease**



The major types of pathogens in municipal wastewater are bacteria, viruses, protozoa, and helminths (parasitic worms). For a detailed list of the main pathogens of concern in municipal wastewater and biosolids, see Appendix C. This list includes survival times of pathogens in soil and on plant surfaces.

Why reduce or eliminate pathogens?

Reducing or eliminating pathogens in biosolids is the first step in weakening or breaking the disease chain. Requirements to reduce pathogens strive to protect public health and the environment by preventing the spread of disease.

Pathogens in wastewater are primarily associated with the solid fraction of wastewater. This means that these solids may have much higher pathogen densities than incoming wastewater, even after biological wastewater treatment.

How do we reduce or eliminate pathogens to prevent disease?

To meet this goal, biosolids must be treated to meet either Class A or Class B pathogen reduction requirements.

Type	Goal of treating for pathogens	Must fulfill these standards:
Class A biosolids	Treat biosolids until they are virtually pathogen free.	• Class A pathogen reduction requirements • At the time of use, test to show that no bacteria have regrown
Class B biosolids	Treat biosolids so that they contain reduced numbers of pathogens, but are not necessarily free of pathogens.	• Class B pathogen reduction requirements, and • certain site restrictions

For Class A biosolids, eliminating pathogens prevents disease. This is not the case with Class B biosolids. To help prevent the spread of disease from Class B biosolids that have been applied to the land, operators must not only meet Class B pathogen reduction requirements, but they must also take some specific precautions (site restrictions) at the application site. One would want to combine treatment processes and site restrictions for Class B biosolids to:

- **Reduce** the number of **pathogens** through treatment processes
- Reduce the **transport** of pathogens
- Limit the **exposure** of humans, animals and crops to pathogens

Transport of pathogens

Animals, such as rodents, insects, or birds, may transport biosolids off the site to which they were applied. This is called transport by **vectors**. To reduce the likelihood of this occurring, biosolids must be treated so that **vectors** are less attracted to the biosolids, or ideally, are no longer attracted to the biosolids. This requirement is discussed in Chapter 4.

In addition, if operators follow the requirements for suitable soils, slopes, hydraulic loading limits and separation distances when applying biosolids, pathogens are less likely to be carried off the site.

Exposure to pathogens

Complying with site restrictions can reduce or eliminate exposure to pathogens. Some examples of how people and animals can become exposed to pathogens are:

Direct exposure:

- Walking through an area shortly after biosolids have been applied
- Handling soil or raw produce from the field
- Inhaling airborne microbes

Indirect exposure:

- Consuming crops or food that have been contaminated by pathogens
- Ingesting drinking water or recreational waters contaminated by runoff from land-applied biosolids

Site restrictions are necessary to allow time for the pathogens to die-off through the natural soil treatment processes discussed in Chapter 2. To review, these soil treatment processes reduce pathogens by allowing the pathogens to be consumed by microorganisms, become attached to soil, and die from being exposed to severe weather conditions (hot and cold, wet and dry) and ultraviolet light.

Some site restrictions are time-dependent. For example, humans and animals are restricted from the site for a certain amount of time after biosolids are applied. In addition, time restrictions apply to the types of crops that may be grown and to harvest dates. Site restrictions are discussed in Chapters 9 and 11.

MN Rules Chapter 7041: Pathogen reduction

📖 Biosolids applied to the land must meet one of the following:

- Class A pathogen reduction requirements
- Class B pathogen reduction requirements ***plus*** site restrictions

📖 Biosolids applied to a lawn or home garden or sold or given away in a bag or other container must meet Class A pathogen reduction requirements.

Pathogen reduction for septage regulated under MN Rules Chapter 7041

See Chapter 14.

Treatment Standards — Class A Biosolids

(always required for biosolids applied to a lawn or home garden, or sold or given away in a bag or other container)

What treatment processes could I use?

The treatment standard for Class A biosolids is to eliminate pathogens (technically, the level of pathogens must be reduced to below detectable limits). When pathogens are eliminated, the first link of the disease chain **- pathogens -** is gone, thereby preventing disease. Because of this, Class A biosolids can be used in areas where humans come into direct contact with the material, such as on a lawn or garden.
To meet the Class A treatment standards, biosolids must meet **both** of these requirements:

1 **Choose one of these alternatives** (see Appendix C for detailed descriptions.

- ❑ Alternative 1: Thermal process
- ❑ Alternative 2: Thermal process plus high pH
- ❑ Alternative 3: Actual measurement of pathogens/treatment process
- ❑ Alternative 4: Actual measurement of pathogens/unknown process
- ❑ Alternative 5: A Process to Further Reduce Pathogens (PFRP)
- ❑ Alternative 6: A process equivalent to a PFRP

and…

2 **Test biosolids for pathogens or indicator organisms before applying to the land or putting into containers for distribution.** This is necessary because after biosolids are treated by one of the methods listed above, bacteria can grow back in the material. To meet this requirement, test for either fecal coliform or Salmonella sp. bacteria. The test must show that *either one* of these requirements is met:

- ❑ The density of Salmonella sp. bacteria is **less than 3 MPN (Most Probable Number) per 4 grams of total solids** (dry weight basis)
- ❑ The fecal coliform density is **less than 1,000 MPN (Most Probable Number) per gram of total solids** (dry weight basis)

Recordkeeping requirements

For recordkeeping requirements for Class A pathogen reduction alternatives, see Table18 in Chapter 13 and the corresponding discussion.

Treatment Standards — Class B Biosolids

What treatment processes could I use?

The treatment standard for Class B biosolids is to reduce pathogens levels significantly. To meet the Class B treatment standard, use one of the following treatment processes listed below or other method that reduces pathogens. Detailed descriptions of these alternatives are on the following pages.

Alternative 1: Fecal coliform testing

Alternative 2: A Process to Significantly Reduce Pathogens (PSRP)

Alternative 3: A process equivalent to a PSRP

Because the treatment standard does not require eliminating pathogens entirely, certain site restrictions apply to areas where Class B biosolids are applied. Chapters 9 and 11 discuss these site restrictions in detail. However, as a brief summary, the following restrictions can break the center link **— exposure —** in the chain of disease prevention at the site:

- ❑ Restrict public access
- ❑ Restrict animal grazing
- ❑ Restrict the types of crops grown
- ❑ Restrict the harvesting of crops

Recordkeeping requirements

For recordkeeping requirements for Class B pathogen reduction alternatives, see Table 19 in Chapter 13 and the corresponding discussion.

Alternative 1 for Class B Biosolids: Fecal coliform testing

For fecal coliform testing, analyze seven representative samples of the biosolids intended to be applied to the land. The fecal coliform density is expected to correlate with densities of viral and bacterial pathogens of biosolids that are treated biologically. The standard is:

The geometric mean of the fecal coliform density must be less than 2,000,000 MPN or CFU per gram dry weight of total solids.
However, in its guidance document, EPA states that the MPN dilution method for fecal coliform analysis is more appropriate than the membrane filtration test for CFU. Therefore, the EPA now recommends using the CFU test for fecal coliform analysis only after operators can demonstrate comparability between these two tests for the specific type of biosolids they generate.

1 **Collect 7 samples.** Multiple samples for each sampling event are required because the analytical methods are not precise and biosolids vary in quality. Using seven samples is expected to reduce the standard error to a reasonable level.

When sampling for fecal coliform bacteria, timing is very important. The EPA Pathogen Equivalency Committee recommends that the samples are collected and analyzed over a two-week period to reduce errors with single sampling events. However, this may not be necessary to get a representative sample. An example of this is a facility that has a storage tank filled with biosolids waiting to be applied. This storage tank receives no additional biosolids after it is sampled. The seven samples can be taken out of the tank at the same time because these samples represent the biosolids in the tank that are intended to be land-applied soon.

A more complicated example is when biosolids are taken from a process unit, such as a digester, and going directly to the field. In this case, the operator must determine sampling times and locations that represent these biosolids. Take samples at a time and location where all biosolids have been treated relatively equally. An example of this is an aerobic digester that receives feed solids daily and is operated in a batch type mode. This digester should be sampled before application over a longer timeframe, such as two weeks. In addition, the operator must consider the time it takes to get the analysis back from the laboratory. This planning is necessary to determine compliance with the Class B standards before land-applying the biosolids.

To determine if samples should be taken over a 2 week period or all at one time to best represent biosolids from either a storage tank or process unit, consider the questions below. These considerations can also help you decide the specific timing and location of taking samples.

- ❑ How well are the biosolids mixed? Do samples have to be taken from various depths or time intervals to represent the mixture from either a storage tank or digester?
- ❑ How consistent is the treatment process that precedes storage? Do the samples represent bisolids that have received the same level of treatment?
- ❑ What is the average operating performance of the treatment process chosen to reduce pathogens? How consistent are the influent characteristics: total and volatile solids content, pathogen densities, retention times and temperatures?

2 **Immediately after collection, cool samples to at least 4 degrees C, but do not freeze.**

3 **Analyze samples within 24 hours.** The operator responsible for sampling must be in contact with laboratory staff so that they know when the samples are expected to arrive (see Chapter 5 for details on sampling and analyzing biosolids).

4 **Calculate fecal coliform count.** To determine that the standard of less than 2,000,000 MPN or CFU is met, calculate the geometric mean of the results of the seven tests. To do this:

A. Take the log of each fecal coliform count

B. Average these log values

C. Take the antilog of the average log value

Example (using a calculator)

On the chart below, notice that the fecal coliform count can be expressed as a number (column A) or in scientific notation (column B).

1. For each sample, enter into the calculator the number from column A or column B and press the *log* key. This gives you the number for column C.

2. Add the numbers in column C and divide by 7 to get the log average. Round off the log average to two digits before running the final calculation (in the example, the log average is rounded off to 5.98).

3. To get the geometric mean of the 7 samples, do ***one*** of the following:

- Enter the log average and press the 10^x function.

or

- Press 10, press the Y^x key, and the log average number and press the equal key.

Example

How to calculate the geometric mean of 7 fecal coliform counts

Sample #	Fecal coliform count A	Fecal coliform count B	$\log_{10}$ C
1	1,000,000	1.0×10^6	6.00
2	90,000	9.0×10^4	4.95
3	2,400,000	2.4×10^6	6.38
4	2,000,000	2.0×10^6	6.30
5	3,500,000	3.5×10^6	6.54
6	100,000	1.0×10^5	5.00
7	5,000,000	5.0×10^6	6.70
			Average = 5.98

Geometric mean = $\mathbf{10^{5.98} = 955{,}000}$

Alternative 2 for Class B Biosolids: Processes to Significantly Reduce Pathogens (PSRP)

Processes to significantly reduce pathogens (PSRP) may be used to meet the requirements for Class B biosolids. The process descriptions are similar to those used in the past in both federal and state regulations. However, a PSRP process description now only applies to the requirements for pathogen reduction; it formerly included conditions related to reducing vector attraction as well (see Chapter 4 for standards to reduce vector attraction).

When done correctly, PSRP:

- ❑ Reduces fecal coliform densities to less than 2 million CFU or MPN per gram of total solids, and
- ❑ Reduces salmonellae and enteric viruses by an approximate factor of 10.

The PSRP processes include:

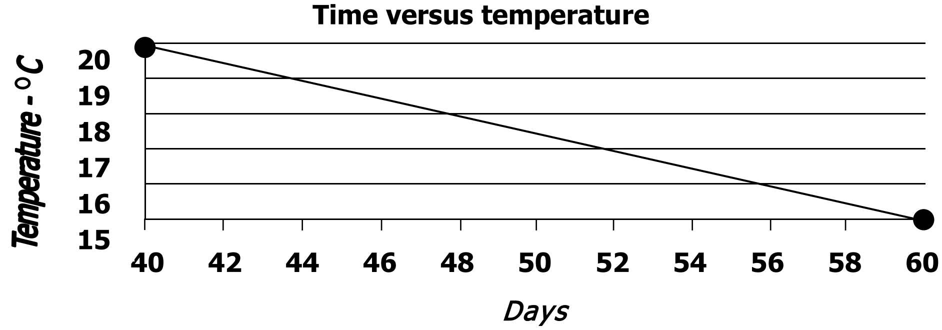
- Aerobic digestion
- Anaerobic digestion
- Lime stabilization
- Composting
- Air drying

Aerobic digestion

In aerobic digestion, biosolids are mixed with air or oxygen to maintain aerobic conditions for a specific mean cell residence time (solids retention time) at a specific temperature in the digesters. The mean cell residence time and temperature must be **between 40 days at 20° C (68° F) and 60 days at 15° C (59° F).**

Although the rule language requires aerobic digester operation "between" certain times for various temperatures, EPA currently has not defined the relationship between the two given end points. The equation presented in the EPA guidance manual is incorrect and to their knowledge, the relationship is not linear as it is for anaerobic digestion. However, until this is clarified, we will use the linear approach.

Former model of aerobic digestion — Time versus temperature



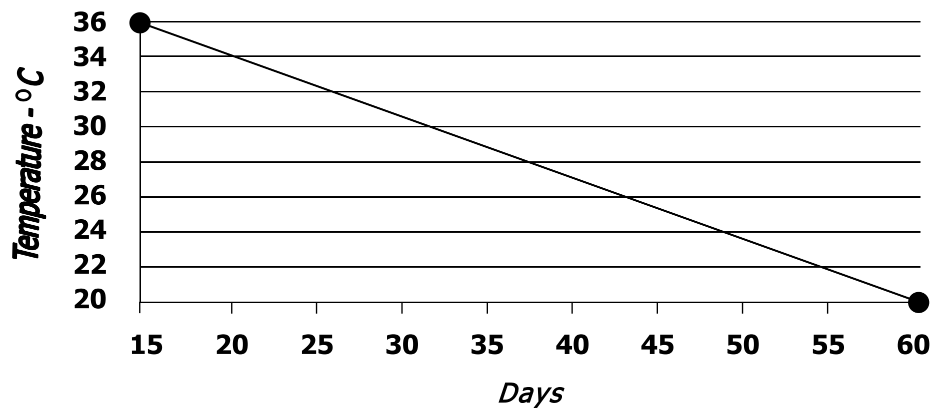
For further reference, process design sheets are in Appendix C.

Anaerobic digestion

In anaerobic digestion, biosolids are treated in the absence of air for a specific mean cell residence time (solids retention time) at a specific temperature. The mean cell residence time and temperature must be **between 15 days at 35° to 55° C (95° to 131° F) and 60 days at 20° C (68° F).**

The following graph shows the relationship between time and temperature and can be used to determine treatment conditions. For further reference, process design sheets for digestion are in Appendix C.

Model of anaerobic digestion — Time versus temperature



If either aerobic or anaerobic digestion is used to meet requirements for Class B pathogen reduction, the operator must do both of the following:

- ❑ Track the digester temperature
- ❑ Calculate the solids residence time **(SRT)** in the digester.

Solids Residence Time (SRT)

The **SRT** is the mean (average) cell residence time that the mass (or weight) of solids, not simply the liquid volume, is retained in the digester under digestion conditions (digestion conditions are defined by specific time, temperature and agitation requirements). SRT is always expressed in days. In its simplest form, the SRT is found by dividing the mass of biosolids in the digester by the average mass of biosolids entering or leaving the digester. The most simplified equation is:

$$\frac{\text{mass of biosolids in digester}}{\text{average mass of biosolids entering or leaving digester per day}} = \text{SRT (days)}$$

In this manual, mass is expressed as pounds. Mass is calculated by multiplying a volume (as gallons) by the percentage of total solids (expressed as a decimal) by 8.34 pounds per gallon (a gallon of biosolids weighs approximately 8.34 pounds). The unit of gallons cancels out when calculating mass and leaves the unit of pounds to represent mass:

$$\cancel{\text{gallons}} \times \begin{array}{c}\text{decimal}\\ \text{fraction for}\\ \text{\% total solids}\end{array} \times \frac{8.34\text{ lbs}}{\cancel{\text{gallon}}} = \begin{array}{c}\text{Mass}\\ \text{(pounds)}\end{array}$$

When you express mass in pounds, the equation for calculating SRT is expanded from the previous two equations to look like this:

$$\frac{\begin{array}{c}\text{Mass of biosolids}\\ \text{in digester}\end{array}}{\begin{array}{c}\text{Mass of biosolids}\\ \text{entering or}\\ \text{leaving digester}\\ \text{per day}\end{array}} = \frac{\begin{array}{c}\text{Volume}\\ \text{in digester}\\ \text{(gal)}\end{array} \times [\text{\% total solids x 8.34 lbs/gal}]}{\begin{array}{c}\text{Volume}\\ \text{entering or}\\ \text{leaving digester}\\ \text{(gal/day)}\end{array} \times [\text{\% total solids x 8.34 lbs/gal}]} = \begin{array}{c}\text{SRT}\\ \text{(days)}\end{array}$$

If the percentage of total solids in the digester is the same as that leaving the digester, this calculation is simplified because you don't need to multiply the gallons by the percentage of total solids or 8.34 pounds per gallon. This is the one case when you can simply divide the two volumes (instead of the mass) to find the SRT.

Calculating SRT in a digester is basically the same as calculating SRT in an activated sludge process.

How to use the worksheets to calculate SRT

Worksheets 1 and 2 on the next few pages can help you calculate SRT. You need to use only one worksheet — the one appropriate for the situation for which you are trying to calculate the SRT. The worksheets do not necessarily provide enough space for all the detailed records of inputs and outputs you may need for your situation. For example, Worksheet 2 has space for only 50 days.

The worksheets are:

Worksheet	Name & purpose
1	How to calculate the SRT for digesters operating under steady state conditions *(when the digester is always full and mixed and the volume of solids flowing into and out of the digester is equal)*
2	How to calculate the SRT for digesters operating under daily fill & batch withdrawal conditions

Before calculating SRT, consider grit accumulation

A digester may lose some of its volume because it accumulates grit. In calculations that use the volume of the digester, calculate and use the **actual volume used in the digestion process**. To find the correct digester volume, subtract the volume taken up by the grit from the total volume of the digester, as follows:

Total volume of digester (gal) ↓		Volume taken up by grit (gal) ↓		
☐	—	☐	=	☐ gallons **Volume of digester to use in calculations**

To find out if grit is accumulating, see *Is grit accumulating in your digester?* in Chapter 4*, Controlling Vector Attraction.*

The actual depth to or thickness of grit accumulation should be sounded using a long stick or pipe, if possible. The operator can also use the digester maintenance records to estimate the amount of grit accumulation over time.

How to calculate the SRT for digesters operating under steady state conditions

(when the digester is always full and mixed and the volume of solids flowing into and out of the digester is equal)

Background

Steady-state conditions in a mixed digester occur when the volumes of biosolids flowing into and out of the digester are equal. Volume can be used to calculate the SRT for a steady-state condition because the concentration of solids in the digester equals the concentration of solids leaving the digester. This occurs when the digester is full and mixed and the volumes added equal the volumes leaving the digester.

Equation for SRT

The equation for Solids Residence Time (SRT) for digesters operating under steady state conditions is:

$$\frac{\textbf{Volume of biosolids in digester (gal)}}{\textbf{Average volume of biosolids entering or leaving digester (gal/day)}} = \textbf{SRT (days)}$$

How to calculate SRT

Calculating the SRT is simplest when the digester is full and mixed. In this situation, the concentration of solids in the digester and concentration of solids leaving the digester should be the same. Simply divide the volume in the digester by the volume leaving the digester.

Volume of biosolids in digester → (gal) [ ]

Volume of biosolids leaving digester → (gal/day) [ ]

= [ ] **days**

SRT

Example

This example uses one primary and one secondary anaerobic digester. The primary digester is kept mixed and full so when solids are fed into it, the same amount flows to the secondary digester. Only the primary digester is heated.

Day	Gallons discharged
1	9,000
2	7,000
3	10,000
4	9,000
5	12,000
6	9,000
7	0

Average = 8,000 gal/day

Primary (heated) digester is kept at a constant volume of 250,000 gallons.

Volume of biosolids in digester → (gal) [250,000]

Volume of biosolids leaving digester → (gal/day) [8,000]

= [31] days

SRT

Month/Year ___________	**Digester volume** ________________			**Digester volume** ________________		
	Day	**Temperature**	**Volume in or out of digester (gals)**	**Day**	**Temperature**	**Volume in or out of digester (gals)**
	1			1		
	2			2		
	3			3		
	4			4		
	5			5		
	6			6		
	7			7		
	8			8		
	9			9		
	10			10		
	11			11		
	12			12		
	13			13		
	14			14		
	15			15		
	16			16		
	17			17		
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	36			36		
	37			37		
	38			38		
	39			39		
	40			40		
	41			41		
	42			42		
Add as	43			43		
many	44			44		
days	45			45		
as you	46			46		
need for	47			47		
your	48			48		
operating	49			49		
conditions	50			50		
		Total			**Total**	
		Average			**Average**	

How to calculate the SRT for digesters operating under daily fill & batch withdrawal conditions

Background

Calculating the SRT is slightly more complicated for **non steady-state** conditions, such as daily fill and batch withdrawal. For these situations, you must incorporate the retention time of mass that is added daily. (For simplicity, we left out multiplying the volume by 8.34 lbs/gal to express mass, as it would cancel out anyway in the equation.)

Equation for SRT

$$\frac{\text{Sum of [(daily feed volume x \% total solids) x (days feed volume is in digester)]}}{\text{Sum of (daily feed volume x \% total solids)}} = \text{SRT}$$

How to calculate SRT

Use these instructions to fill in the chart on the back side of this worksheet and to calculate SRT.

Step 1 Enter values for feed volume in column **a.**

Step 2 Convert % total solids (column **b**) to a decimal fraction & put answer in column **b**.

Step 3 In each row, multiply **a** and **b (a x b)** and put the answer in column **c**.

Step 4 In each row, multiply **c** and **d (c x d)** and put the answer in column **e**.

Step 5 Add up column **c**.

Step 6 Add up column **e**.

Step 7 To calculate the SRT, divide the total of column **e** by the total of column **c**.

$$\frac{\text{Total of column e} \rightarrow \boxed{}}{\text{Total of column c} \rightarrow \boxed{}} = \boxed{} \text{ days}$$

SRT

Month/Year ___________	**Day**	**Temperature**	**Feed volume in gallons (a)**	**% total solids of feed, as decimal fraction (b)**	**a x b (c)**	**Days in digester (d)**	**c x d (e)**
	1						
	2						
	3						
	4						
	5						
	6						
	7						
	8						
	9						
	10						
	11						
	12						
	13						
	14						
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	36						
	37						
	38						
	39						
	40						
	41						
	42						
Add as	43						
many	44						
days	45						
as you	46						
need for	47						
your	48						
operating	49						
conditions	50		0	—	—	—	—
					Total c		**Total e**

Example

This situation uses one unheated aerobic digester. Solids are fed to the digester daily. When the digester is full, it is emptied except for a seed volume of 4,000 gallons. Find the SRT.

Digester volume = 60,000 gallons
Seed volume = 4,000 gallons

Day	Feed volume in gallons (a)	% total solids of feed as decimal fraction (b)	a x b (c)	Days in digester (d)	c x d (e)
1	9000	3.9 = **0.039**	**351**	6	**2106**
2	7000	4.2 = **0.042**	**294**	5	**1470**
3	10,000	5.6 = **0.056**	**560**	4	**2240**
4	9,000	4.8 = **0.048**	**432**	3	**1296**
5	12,000	3.5 = **0.035**	**420**	2	**840**
6	9,000	3.0 = **0.030**	**270**	1	**270**
7	0	—	—	—	—
			total = 2327		**total =** 8222

Step 1 Enter values for feed volume in column **a.**

Step 2 Convert % total solids (column **b**) to a decimal fraction & put answer in column **b**.

Step 3 In each row, multiply **a** and **b (a x b)** and put the answer in column **c**.

Step 4 In each row, multiply **c** and **d (c x d)** and put the answer in column **e**.

Step 5 Add up column **c**.

Step 6 Add up column **e.**

Step 7 To calculate the SRT, divide the total of column **e** by the total of column **c**.

$$\frac{\text{Total of column } \mathbf{e} \rightarrow \mathbf{8222}}{\text{Total of column } \mathbf{c} \rightarrow \mathbf{2327}} = \mathbf{3.5} \text{ days}$$

SRT

Lime stabilization

In lime stabilization, sufficient lime is added to the biosolids to raise the pH to 12 for 2 hours of contact. The EPA originally approved this PSRP process for lime; therefore using other alkaline materials would have to be approved as a PSRP equivalent process. The pH must be measured at or adjusted to 25 ^{o} C.

How to adjust pH for temperature correction using lime or other alkaline material

Measure the pH in a slurry* at 25 ^{o} C. This can be done in one of two ways:

1. Biosolids samples may be taken and cooled or warmed, whichever is appropriate, to 25^{o}C.

or

2. The operator can adjust the pH results, based on the temperature of the biosolids being measured, using the following calculations:

Actual pH	=	measured pH	+	correction factor *This can be either a positive or negative number (see the following calculation.)*

Correction factor	=	0.03 pH units	x	(temperature $_{measured}$ - 25^{o} C)

**How to make a slurry:* *If biosolids have been dewatered to a cake form, create a slurry by adding 20 ml of 0.01 M $CaCl_2$ to 10 grams of biosolids. Mix the cake occasionally for half an hour, waiting for the sample to clarify if necessary, and then measure the pH.*

Example

If the measured pH is 12.30 at 30^{o} C:

First calculate the temperature correction factor:

Correction factor	=	0.03 pH units	x	(30 ^{o} $_{measured}$ - 25^{o} C)
+0.15	=	0.03 pH units	x	5

Next, calculate the actual pH:

Actual pH	=	measured pH	+	correction factor
12.45	=	12.30	+	0.15

Air drying and drying beds

Air drying and drying beds for biosolids are rarely used to meet Class B standards. Generally, they are used for storage. In this method, biosolids are applied to a depth of nine inches or less on sand beds and are dried for at least three months. For two of the three months, the average daily temperature must be above 0^o C (32^o F). The average daily temperature equals the daily maximum temperature plus the daily minimum temperature divided by 2.

Composting

Using either the within-vessel, static aerated pile or windrow composting methods, the temperature of the biosolids must be raised to 40^o C (104^o F) or higher and must remain at this temperature for 5 days. For 4 hours during the 5-day period, the temperature in the compost pile must exceed 55^o C (131^o F). See the Appendix C for a process design sheet.

Alternative 3 for Class B Biosolids: PSRP Equivalent Processes

The EPA may approve a PSRP equivalent process. The EPA Pathogen Equivalency Committee will provide guidance and recommendations for approval. A partial list of approved equivalent processes is in Appendix C. For information on how to apply for an equivalency, see the EPA publication, *Control of Pathogens and Vector Attraction Reduction* (EPA/625/R92/013, revised October 1999). Order by calling 1-800-490-9198.

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Chapter

4

Controlling

Vector Attraction

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What causes vector attraction and why is it a problem? Vectors include insects, rodents, birds and other animals that are capable of transporting a pathogen from one organism to another.

As discussed in the Chapter 3, pathogens pose a disease risk only if there are routes by which the pathogens can contact humans or animals. A principal method to transport pathogens is by vectors. The unstabilized portion of organic matter in biosolids is a food source for microorganisms and vectors — its odor attracts vectors.

Vector attraction can be reduced in the following ways:

- By treating unstabilized biosolids so that vectors are no longer attracted to the biosolids.
- By placing a barrier between the biosolids and vectors

MN Rules Chapter 7041: Reducing vector attraction

Historical note: Those who manage biosolids must meet both the standards for vector attraction reduction and the requirements for pathogen reduction. In the past, both requirements were under the same standard.

📖 When bulk biosolids are applied to agricultural land, forest, a public contact site or a reclamation site, **one** of Options 1 though 10 for reducing vector attraction must be met. (Options 9 and 10 create a barrier between potential pathogens and vectors so the pathogens cannot be transmitted from the biosolids to the vector.)

📖 When bulk biosolids are applied to a lawn or home garden or when biosolids are sold or given away in a bag or other container, **one** of Options 1 through 8 for reducing vector attraction must be met. (Options 1 through 8 involve treating biosolids to make them less attractive to vectors.)

How can I meet the standards?

Those who prepare biosolids have ten options from which to choose to meet the standards for vector attraction reduction. Your situation will determine your choices, as outlined in this chapter.

More than one option may be used during the year. For example, injection (a barrier option) may be used to meet Vector Attraction Reduction (VAR) requirements in spring and fall when no crops are growing. Then if biosolids are surface-applied to hay that summer and injection is not possible, the VAR requirement would have to be met by choosing another option, such as Option 1 — reducing volatile solids by at least 38%.

Options that can be used to meet VAR standards

These are the options available to meet VAR standards:

Option 1: Volatile Solids Reduction (VSR) of 38%
Option 2: Bench scale digestion of anaerobically-digested biosolids
Option 3: Bench scale digestion of aerobically-digested biosolids
Option 4: Specific Oxygen Uptake Rate (SOUR) for aerobically digested biosolids
Option 5: Aerobic processes at greater than 40^oC (104^oF)
Option 6: Adding alkali
Option 7: Reducing moisture of biosolids that contain only stabilized solids by drying to 75% total solids.

Option 8: Reducing moisture of biosolids that contain unstabilized solids by drying to 90% total solids
Option 9: Injecting biosolids underground
Option 10: Incorporating biosolids into the soil

Detailed descriptions of these options follow.

Recordkeeping requirements

For recordkeeping requirements for biosolids processing options for vector attraction reduction, see Table 20 in Chapter 13 and the corresponding discussion.

Controlling vector attraction for septage regulated under MN Rules Chapter 7041

See Chapter 14.

Option 1: Volatile Solids Reduction (VSR)

What is VSR?

Volatile Solids Reduction (VSR) is typically achieved by anaerobic or aerobic digestion, which degrades most of the organic material (food source for microorganisms) to less biodegradable forms. Any biodegradable material that remains after digestion should degrade slowly — so slowly that vectors that would normally be attracted to decomposing solids and their odors are not drawn to it.

You must be able to compare the same mass of biosolids entering and leaving the treatment process to be able to use VSR Option 1. If using Option 1, biosolids meet the standards for vector attraction reduction **if the mass of volatile solids is reduced by at least 38% in a treatment process.** Reduction of volatile solids cannot be done by diluting with inorganic material.

A 38% volatile solids reduction is the amount that volatile solids should be reduced at the *good practice* recommended conditions for anaerobic digestion at 15 days residence time at 35^{o} C (95^{o} F) in a completely mixed high-rate anaerobic digester. Option 1 can also be used for aerobically digested and composted biosolids, if desired.

When can you use VSR?

As stated earlier, you must be able to compare the same mass of biosolids entering and leaving the treatment process to be able to use Option 1 (VSR).

Since volatile solids reduction may also occur during some types of storage, the rule allows the calculation to be made across both the treatment and storage processes.

Concepts of calculating VSR

Volatile Solids Reduction (VSR) is calculated by a volatile solids mass balance across the digestive process (it is optional to include volatile solids reduction across the storage process) — the mass or weight of volatile solids coming into the digester (the inputs) must equal the mass or weight of volatile solids leaving the digester (the outputs) plus the mass of volatile solids lost during digestion.

The inputs include any feed sources to the digester. The outputs include:

- the mass of volatile solids remaining in the digested biosolids
- the mass of volatile solids removed by decanting

The quantity of input and output volatile solids is measured as mass. In this manual, mass is expressed in pounds.

To be able to calculate VSR using any of the VSR equations, you must first be able to calculate the mass of volatile solids (VS). Calculate the **mass of volatile solids** as follows:

Mass of volatile solids (VS)	=	volume (gals)	x	% total solids (in decimal form)	x	% volatile solids (in decimal form)	x	8.34 lbs/gal

**The percent total solids and volatile solids on a dry weight basis versus using actual concentrations in milligrams per liter is used because it is data commonly available to operators.*

Equations for calculating VSR

The **most basic equation** for calculating volatile solids reduction (VSR) is:

$$\% \text{ VSR} = \frac{\text{mass of volatile solids (VS) inputs} - \text{mass of volatile solids (VS) outputs}}{\text{mass of volatile solids (VS) inputs}} \times 100$$

Subtracting the outputs from the inputs gives you the mass of volatile solids lost by digestion. The basic equation above does not identify all detailed input and output parameters that must be used in the calculation. Detailed equations are on the following pages. Out of the following, you must choose the equation that is right for your operating conditions:

- Full Mass Balance Equation
- Van Kleek Equation
- Approximate Mass Balance Equation

How to choose the right equation to calculate VSR

Table 2

How to choose the right equation to calculate VSR

Type or situation of digester	Use this equation:
For steady-state, continuous mix digesters with no grit accumulation and no decant	Van Kleek Equation or Approximate Mass Balance Equation
For all other steady state or nearly steady state, continuous mix digesters, with or without grit accumulation and/or decant	Approximate Mass Balance Equation
For non-steady state type digesters	Full Mass Balance Equation

For a detailed discussion of each equation, including when it is appropriate to use each one, see the appropriate following section.

For a detailed discussion on VSR, see the EPA publication *Control of Pathogens and Vector Attraction Reduction*, EPA/625/R92/013, revised October 1999. Order by calling 1-800-490-9198.

How to calculate VSR using the Full Mass Balance Equation

To calculate a Full Mass Balance of volatile solids reduction, the biosolids manager must know all of the following (must be able to calculate the mass of these streams):

- ❑ for **all** daily input and output streams:
  - volumes
  - total solids concentration
  - volatile solids concentration
- ❑ the mass of volatile solids left in the digester when you start and end the digestion process

Collecting this amount of data is not typical for most treatment plant operators and doing the calculations could be exhausting. From this standpoint, it may be easier to select another option for digested biosolids, such as Option 2, 3, or 4, if this is the only equation that is appropriate for your operating conditions. An example of operating conditions that would make it necessary to use the Full Mass Balance Equation is:

- start with a digester 1/4 full
- solids are fed to the digester periodically until it is full
- supernatant is decanted periodically and more solids are fed to the digester until settling no longer occurs
- the volume of the digester is reduced until it is about 1/4 full

Full Mass Balance Equation

$$\%\ VSR = \frac{\text{mass of } VS_{feed} + \text{mass of } VS_{initial} \text{ in digester} - \text{mass of } VS_{decanted} - \text{mass of } VS_{\substack{digested\\biosolids}} - \text{mass of } VS_{remains} \text{ in digester}}{\text{mass of } VS_{feed}} \times 100$$

Although using the Full Mass Balance Equation is tedious, it can be used for basically all digester operating conditions. As you will see, this is not the case for some other equations. Under certain operating conditions that are described in detail in the following sections, you can use the Van Kleek Equation or Approximate Mass Balance Equation, both of which are simpler to use.

How to calculate VSR using the Van Kleek Equation

The Van Kleek Equation is relatively simple because it uses only concentrations of volatile solids. However, the Van Kleek Equation should only be used when all of the following are true:

- ☐ the digester is operating under **steady state conditions** — feed rates equal the biosolids removal rates
- ☐ no grit (fixed solids) is settling out in the digester (in this chapter, see *Is grit accumulating in your digester?*)
- ☐ the fraction of volatile solids is the same in the decant (supernatant) as in the digested solids, or there is no decant at all

Van Kleek Equation

$$\% \text{ VSR} = \frac{VS_{feed} - VS_{digested}}{VS_{feed} - (VS_{feed} \times VS_{digested})} \times 100$$

Where: % VSR = percent Volatile Solids Reduction
VS = % Volatile Solids (in decimal form)

If grit accumulation occurs, the Van Kleek method underestimates VSR.

A data tracking worksheet for calculating VSR using the Van Kleek Equation (Worksheet 3) is found later in this chapter. You can enter up to 50 days of data on the worksheet. If you need to track data for more than 50 days, continue on another copy of the worksheet.

How to calculate VSR using the Approximate Mass Balance Equation

The assumptions made in the Approximate Mass Balance Equation are:

- ☐ the digester is operated at or reasonably close to steady state conditions — feed rates and removal rates are relatively constant on a daily basis, with or without grit accumulation.
- ☐ daily flows are reasonably uniform in compostion
- ☐ no substantial accumulation of volatile solids is in the digester from settling or scum accumulation

Approximate Mass Balance Equation

$$\% \text{ VSR} = \frac{(\text{Mass of VS}_{feed}) - (\text{Mass of VS}_{decant}) - (\text{Mass of VS}_{digested})}{(\text{Mass of VS}_{feed})} \times 100$$

For the equation used to calculate the mass of volatile solids, see "Concepts of calculating VSR" earlier in this chapter.

Worksheet 4 found later in this chapter is for tracking data for calculating VSR using the Approximate Mass Balance Equation. You can enter up to 50 days of data on the worksheet. If you need to track data for more than 50 days, continue on another copy of the worksheet.

Comments on using the Approximate Mass Balance & Van Kleek Equations

If you choose to use one of these equations, you will no doubt be asking yourself when, at what frequency, and over what length of time sampling should occur.

In all cases, choose sampling times for input, output and product volatile solids concentrations based on the fact that the calculation must represent the volatile solids reduction of a **particular mass** of biosolids being digested. In other words, the calculation represents the loss of VS from all the input components to a product made up of those specific components. To accomplish this, sampling should continue over an extended time period to account for variability of the inputs, outputs and quality of the biosolids product. In addition to variability, consider the length of time for sampling in relationship to the frequency at which biosolids are applied (see examples below). How often you sample should be based on your knowledge of the variability of input characteristics.

Unless the Full Mass Balance Equation is used, the concentration values from these samples are averaged to calculate VSR. An average weighted value should be used in the calculation. Results will only be as accurate as the data used in the calculation. Poor sampling is probably the greatest cause of error.

Example 1

If biosolids are digested in a steady-state process and their composition remains reasonably uniform, you could average volatile solids values taken over a period of one or two times the average solids retention time. Using values collected over two times your SRT should result in a more accurate calculation.

Example 2

If biosolids are digested for 20 days and then stored in a tank for three months before removing and land applying, you might choose to evaluate VSR over both the digestion and storage processes. Further reduction in the VS may occur during storage. In this case, the biosolids product volume in the tank represents three months of inputs to the digester and storage tank. In order to calculate the loss of VS, track all volumes, the input VS to the digester, any decant VS from the digester and/ or storage for three months, and the VS in the end product.

If your type of operation requires you to use a treatment process (versus a barrier method) for vector attraction reduction and you cannot use either the Van Kleek or Approximate Mass Balance Equation, try using Options 2, 3 or 4 for digested biosolids.

Options 2, 3 and 4 can be used when it is not possible to calculate the 38% volatile solids reduction (for example, when input and output data cannot be collected). This method can also be used when the biosolids are assumed to be stabilized before entering the digester and the result of a calculation for VSR shows less than 38% reduction. For example, it is unlikely that a 38% VSR will occur in a digester if the feed solids are already quite stabilized because they are coming from a wastewater treatment unit with long detention times, such as an oxidation ditch. Details on conducting tests for options 2, 3, and 4 are in Appendix D.

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Worksheet 3

Data tracking for calculating Volatile Solids Reduction (VSR) using the Van Kleek Equation

FOR STEADY-STATE, CONTINUOUS MIX DIGESTERS WITH NO GRIT ACCUMULATION AND NO DECANT

Month/Year ______________ **Facility** ______________________________

Day	Digester feed – Source 1			Digester feed – Source 2			Digested biosolids		
(Add days as needed.)	Gallons	TS (%)	TVS (%)	Gallons	TS (%)	TVS (%)	Gallons	TS (%)	TVS (%)
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
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31									
32									
33									
34									
35									
36									
37									
38									
39									
40									
41									
42									
43									
44									
45									
46									
47									
48									
49									
50									
Average	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)

Worksheet 3 page 2 of 2

How to calculate the weighted average for 2-digester feed sources (in %TS)

If the digester receives only one feed source, this calculation is not necessary (in this case, use the value obtained for (3) from the reverse side of this form in place of (10) in the **Average VSR** calculation below.)

$$\frac{(\boxed{(1)} \times \boxed{(2)} \times \boxed{(3)}) + (\boxed{(4)} \times \boxed{(5)} \times \boxed{(6)})}{(\boxed{(1)} \times \boxed{(2)}) + (\boxed{(4)} \times \boxed{(5)})} = \boxed{(10)}\ \%$$

How to calculate the average VSR using the Van Kleek Equation

If a significant amount of grit accumulates in the digester, the value calculated for **Average VSR** by this method will be conservative (i.e.; lower than the actual value).

$$\frac{\boxed{(10)} - \boxed{(9)}}{\boxed{(10)} - (\boxed{(10)} \times \boxed{(9)})} \times 100 = \boxed{}\ \%$$

Worksheet 4

Data tracking for calculating Volatile Solids Reduction (VSR) using the Approximate Mass Balance Equation

FOR ALL OTHER STEADY STATE (OR NEARLY STEADY STATE) CONTINUOUS MIX DIGESTERS WITH OR WITHOUT GRIT ACCUMULATION OR DECANT

Month/Year ____________ **Facility** ________________________

Day	**Digester feed – Source 1**			**Digester feed – Source 2**			**Supernatant**			**Biosolids removal**		
(Add days as needed.)	Gallons	TS (%)	TVS (%)	Gallons	TS (%)	TVS (%)	Gallons	TS (%)	TVS (%)	Gallons	TS (%)	TVS (%)
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
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23												
24												
25												
26												
27												
28												
29												
30												
31												
32												
33												
34												
35												

Worksheet 4: Data tracking for calculating Volatile Solids Reduction (VSR) using the Approximate Mass Balance Equation
Page 2 of 2

Day *(Add days as needed.)*	Digester feed – Source 1 Gallons	Digester feed – Source 1 TS (%)	Digester feed – Source 1 TVS (%)	Digester feed – Source 2 Gallons	Digester feed – Source 2 TS (%)	Digester feed – Source 2 TVS (%)	Supernatant Gallons	Supernatant TS (%)	Supernatant TVS (%)	Biosolids removal Gallons	Biosolids removal TS (%)	Biosolids removal TVS (%)
36												
37												
38												
39												
40												
41												
42												
43												
44												
45												
46												
47												
48												
49												
50												
Average	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)

How to calculate the average VSR using the Approximate Mass Balance Equation

$$\frac{\left((1) \times (2) \times (3)\right) + \left((4) \times (5) \times (6)\right) - \left((7) \times (8) \times (9)\right) - \left((10) \times (11) \times (12)\right)}{\left((1) \times (2)\right) + \left((4) \times (5) \times (3)\right) + \left((4) \times (5) \times (6)\right)} \times 100 = \underline{\qquad} \%$$

Is grit accumulating in your digester?

Example

This example uses a 500,000 gallon primary digester with the following characteristics:

- The digester feed averages 30,000 gallons per day of a thickened combination of waste activated and primary solids at 5.0% total solids and 82.0% volatile solids.
- The average decant is 8,000 gallons per day at 0.80% total solids and 65.0% volatile solids
- The average biosolids production is 22,000 gallons per day at 3.39% total solids and 68.6% volatile solids

Step 1: What are the fixed solids inputs?
If 82% of input total solids are volatile solids, then 18% are fixed solids. Therefore,

30,000 gals	x	8.34 lbs/gal	x	5% total solids (in decimal form)	x	18% fixed solids (in decimal form)	=	2252 lbs/day fixed solids input

Step 2. What are the fixed solids outputs?
A. From the decant: If 65.0% of the total solids are volatile solids, then 35.0% are fixed solids. Therefore,

8,000 gal/day	x	8.34 lbs/gal	x	0.08% total solids (in decimal form)	x	35% fixed solids (in decimal form)	=	187 lbs/day fixed solids in decant

B. From the biosolids: If 68.6% of total solids are volatile solids, then 31.4% are fixed solids. Therefore,

22,000 gal/day	x	8.34 lbs/gal	x	3.39% total solids (in decimal form)	x	31.4% fixed solids (in decimal form)	=	1953 lbs/day fixed solids in output solids

C. Calculate the total output fixed solids as follows:

1953 lbs	+	187 lbs	=	2140 lbs/day of fixed solids output

Step 3. How much grit has accumulated?
The input fixed solids (2252 lbs/day) does not equal the output fixed solids (2140 lbs/day). Therefore, the amount of grit that is accumulating per day is the difference between these values:

2252 lbs/day	-	2140 lbs/day	=	112 lbs/day

Future help

EPA staff is working with states to develop computer programs that will make VSR computations easier. These programs could possibly advise operators on whether the data used and end result is statistically valid. This will hopefully provide some consistency at the national level for determining VSR.

Option 2: Bench scale digestion of anaerobically-digested biosolids

Under this option, anaerobically-digested biosolids meet the standards for vector attraction reduction when further anaerobic digestion in a bench scale test shows that the volatile solids are reduced by less than an additional 17%. The bench scale test is run at **30°C to 37°C (86°F to 99°F) for 40 days.**

This option can also be used for liquid biosolids removed from long term storage in a lagoon.

See Appendix D for details on conducting this test.

Option 3: Bench scale digestion of aerobically-digested biosolids

Under this option, aerobically digested biosolids with 2% or less total solids meet the standards for vector attraction reduction if they lose less than 15% volatile solids when they are aerobically batch-digested in the laboratory at **20^{o}C (68^{o}F) for 30 days.**

Biosolids with greater than 2% total solids can be diluted with effluent to 2% total solids. See Appendix D for details on conducting this test.

Option 4: Specific Oxygen Uptake Rate (SOUR) for aerobically digested biosolids

Aerobically digested biosolids that have been processed at a temperature between 10 and 30^o C meet the standards for vector attraction reduction when **the SOUR of the biosolids is equal to or less than 1.5 mg of oxygen per hour per gram of total solids at 20^o C (68^o F).**

This test is based on the amount of oxygen that the microorganisms in the biosolids consume when degrading organic matter. If they consume very little oxygen, the biosolids should be quite stable — reducing odors that attract vectors. The SOUR method may be unreliable at a solids content above 2%, and it requires a poorly defined temperature correction at temperatures differing substantially from 20^o C (68^o F).

SOUR cannot be applied to solids digested outside the 10-30^o C range. The temperature of the biosolids being tested cannot be adjusted because the change in temperature can cause short-term instability in the oxygen uptake rate. See Appendix D for guidance on performing the SOUR test.

A computer program, *SOUR Test for Biosolids Treatment*, is available for you to download from the State of Pennsylvania. Find it at the following address:

www.dep.state.pa.us/dep/biosolids/biosolids.htm

Option 5: Aerobic processes at greater than 40°C (104°F)

This option applies primarily to composted biosolids. The biosolids must be treated for **14 days or longer during which time the temperature must be over 40°C (104°F) and the average temperature higher than 45°C (113°F).**

Option 6: Adding alkali

Biosolids meet the standards for reduced vector attraction if sufficient alkali is added to accomplish all of the following:

- raise the pH to at least 12
- maintain a pH of at least 12 without adding more alkali for 2 hours
- maintain a pH of at least 11.5 without adding more alkali for an additional 22 hours

Here the term **alkali** means a substance that increases the pH. Raising the pH of biosolids reduces its attraction to vectors by reducing or stopping biological activity. However, this is not permanent. If the pH drops, the surviving microorganisms can become active, and the biosolids can putrefy and potentially attract vectors. The more soluble the alkali, the faster this is likely to happen.

With this option, biosolids can be stored for several days at the treatment works, transported, and then applied to soil without the pH falling to where the biosolids can begin to attract vectors.

For information on how to adjust pH for temperature correction, see *Lime stabilization* near the end of Chapter 3.

Option 7: Reducing moisture of (drying) biosolids that contain only stabilized solids

Under this option, biosolids meet the standards for vector attraction reduction when both of the following are true:

- the biosolids do not contain any unstabilized solids generated during primary wastewater treatment. Partially degraded food scraps and feces, likely to be present in solids, could attract vectors even if the solids content is over 75%.
- the solids content of the biosolids is at least 75% before the biosolids are mixed with other solids

The way operators handle or store dried biosolids before use or disposal can create or prevent vector attraction. For example, if dried biosolids are exposed to high humidity, microbes may start decomposing the biosolids again, creating odors.

Option 8: Reducing moisture of (drying) biosolids that contain unstabilized solids

For biosolids to meet the standards for reduced vector attraction, **the solids content must be 90% or greater.**

To achieve this, you must remove water from the biosolids — you are not allowed to add inert solids to meet the standard. Removing water from biosolids severely limits biological activity in the biosolids and strips off or decomposes the volatile compounds that attract vectors. Drying biosolids to this extreme deters vectors in all but the most unusual situations.

The way operators handle or store dried biosolids before use or disposal can create or prevent vector attraction. For example, if dried biosolids are exposed to high humidity, microbes may start decomposing the biosolids again, creating odors.

Option 9: Injecting biosolids underground

Biosolids can be injected below the soil surface to meet the standards for vector attraction reduction. Injection works by creating a barrier between the vectors and biosolids. The soil also removes water from the biosolids, which reduces the biosolids' mobility and odor.

When injection is used, no significant amount of biosolids can be present on the land surface within one hour after injection. In addition, special restrictions apply to Class A biosolids when this option is used to meet VAR. Because bacteria grow especially well in Class A biosolids, the biosolids must be injected within 8 hours after the pathogen-reduction process is finished. During these first 8 hours, levels of pathogenic bacteria should still be quite low. However, after the first 8 hours, bacteria may grow rapidly.

Option 10: Incorporating biosolids into the soil

Under this option, biosolids applied to the land **must be incorporated into the soil within 6 hours after application, unless the EPA approves otherwise.**

The EPA may extend the timeframe if, for example, a site is remote or if vectors are not present at a specific time of year.

Chapter 5

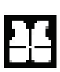
Sampling & analyzing Biosolids

Sampling and analysis is an integral part of monitoring the quality of biosolids going to the field. Accurate information about biosolids is used to determine compliance with regulations and inform users of what the product contains so that it can be used in an environmentally sound way.

A note on safety when collecting biosolids samples

Because biosolids can contain pathogens, the act of sampling can expose the operator to pathogens in biosolids. Take the following precautionary measures:

- ❑ Stay current on all standard adult immunizations, including tetanus and typhoid.
- ❑ Wear rubber or latex gloves and eye protection whenever sampling biosolids.



- ❑ Wear personal floatation devices when sampling lagoons from a boat. When sampling from shore, have personal flotation devices readily available.
- ❑ Thoroughly wash and immediately treat any exposed skin, cuts or scrapes that come into direct contact with biosolids.
- ❑ **Never** sample in confined spaces, unless trained to do so.

MN Rules Chapter 7041: Collecting representative samples

The person who prepares biosolids, which are intended to be applied to the land, is responsible for collecting and analyzing **representative samples** of biosolids.

A laboratory usually analyzes the samples, but it is the preparer's responsibility to make sure it is done correctly. To develop a sampling plan, the preparer must answer several questions, which is the focus of this chapter. To help you develop a sampling plan, see Worksheet 5, *Biosolids sampling plan,* and Worksheet 6, *Record of biosolids samples & analyses.*

Representative samples are accurate samples

To be **representative**, a sample and its analysis must be accurate. Insuring accuracy depends on both the person doing the sampling and the laboratory performing the analysis.

The person doing the sampling is responsible for correct results by insuring that:

- ❑ biosolids are stored and shipped at 4^{o} C
  - ❑ **Exception:** If a sample is being taken to run VAR options 2 or 3 (bench scale digestion), insure that the temperature is maintained by taking a very large sample or by insulating the sample container. For these tests it is also important that aerobic samples get to the laboratory so testing can begin within 2 hours (do not aerate the sample during transport). Also, make sure that anaerobic samples remain anaerobic.
  - ❑ For rapid cooling of hot or thick biosolids, use an ice water bath — do not use containers larger than a quart.
- ❑ the analysis occurs within the allowed timeframes and the laboratory uses the correct analytical methods and detection limits. Although this seems to be more the laboratory's responsibility than yours, provide the laboratory with the maximum holding times for the specific parameters for which you want the sample analyzed. A good way to ensure that this information gets to the lab and at the same time provides you with sampling records is to:
  - Decide if you'll use Worksheet 6*, Record of biosolids samples and analyses*, or create a similar form that contains the same information. Then fill it out for a specific sampling date. The completed record may be referred to as the sample's *label*.
  - For your records, make a copy of your completed Worksheet 6, *Record of biosolids samples and analyses* (or the form you've created).
  - Attach the original form to the sample when shipping it.

Worksheet 5

Biosolids sampling plan

*Use this guide to develop your sampling plan —
consider the discussions on representative sampling in this chapter.*

Parameter	✓	Sampling dates	Additional analyses	Sampling point	Type of sample:		Number of samples taken	Holding time/ container/ preservation *(Preserve all samples at 4° C except those for VAR test.)*	Name of person taking sample
					grab	composite			
Nutrients									
Metals — all									
Metals — specific ones									
Pathogens/ indicator organisms *(If samples are taken for Class A biosolids, use sterile sampling containers & tools & contact lab staff ahead of time so they can be ready to run analyses within holding time.)*									
Vector Attraction Reduction (VAR)								*Preserve samples for VAR at temperature at which it was taken.*	
Other (name) _______									

Worksheet 6

Record of biosolids samples and analyses

Sample ID # ____________

Name of person taking sample ____________

Sampling location ____________

____

____

Date & time sample taken ____________

Sample type _______ grab
_______ composite

Container type ____________

Sample volume ____________

Method of preserving sample ____________

____

Maximum holding time ____________

Comments ____________

____

____

____

____

____

Name of laboratory ____________

Date & time analyses conducted ____________

Check the parameters requested ✓	Parameters	Method of preparing sample	Method of analyzing sample[1]	Limit of concern[2]
	Total solids		2540G	
	Volatile solids			
	pH		9045	
	Total Kjeldahl nitrogen			
	Ammonia nitrogen			
	Potassium			
	Arsenic[3]	3050/3051	6010/7060/7061	41 mg/kg
	Cadmium	3050/3051	6010/7131/7130	39 mg/kg
	Copper	3050/3051	6010/7210/7211	1500 mg/kg
	Lead	3050/3051	6010/7421/7420	300 mg/kg
	Mercury[4]	7471	7470/7471	17 mg/kg
	Molybdenum	3050/3051	6010/ 7481/ 7480	75 mg/kg
	Nickel	3050/3051	6010/ 7920	420 mg/kg
	Selenium	3050/3051	6010/ 7741/7740	36 mg/kg
	Zinc	3050/3051	6010/ 7950/ 7951	2800 mg/kg
	Fecal coliform Class A		SM9221E	1000 MPN/g
	Fecal coliform Class B		SM9221E or SM9222D	2,000,000 MPN or CFUs
	Bench scale digestion			
	Other:			
	Total Phosphorus			

[1] *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, Second Ed.* **(1982) with updates I (April 1984) and II (April 1985) and Third Ed. (Nov. 1986) with Revision I (Dec. 1987)**

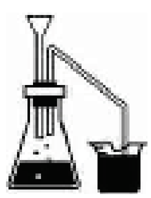
[2] **Not detection limits but if detection limit is greater, analysis is not useful to determine compliance with *clean biosolids limits*.**

[3] **Both 7060 and 7061 are appropriate methods. However, high concentrations of chromium, cobalt, copper, mercury, molybdenum, nickel, and/or silver, can cause analytical interference when using method 7061 (gaseous hydride). Therefore, method 7060 is often preferable to method 7061.**

[4] **Method 7470: Procedure is approved for determining the concentration of mercury in mobility-procedure extracts, aqueous wastes, and ground waters. Method 7470 can also be used for analyzing certain solid wastes; however, method 7471 is usually the preferred method of choice for these types of wastes.**

- ❑ Chain of Custody is followed. When samples are collected and transported to a lab, it is important to track the persons involved who handle the sample and at the time at which each person took possession of the sample. This is called a chain of custody record. The lab usually supplies a chain of custody sheet with the sampling kit or containers. However, if necessary, anyone can create a chain of custody record sheet. It should have, at a minimum, the following:
  - ❑ sample collector's name and signature
  - ❑ date and time of collection
  - ❑ place and address of collection
  - ❑ date, time and signatures of all persons taking possession of the sample
- ❑ the results are critically reviewed to:
  - ❑ see if they make sense
  - ❑ check that the correct analytical methods were used
  - ❑ check if standards are met. You may have to contact the lab immediately to run another analysis if you suspect an error or if standards are not met.

For what parameters should I test?



You *always* need to test biosolids for nutrients and metals. However, depending upon treatment choices made up to this point, you may also need to run tests for indicator organisms or standards for pathogens or vector attraction reduction.

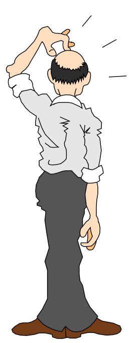
Always need to test for:	May also need to test for:
nutrients	indicator organisms
metals	pathogen standards
	vector attraction reduction standards
	organic compounds

Sampling requirements for organic compounds

Running analyses for various organic compounds is not routinely required for biosolids, unless the biosolids are removed from an old pond or lagoon (in this case, also run a PCB analysis). If samples are taken for analysis for organic compounds, contact the laboratory for the sampling containers and procedures.

How often should I sample? How many samples should I take?

Minimum sampling requirements



Collecting and analyzing representative samples is at the heart of a biosolids sampling program. To develop a sampling plan, thoroughly consider your landspreading program to determine what will give representative samples. In some cases, biosolids must be sampled and analyzed more often than the following minimum frequency required by rule.

Minimum sampling frequency

Amount of biosolids applied (tons/ 365 days)	Frequency (per 365 days)
>0 but < 320	1
≥ 320 but < 1,650	4
≥ 1,650 but < 16,500	6
≥ 16,500	12

If metal concentrations are high, sample more often

If metal concentrations are greater than 50% of the ceiling concentration (see Table 3) analyze biosolids more often than the minimum sampling frequency. When metals reach elevated concentrations, it is important to get a handle on what's happening because it may help the operator determine if a pretreatment program needs to be initiated or enforced.

Table 3

Metal concentrations that signal that more frequent sampling is needed—

sample for these parameters at *twice* the minimum frequency

Parameter	mg/kg of dry weight
arsenic	38
cadmium	43
copper	2150
lead	420
mercury	28
molybdenum	38
nickel	210
selenium	50
zinc	3750

Sampling more frequently may be necessary for situations besides for elevated metal concentrations.

When determining how often to sample, ask the question, *Does the analysis represent biosolids going to the field?* Consider at a minimum, the following items, and always keep in mind that the biosolids must meet standards for quality control if they are to be used appropriately:

- ❑ Consistency of historical analytical data
- ❑ Frequency of spreading operations and when biosolids are applied
- ❑ Consistency of treatment plant operating conditions (including variability because of season)
- ❑ Consistency of influent quality (inorganic and organic) to the treatment plant
- ❑ Look at the use of biosolids quality information from the users perspective. For example, a facility has a minimum sampling frequency of once per year but biosolids are currently applied twice per year. The operator does not yet know if the quality of the biosolids is the same at both times of the year. In this case, start sampling during both applications to establish the biosolids quality. Continue the additional sampling and analysis until the preparer and user are confident they have accurate information. Then, depending on how consistent the biosolids quality is, the operator may be able to reduce the sampling frequency for specific parameters.

When reduced sampling may be appropriate

After biosolids have been monitored for two years at the minimum sampling frequency and, when necessary, at more frequent intervals for elevated metal concentrations, the biosolids preparer may request the MPCA to approve a plan for reduced sampling frequency. However, the frequency must be at least once per 365 day period that biosolids are applied.

If you've decided to request approval for a reduced sampling frequency, justify your request to the MPCA by supplying data that shows all of the following has occurred over time:

- ❑ biosolids quality does not vary significantly
- ❑ that there is no upward trend in pollutant concentration
- ❑ that the concentrations are not close to the ceiling limits (see Chapter 6)

When and where should I collect samples?

Analytical results should be available **before** land-applying biosolids for a variety of reasons. Consider all of the following timing requirements when developing a sampling plan:

- ❑ Results should be available **before** land-applying biosolids to determine compliance with standards, particularly the ceiling concentrations. A violation occurs only when biosolids that do not meet standards are applied to the land. Tests to determine compliance with pathogen or vector attraction reduction requirements may also need to be done.
- ❑ Results are needed to calculate application rates.
- ❑ The time it takes to ship and analyze samples and get the results back.

The best place to collect a **representative** sample is where biosolids are **moving** because they are probably mixed well. For example, a well-mixed sample may be taken where biosolids are being pumped or from a conveyor belt if they are dewatered. Also consider for what the sample will be analyzed, as well as whether it represents biosolids going to the field.

It may be appropriate to sample for certain parameters at different times. For example, it may be necessary to determine whether biosolids coming from a digester meet vector attraction reduction requirements before they are dewatered and stockpiled. In this case, it would **not be appropriate** to analyze for the nutrient content at the same time because the amount of nitrogen (and the solids content) could vary from the time of dewatering and storage to time of use. If samples are taken where biosolids are stationary, the sample must **represent** the entire volume that will be applied.

How many samples of what types should I take?

The rule does not specify how many samples must be taken at a given sampling frequency, except when sampling for fecal indicator organisms to meet pathogen reduction requirements. When determining how many samples to take, once again consider how confident you are in collecting samples that **represent** the biosolids (the product). Consider the quantity and consistency of biosolids, as well as the type of assessment being made (i.e., metals or fecal indicator organisms). For example, more samples are needed to represent stratified versus well-mixed tanks, as well as for large versus small quantities, even if they are well-mixed.

Using grab vs. composite samples

A grab sample is a sample collected from one location at one time. A composite sample is made up of several grab samples taken over a specific time period or throughout a volume of biosolids.

Whether a grab or composite sample is necessary depends on what the sample is being analyzed for and what the operator thinks is **representative**. When analyzing for metals and nutrients, the rule requires that a minimum composite of four grab samples be taken over a 24 hour period for liquid. The rule also specifies that 10 grab samples be composited if taken from lagoons, stockpiles or drying beds.

Sampling for fecal indicator organisms

Generally, it is impractical to consider using composite samples for running a fecal indicator organism test because of the short holding time allowed before analysis. Seven different grab samples are usually taken for this analysis, even though each of the seven samples could be made up of a composite taken over a short period of time, such as one hour.

What equipment do I need for sampling?

When sampling Class A biosolids for microbial tests, clean and sterilize containers, trowels and other sampling equipment. Appropriate sample containers for specific parameters are shown in Table 4. Equipment must be available to immediately cool samples, unless the sample is for an extended bench scale test for vector attraction reduction.

Table 4

Sampling essentials

Parameter	Container	Holding time	How to preserve sample
metals (not mercury)	plastic or glass	6 months	cool to 4° C
mercury)	plastic or glass	28 days	cool to 4° C
total Kjeldahl nitrogen	plastic or glass	28 days	cool to 4° C
nitrate nitrogen	plastic or glass	28 days	cool to 4° C
ammonia nitrogen	plastic or glass	28 days	cool to 4° C
phosphorus	plastic or glass	28 days	cool to 4° C
pH	plastic or glass	none — perform immediately	N/A
PCBs	amber glass	14 days	cool to 4° C
fecal coliform	plastic or glass	24 hours	cool to 4° C and do not freeze
total, fixed and volatile solids	plastic or glass	7 days	cool to 4° C
specific oxygen uptake rate	plastic or glass	none — perform immediately	N/A
enteric viruses	plastic or glass	0 °F (-18 °C) for up to 14 days °	
Helminth ova	plastic or glass	30 days	cool to 4° C
Salmonella Sp.	plastic or glass	24 hours	cool to 4° C

Chapter

6 Metal Limits

Four sets of standards limit the amount of metals in biosolids applied to the land. These standards are discussed in this chapter and include:

1. Ceiling concentrations
2. Cumulative pollutant loading rates
3. Pollutant concentrations
4. Annual pollutant loading rates

The metals that are regulated and their associated limits are derived from EPA's risk assessment and the quality of biosolids produced in the United States. For an in depth discussion, obtain the *Guide to the Biosolids Risk Assessment for the Part 503 Rule* (see Appendix H for a list of available publications).

Standard 1: Ceiling concentrations (limits) of metals

MN Rules Chapter 7041

Biosolids must not be applied to the land if the concentration of any pollutant in the biosolids exceeds the ceiling concentrations (limits) in Table 5.

Table 5

Ceiling concentrations of metals

Pollutant (metal)	Ceiling concentration (mg/kg)
arsenic	75
cadmium	85
copper	4300
lead	840
mercury	57
molybdenum	75
nickel	420
selenium	100
zinc	7500

Biosolids that are applied to land must not exceed the ceiling concentrations in Table 5. **Every value for every metal must be less than the ceiling concentration — they are not concentrations averaged over time.** These limits prevent biosolids with high pollutant concentrations from being applied to the land. Remember, the biosolids rules focus on biosolids quality and the **sustainable** use of biosolids.

If any test result shows a concentration greater than any of the limits in Table 5, the biosolids cannot be applied unless the concentration is lowered to below the ceiling limits.

Metals over the ceiling concentration? First check for errors.

If any test result shows a concentration greater than one of the ceiling limits, the biosolids cannot be applied unless the concentration is lowered to below its limit in Table 5. However, first do the following to check for errors in sampling and analyses:

- ❑ Check the laboratory analysis. Is the concentration unusual?
- ❑ Check with the laboratory for reporting errors, analytical errors or problems with detection limits.
- ❑ Review sampling procedures. Retest immediately and consider splitting a sample between two labs.

Possible solutions

You'll need to identify the source of the metal and reduce it. Focus on industrial users. However, until the source of the metal is removed, it's possible to apply biosolids if the metal concentrations are brought down below the ceiling concentration. Diluting with other solids or using another disposal option can accomplish this.

How to estimate amount of material needed to dilute biosolids

If you choose to dilute the biosolids, you will need to resample the biosolids using a representative sample. Resampling is necessary to show that, after blending, the biosolids are below the ceiling concentration for metals. Depending upon what material is used to dilute the biosolids, you may also need to run tests to see if the biosolids meet the standards for pathogen reduction or vector attraction reduction.

The formula for estimating the amount of dilution material needed to reduce a metal's concentration to below its ceiling limit is (this is **only** an estimate):

$$Tm = \frac{S_t \text{ x } (S_c - C_c)}{D_s \text{ x } (C_c - D_c)}$$

T_m	*dilution material needed (tons)*
S_t	*sludge weight (dry tons)*
S_c	*sludge concentration of metal (mg/kg)*
C_c	*ceiling concentration of metal being diluted (mg/kg)*
D_s	*total solids content of dilution material (decimal)*
D_c	*metal concentration of dilution material (mg/kg)*

Background: How the ceiling concentration limits are derived

The ceiling concentration limits are the least stringent of the following two values:

- the value derived from the EPA risk-based cumulative loading rates (Table 6) by assuming a 10 metric ton per hectare per year loading rate for 100 years at the pollutant concentrations (Table 7), or
- the 99th percentile value for that pollutant from the 1988 National Sewage Sludge Survey (NSSS).

For example, the ceiling concentration for arsenic is 75 mg/kg based on the fact that 99% of biosolids analyzed in the NSSS had concentrations of arsenic less than this amount. If the ceiling concentration for arsenic was based on the risk assessment cumulative rate of 41 kg/hectare it would be 41 mg/kg, which is not the less stringent of the two values. (It is just by chance that both the risk based number and 99th percentile value for nickel and selenium are the same.)

Standard 2: Cumulative pollutant loading rates

MN Rules Chapter 7041

📖 Bulk biosolids applied to agricultural land, forest, a public contact site or reclamation site must not exceed the cumulative pollutant loading rate in Table 2 or meet the pollutant concentrations (Table 7) and be classified as exceptional quality biosolids.

Table 6

Cumulative pollutant loading rates of metals

Pollutant (metal)	Rate (lbs/acre)
arsenic	37
cadmium	35
copper	1339
lead	268
mercury	15
nickel	375
selenium	89
zinc	2500

The cumulative pollutant loading rates in Table 6 are the total amounts of metal that can ever be applied to a site via biosolids. For biosolids applied in bulk, except those that are classified as exceptional quality biosolids, the cumulative amount of metal must be calculated on a yearly basis (crop year or 365 days). Instructions on calculating cumulative amounts of biosolids are in Chapter 10.

The cumulative rates are derived from EPA's risk assessment, which considered 14 different pathways of exposure to highly exposed individuals. This included humans, animals (including small organisms) and plants. The cumulative rates are based on the most limiting pathway and are as follows:

Pollutant		Limiting pathway
arsenic, cadmium, lead, mercury & selenium	→	a child directly ingesting biosolids
copper, nickel & zinc	→	plant phytotoxicity
molybdenum *(The cumulative pollutant loading rate has not yet been established for molybdenum, but this is the risk pathway that will be used.)*	→	an animal eating feed grown on soils that have received biosolids

Standards 3 & 4: Pollutant concentrations & annual pollutant loading rates

MN Rules Chapter 7041

📖 Bulk biosolids applied to a lawn or home garden must not exceed the pollutant concentration in Table 7.

📖 If biosolids are sold or given away in a bag or other container, they must meet one of the following:

- the pollutant concentrations in Table 7
- the product of the concentration of each pollutant and the Annual Whole Sludge Application Rate (AWSAR) must not cause the annual pollutant loading rate to exceed those in Table 8 (see page 56 of 7041.3100 in Appendix A if you need instructions on how to calculate AWSAR).

Table 7

Pollutant concentrations for exceptional quality biosolids

Pollutant (metal)	Concentration (mg/kg)
arsenic	41
cadmium	39
copper	1500
lead	300
mercury	17
nickel	420
selenium	100
zinc	2800

Table 8

Annual pollutant loading rates for biosolids sold or given away in a bag or other container

Pollutant (metal)	Rate (lbs/acre)
arsenic	1.8
cadmium	1.7
copper	67.0
lead	13.0
mercury	0.76
nickel	19.0
selenium	4.5
zinc	125.0

To be considered exceptional quality, biosolids must meet the pollutant concentration limits in addition to meeting Class A Pathogen Reduction requirements **and** one of Options 1 through 8 for reducing vector attraction. These concentrations are monthly averages, so it is necessary to produce biosolids of this quality on a consistent basis to meet the concentration limits. It's useful to have a number of values to average each month that you are taking samples. The pollutant concentrations were derived from the risk based cumulative application rates by assuming a 10 metric ton per hectare application rate for 100 years, as discussed under ceiling concentrations.

Annual pollutant loading rates only apply to, and are calculated for, biosolids that do not meet the pollutant concentrations shown above and are sold or given away in a bag or other container. Persons who prepare biosolids of this quality must label their product or provide an information sheet to users to inform them of the maximum rate that the biosolids can be applied to stay under the limits.

Chapter

7

Soil Suitability

S O I L

A cloak of loose, soft material, held to the earth's hard surface by gravity, is all that lies between life and lifelessness. Crumbling rock, grit and grime, and decaying residue -- abrading by wind and water — weather into soil — Mother Earth. This loose hide lives — yields, yet does not yield to the forces of climate, having formed through the ages from meteorological, geological, and biological action on rock. The soil not only was born out of fire, flood, and ice but it lives and continues to renew life. At first, animal and plant residues decayed into simpler constituents, renewing the nutrient elements available for new life in a perpetual cycle, but now, wastes accumulating from the population bulge of human beings add serious proportions to the burden of cycling and recycling.

Wallace H. Fuller
Soils of the Desert Southwest
University of Arizona Press, 1975

What is soil?

The soil is a very important consideration when choosing a site on which to recycle biosolids. Soil provides a medium for:

- Plant root growth
- Water entry and movement
- Immobilization of pollutants

Not all soils are equal. Minnesota has several hundred soil types. Some soils are better suited for biosolids application than others. In this chapter, we discuss what makes soils different and what soil characteristics should be considered when choosing land application sites.

Soil that is ideal for plant growth contains the following approximate percentages:

- Inorganic matter 45%
- Organic matter 5%
- Water 25%
- Air 25%

The inorganic matter in soil is mineral weathered from rock. The organic matter consists of decaying plant and animal matter, and it also contains living microorganisms. Water and air in soil are retained in pore space. On average, soil is one-half pore space.

Soil texture

Soil texture is determined by the relative proportions of sand, silt and clay particle sizes in a soil sample. Soil texture is one of the most important soil characteristics in locating recycling sites for biosolids because it influences many other soil properties, including porosity, aeration, water-holding capacity, nutrient-holding capacity, metal retention and erodibility.

The USDA-Natural Resources Conservation Service (NRCS) uses particle size to classify soil texture. These classes are:

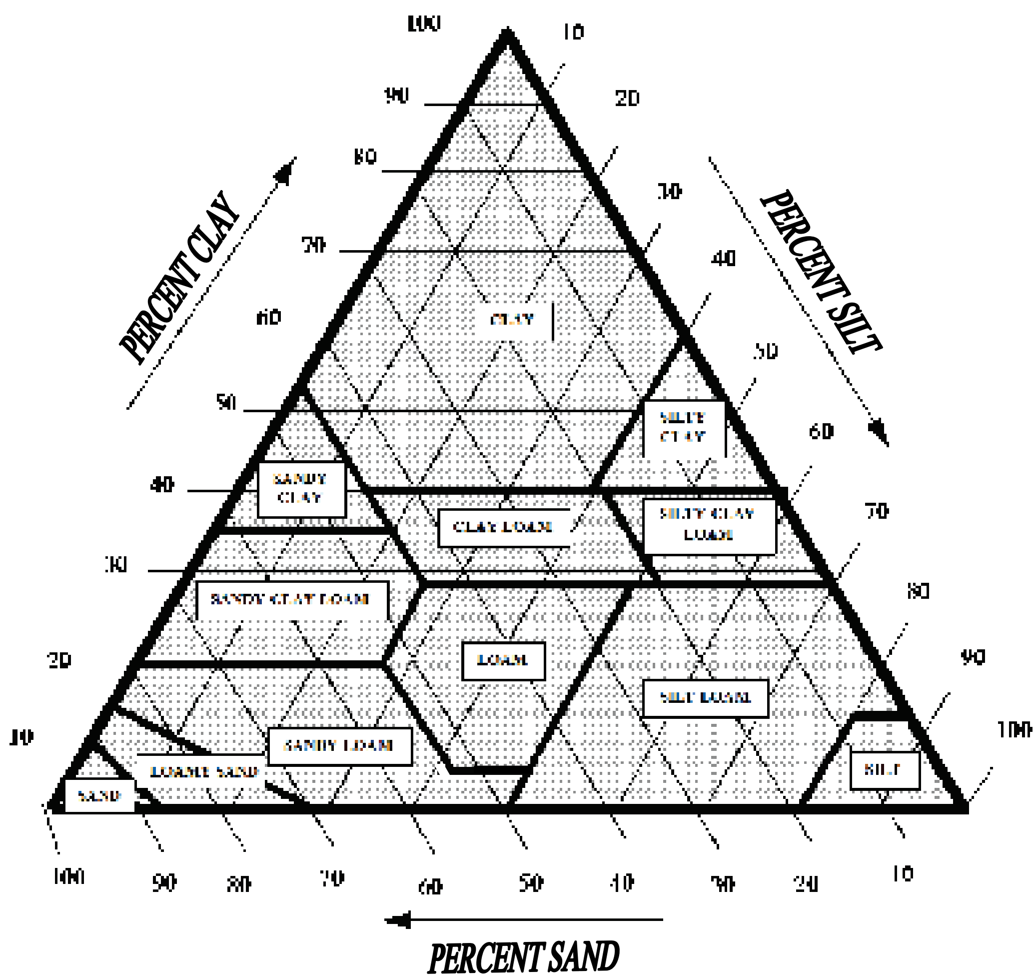
Particle size class		Grain size
sand	→	0.05 to 2.0 mm
silt	→	0.002 mm to 0.05 mm
clay	→	less than 0.002 mm (< 2 µm)

Soil texture can be determined by two methods:

1. **Hand texturing** is done by feel (see Appendix F for a description of this method).

2. **Particle size distribution** is done by laboratory analysis. In the laboratory, staff separate and weigh the sand, silt and clay particles. Then they graph the percentage, by weight, of each particle size on the **Texture Triangle** (see Figure 1). The points where the lines intersect on the triangle indicate the texture.

Figure 1
USDA Soil Textural Triangle



As shown in Figure 1, the NRCS identifies twelve basic textural classes of soil. For our purposes, these twelve classes can be categorized into coarse, medium and fine textures as follows:

Coarse Texture	Medium Texture	Fine Texture
sand	loam	clay loam
loamy sand	silt loam	silty clay loam
sandy loam	silt	sandy clay
	sandy clay loam	silty clay
		clay

**The sand, loamy sand, and sandy loam classes may be further divided into coarse, fine or very fine.*

For purposes of biosolids recycling in Minnesota, soil texture can be obtained in two ways. In fact, during the site approval process, the operator will need to use both of these sources:

1. Consult the applicable NRCS county soil survey for the site or soil in question.
2. Take a representative soil sample at the application site and analyze the soil's texture through a laboratory.

MN Rules Chapter 7041: Soil texture and land application

📖 The soil texture (USDA classification) at the zone of biosolids application must be fine sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay or clay.

📖 Daily surface applications of liquid biosolids must not exceed the following:

- Coarse-textured soils — 25,000 gallons per acre
- Medium-textured soils — 15,000 gallons per acre
- Fine-textured soils — 10,000 gallons per acre

📖 Long-term bulk biosolids storage areas shall be located in areas where the texture of all the horizons in the soil profile to a depth of five feet is sandy loam or finer, unless an impervious pad with a drainage collection system is constructed.

Soil horizons create the soil profile

The terms **soil horizon** and **soil profile** are important to understand when discussing soil properties.

Soil horizons (layers)

A soil horizon is a layer of soil, approximately parallel to the surface, that has fairly uniform characteristics of texture, color and structure. One or more of these characteristics is different from layers above or below that layer, or horizon. Each layer constitutes a separate soil horizon. For instance, topsoil contains organic matter and is normally darker than the soil directly beneath it. Consequently, the topsoil is a soil horizon.

Most soils have three major horizons:

A Horizon — topsoil
B Horizon — subsoil
C Horizon — parent material

Well-developed soils may have four or more horizons, and immature soils may have only two horizons. Soil classifiers can further divide horizons into transitional and specialty horizons.

You can get soil horizon descriptions from NRCS county soil surveys.

Soil profiles (all the horizons)

All of the horizons (layers) in a soil make up its soil profile. A soil profile is a vertical section or core of the soil that extends through all its horizons and into the parent material. The parent material is the geologic deposit or bedrock from which the soil formed.

You can get soil profile descriptions from NRCS county soil surveys.

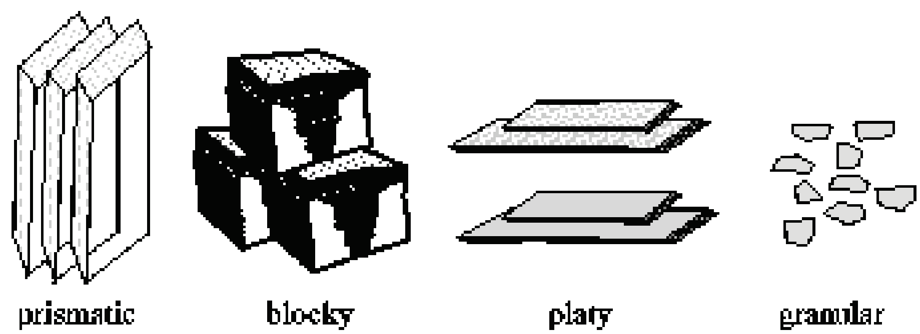
Soil permeability

Permeability is the quality of the soil that lets water move downward through the profile. Permeability is a rate, measured as the number of inches per hour that water moves down through saturated soil. The NRCS uses the following terms to describe permeability:

Permeability		
very slow	→	less than 0.06 in./hr.
slow	→	0.06 to 0.2 in./hr.
moderately slow	→	0.2 to 0.6 in./hr.
moderate	→	0.6 to 2.0 in./hr.
moderately rapid	→	2.0 to 6.0 in./hr.
rapid	→	6.0 to 20 in./hr.
very rapid	→	more than 20 in./hr.

Soil texture and structure influence a soil's permeability rate. In general**,** coarse-texture soils have more rapid (higher) permeability rates than fine-texture soils. However, soil structure can also influence permeability rates. Soil structure describes the shapes in which soil particles are clumped together. Sand in a sand dune (single grain) or clay in a hardpan (massive) are examples of soils that lack structure. See Figure 2 for common soil structure types.

Figure 2
Examples of soil structure



Applying liquid biosolids to soils that have slow permeability rates is a concern for biosolids operators. Under these conditions, biosolids can run off the site before filtering into the soil. This may cause localized ponding, which in turn, can result in various application rates across the site. In the worst case, biosolids may run off the site to surface waters, road ditches or neighboring property.

Soil permeability rates are found in the NRCS county soil survey for the site or soil in question.

MN Rules Chapter 7041: Permeability rates of soils

📖 Liquid biosolids must not be applied to soils with surface permeabilities of less than 0.2 inch per hour unless the biosolids is injected or incorporated within 48 hours of surface application.

Highly permeable soils

The previous paragraphs and rule citation discuss potential problems of soils that have slow permeability rates. At the other end of the spectrum, applying biosolids to soils with rapid permeability rates can also result in problems. For this reason, a special category of soils, **highly permeable soils**, was developed. The MPCA uses a NRCS rating system to determine which soils should be placed into the highly permeable soil category.

Any soil that has an NRCS-rated soil pesticide loss potential by leaching as *severe: poor filter* is considered a highly permeable soil for biosolids application.

To determine if soils are designated as highly permeable, consult the table, *Soil-Pesticide Loss Potential,* for the soil types found in your county. To get this table, contact your county Soil and Water Conservation District (SWCD) or NRCS office.

To use the table, look at the column labeled *Pesticide loss potential — leaching*. If the rating in this column is **severe: poor filter**, the soil is considered a highly permeable soil. Table 9 is an example of this type of information, and it is specifically for Chisago County. From this table, the Pomroy, Chetek and Zimmerman soil types are considered highly permeable soils and the Anoka, Bluffton and Nebish soils are not.

MN Rules Chapter 7041: Highly permeable soils

The following rule citations pertain **only** to highly permeable soils:

📖 The minimum separation distance between the zone of bulk biosolids application and the seasonal high water table and bedrock is five feet.

📖 Bulk biosolids must not be applied to the land during June, July, August or September unless a crop is growing on the land or a crop is seeded within 14 days following bulk biosolids application.

📖 Bulk biosolids applied in October shall be surface applied or applied with a nitrification stabilizer that extends the time the nitrogen component remains in the soil in the ammonical form.

Table 9

Soil-pesticide loss potential

Chisago County, Minnesota (January 15, 1992)

Soil name & map symbol	Pesticide loss potential — leaching	Pesticide loss potential — runoff
40B------------------------- Nebish (MN0138)	Moderate: low adsorption	Moderate: runoff
40C------------------------- Nebish (MN0138)	Moderate: low adsorption	Severe: runoff
40D------------------------- Nebish (MN0138)	Slight	Severe: runoff
40F------------------------- Nebish (MN0138)	Slight	Severe: runoff
75--------------------------- Bluffton (MN0184)	Severe: wetness	Severe: artificial drainage
119B----------------------- Pomroy (MN0279)	Severe: poor filter	Moderate: runoff
119C----------------------- Pomroy (MN0279)	Severe: poor filter	Moderate: runoff
155B----------------------- Chetek (WI0120)	Moderate: low adsorption, poor filter	Moderate: runoff
155C----------------------- Chetek (WI0120)	Severe: poor filter	Moderate: runoff
158B----------------------- Zimmerman (MN0252)	Severe: low adsorption poor filter	Slight
158C----------------------- Zimmerman (MN0252)	Severe: low adsorption poor filter	Moderate: runoff
159B----------------------- Anoka (MN0215	Moderate: low adsorption poor filter	Slight
159C----------------------- Anoka (MN0215)	Severe: low adsorption	Moderate: runoff

Seasonal high water table and depth to bedrock

To properly treat biosolids, soil must contain air, or be **aerobic**. The soil profile must be deep enough (i.e., have enough volume of aerated soil) to properly treat the biosolids. For the soil to be aerobic, it cannot be saturated with water. For these reasons, the level of the high water table and the depth to bedrock are important in choosing land application sites.

The volume of biosolids applied to a crop should provide no more available nitrogen (all biosolids contain nitrogen) than what can be used by the plants. In order for a crop to use nitrogen, the roots cannot be in water-saturated soil, and the soil must be deep enough for the roots to grow well. Other constituents in biosolids, such as pathogens, metals, and organic compounds, are also better treated and retained in deep, unsaturated soils.

For the reasons mentioned above, the best sites on which to apply biosolids are those with soils that have seasonal high water tables and bedrock that is deep, relatively speaking. The term **seasonal high water table** is the highest level of a saturated zone in the soil in moist years. Soil colors indicate the depth to the seasonal high water table:

dull or grayish colors or mottled	→	saturated soil
tan, brown, red or brightly-colored	→	unsaturated soil

To lower the water table, some soils with naturally high water tables are drained. Installing drain tiles is one method of subsurface drainage. In the past, drainage systems were installed by digging trenches below the water table and placing adjoining clay tiles (one to two feet long) along the bottom of the trench. Today, trenching machines are used to dig the trench and automatically place continuous, perforated plastic tubing into the trench. In either case, when water tables rise, water enters the drainage system and is discharged elsewhere.

The depth to bedrock and the seasonal high water table for given soil types are generally found in NRCS county soil surveys. In these surveys, two types of water tables are indicated: **apparent** and **perched**. For biosolids recycling, only the apparent water table depths must be considered. A soil type with a perched water table has unsaturated soil above and below the saturated zone and will still perform as an effective filter.

MN Rules Chapter 7041: Seasonal high water table and bedrock

📖 A soil profile must provide at least a three-foot depth between the zone of biosolids application and the seasonal high water table and bedrock.

📖 For highly permeable soils, the soil profile must provide at least a five-foot depth between the zone of biosolids application and the seasonal high water.

📖 A perched water condition shall not be considered a seasonal high water table.

📖 The depth to subsurface drainage tiles shall be considered the depth to the seasonal high water table for sites with tile drainage systems that are designed according to or equivalent to NRCS engineering standards and criteria.

Soil pH

Soil pH is a measure of the acidity or alkalinity of a substance. In biosolids recycling, soil pH is important for two reasons:

1 **Crop growth and nutrient availability.** Nutrients are most available to plants at a soil pH range of 5.5 to 7.5. In addition, the favorable pH range for most common crops is also 5.5 to 7.5. (One common crop where soil pH plays a significant role is alfalfa. For alfalfa to yield a good crop, the soil must have a pH above 6.5.) Since we depend on crops to remove nitrogen supplied by biosolids, ensure that the soil pH is optimal for plant growth and nutrient uptake. If crops are stressed because of unsuitable soil pH or other conditions, the nitrogen that is applied could leach to ground water before being used by the crop.

2 **To reduce the plant-availability of trace metals, such as cadmium.** Under low soil pH conditions, plants and crops can take up considerable amounts of cadmium through the roots. If this happens, there is a greater chance of cadmium passing through the food chain.

If soil pH is low, certain substances can be amended to the soil to raise the pH. Suitable soil amendments for biosolids application sites include agricultural limestone, spent water treatment lime, wood ash, lime kiln dust, marl and bone meal. The finer the particle size of the amendment, the faster the pH will rise. Agricultural limestone will take approximately one year to change soil pH, whereas spent water treatment lime will take only a few weeks.

Soil pH at biosolids recycling sites is determined by direct analysis of composite soil samples. Soil sampling techniques are discussed in Chapter 10.

MN Rules Chapter 7041: Soil pH

📖 The pH of the soil must be 5.5 or greater.

Soil phosphorus level

In Minnesota, phosphorus is the leading contributor to eutrophication of lakes. Phosphorus enters surface waters by many different routes. One route is through soil erosion. Since soil phosphorus is not readily soluble, runoff from biosolids application sites should not contribute a major amount of phosphorus to nearby surface waters. However, erosion and movement of soil particles can contribute phosphorus to lakes and streams. For this reason, biosolids operators must ensure that biosolids application programs are following best management practices for slopes and surface water setbacks.

As one can imagine, soils with high phosphorus levels are more of a threat to surface water pollution than those with low phosphorus levels. When biosolids are applied annually to a site, soil phosphorus levels can build up in the soil to high levels. This can happen when biosolids are applied to meet a crop's nitrogen demand when the biosolids application supplies more phosphorus than the plants need.

High levels of soil phosphorus are not necessarily a problem to crops, nor are high levels always a threat to surface waters. If soil conservation practices are followed at the biosolids application site, it is unlikely that high soil phosphorus levels will be a threat to off-site surface waters.

Determine soil phosphorus levels of soil at biosolids recycling sites by analyzing composite soil samples (see Chapter 10).

MN Rules Chapter 7041: Soil phosphorus level

📖 Bulk biosolids application to a site must be suspended when the soil extractable phosphorus content, determined by the Brays P-1 test, exceeds 200 parts per million (400 pounds per acre) in the surface six inches of soil unless it is demonstrated through a management plan approved by the MPCA that all erosion control practices as determined necessary by the NRCS are in place and maintained.

Soluble salt content of soil

All soils contain salts. Many salts, such as potassium, calcium and magnesium are essential in soil because they are plant nutrients. However, when the level of salts becomes excessive in soil, most plants and crops are negatively affected. Reduced plant vigor, stunting, low yields, poor germination and seedling mortality may result. Fertilizers, manures, road spray and biosolids contribute salts to soils. Some soils also have naturally high salt levels.

As mentioned before, growing conditions for crops at biosolids application sites should be optimal. This is important to ensure that the nitrogen applied (as biosolids) is taken up by the crop, thereby reducing the chance for nitrogen to leach into ground water. In general, soluble salt contents below 4 mmhos/cm will not impact common agricultural crops or plant species in Minnesota.

In the western United States, soils with high soluble salt contents are common. To reduce the salt content, farmers flush or leach the soils with irrigation water. However, this type of remedy is not feasible for biosolids operators unless the application site is irrigated. If the site is not irrigated, natural precipitation will eventually reduce the soluble salt content.

Determine soluble salt content of soil at biosolids recycling sites by analyzing composite soil samples (see Chapter 10). The analysis consists of passing an electrical current through a saturated soil sample. The higher the salt level, the higher the sample's electrical conductivity.

MN Rules Chapter 7041: Soluble salt content of soil

📖 Bulk biosolids application to a site must be suspended when the electrical conductivity of the saturation extract of the soil exceeds four millimhos per centimeter as determined by the soluble salt test.

Organic soils

In Minnesota, many regions have predominantly organic soils. Peat bogs and fens are examples of areas having organic soils. Organic soils evolve when vegetative production exceeds decomposition. These conditions generally occur in cool, wet climates.

In their natural state, organic soils have very shallow water tables and are unsuitable for biosolids application. However, many organic soils have been artificially drained, primarily by ditching, so they can be used for growing crops. Under this situation, biosolids may be a suitable soil amendment.

The locations of organic soils are shown on NRCS county soil surveys.

MN Rules Chapter 7041: Organic soils

📖 Organic soils or peat soils must not be used for bulk biosolids application unless subsurface drainage is provided by a system designed according to or equivalent to NRCS engineering criteria.

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Chapter 8

Using legal descriptions &

County soil surveys

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The preceding chapter discusses the soil characteristics that biosolids managers must consider before seeking MPCA approval for land applying biosolids. The soil characteristics that have regulatory limits are listed below, along with information on where it can be found.

Soil characteristic	Where it can be found
soil texture seasonal high water table depth soil permeability bedrock depth organic soils	NRCS[1] county soil surveys
highly permeable soils	County SWCD office
soil texture soil pH soil phosphorus level soil soluble salt content	Soil sampling & analysis

[1]*NRCS = Natural Resources Conservation Service*

Because much of the information one needs to determine soil suitability is found in NRCS county soil surveys, it is important that biosolids managers become familiar with these useful tools. The first step in using a soil survey is to find the proposed biosolids application site on the appropriate map sheet in the soil survey. To do this, one must be able to interpret legal descriptions.

Using legal descriptions

All property is described by its location within a grid system that was developed by surveyors and the U.S. government. You can get legal descriptions from tax records and county plat map books.

The legal description describes units of land broken down into the smallest unit of land. These units of land are given in the following order, from smallest to largest:

- portion of section (parcel) — *smallest*
- section ↓
- township and range — *largest*

However, to use a legal description to find a parcel of land, you must start with the largest unit, the township, which is found at the end of the legal description.

Example

In this chapter, we use the following example to illustrate how to locate a piece of property using a legal description:

SE ¼ of SW ¼ of Section 10, Township 34 North, Range 21 West

To find this piece of property, locate the units of land in the following order:

1. township and range (T34N, R21W)
2. section (10)
3. parcel (SE ¼ of SW ¼)

Townships & ranges

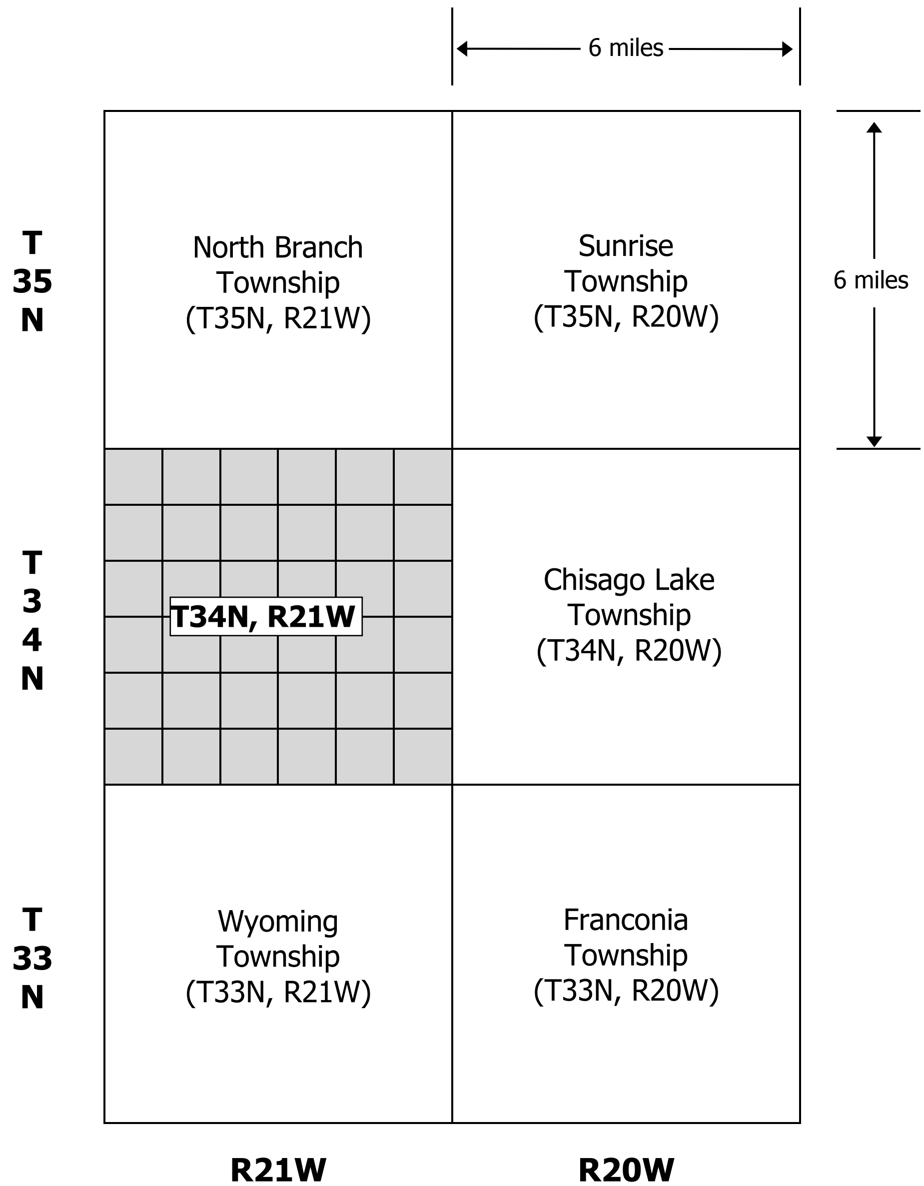
Township and range numbers are assigned to a grid system (system of squares) that surveyors use to identify specific areas of land. A township/range is normally six miles square (except when the curvature of the earth must be compensated). The township coordinate describes the location in an east-west orientation. In contrast, the range coordinate describes the location in a north-south orientation.

The geographical term **township** should not be confused with the governmental term **township**. Township government units normally have names. These townships are units of government that may be larger or smaller than six square miles.

Next is a township/range numbering scheme and township names for a portion of Chisago County.

Figure 3
Locating townships in a county

In gray is the example township of **T34N, R21W**. Each township/range coordinate contains 36 sections.

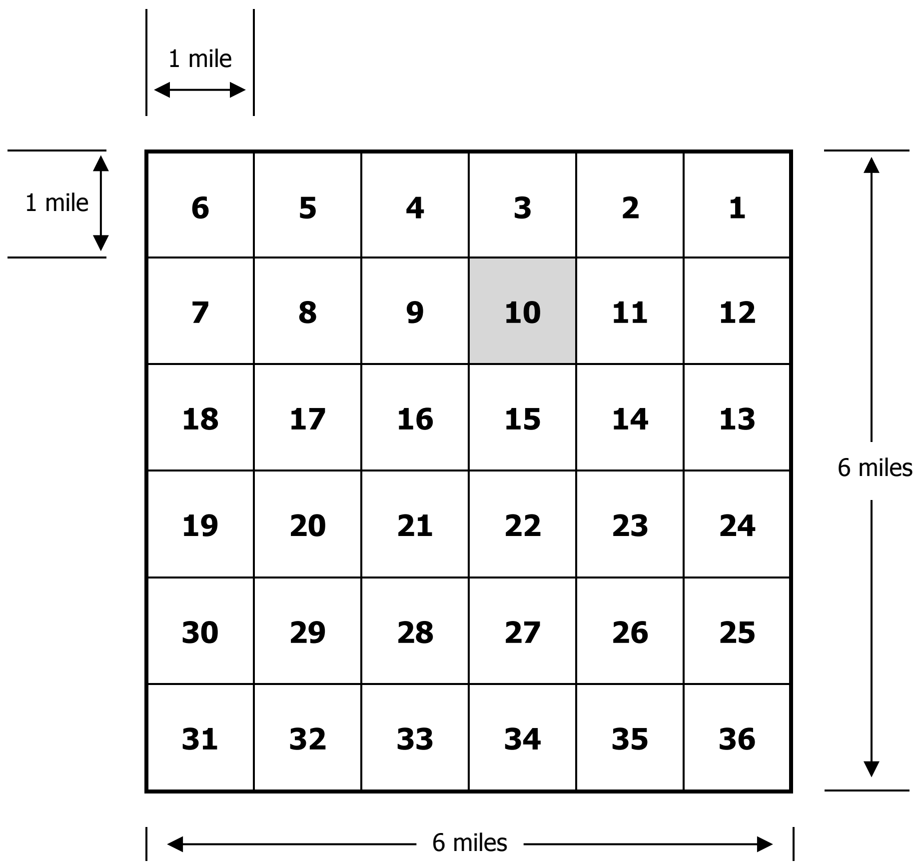


Sections

The next smallest unit of land is the **section**. Each township/range grid contains 36 sections. Sections are normally one mile square (once again, except when the curvature of the earth must be compensated) and contain 640 acres. The system below is always used to number sections.

Figure 4
Locating sections in a township

Sections in a township are numbered as shown in this diagram. In gray is Section 10 of our example. As stated earlier, each township contains 36 sections, and each section is 1 mile by 1 mile.



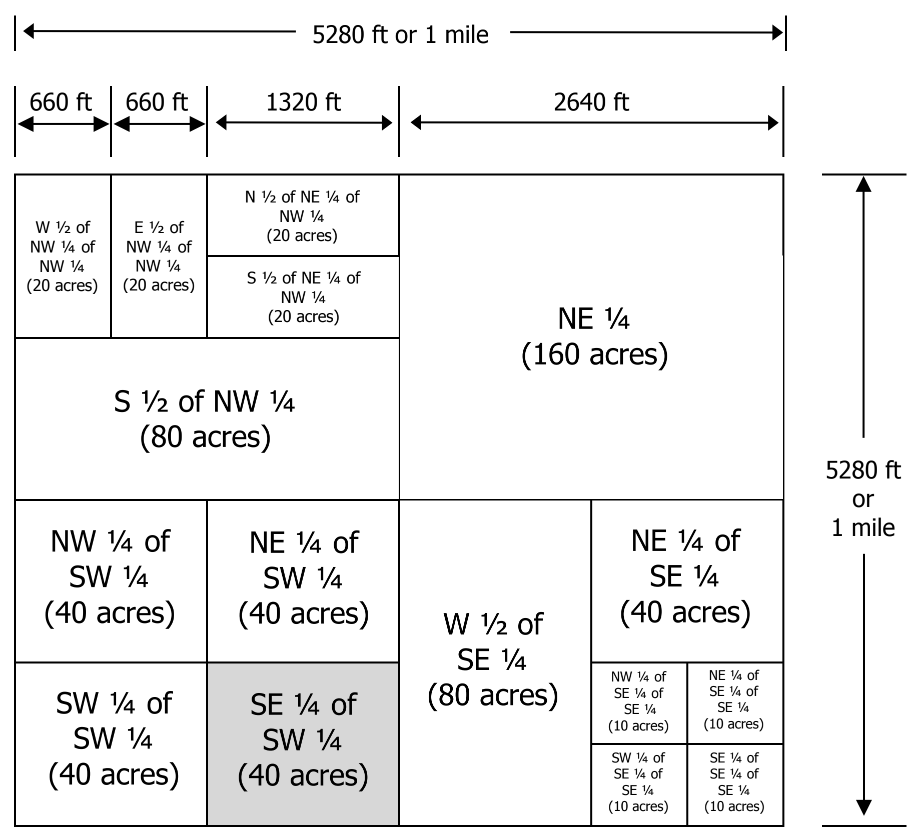
Parcels (parts of sections)

The parcel is the smallest unit of land for unplatted land (unplatted land is given a Lot/Block/Subdivision numbering scheme). Land within a section is broken down into quarters or halves, and the location of that quarter or half is described using compass directions (N, S, E, W).

Figure 5

Locating parcels of a section

In gray is the SE ¼ of the SW ¼ of Section 10 of our example. As you can see, pieces of land can be subdivided into very small areas, as in the lower right corner.



Using county soil surveys

"Modern" soil surveys (those taken since about 1970) contain a variety of information including:

- aerial photographs
- detailed soils information
- evaluations of soil types for an assortment of land uses

Appendix F contains a map showing the status and availability of soil surveys for Minnesota. The Web site for Minnesota soil survey information is **http://www.mn.nrcs.usda.gov/soils/soils.html.**

Index to map sheets

The main purpose of the *Index to Map Sheets* is to show the map sheet number on which the detailed soils map can be found. To find the appropriate map sheet number, locate the legal description on the *Index to Map Sheets*.

To use a county soil survey, first review the *Index to Map Sheets*. This index is generally a large foldout map of the entire county and is usually located just after the text of the survey. The *Index to Map Sheets* shows the boundaries of the county, cities, lakes and watercourses, major roads, township and range numbers, and section borders. Not all sections are numbered on the map — only the sections in the corners of a township/range coordinate are numbered (i.e., Sections 1, 6, 31 and 36).

Map sheets (detailed soils maps)

Most county soil surveys have several dozen detailed soils maps or *Maps Sheets*. These sheets are found at the end of the soil survey.

Soil surveys use aerial photographs as a base for these maps. Generally the scale of these maps is one of the following:

1:24,000	or	1 inch = 2,000 feet	or	2.64 inches = 1 mile
1:20,000	or	1 inch = 1,667 feet	or	3.17 inches = 1 mile
1:15,840	or	1 inch = 1,320 feet	or	4.00 inches = 1 mile

The map sheets (aerial photographs) have usually been altered by soil scientists to show the features listed below. A description or legend of these features is found on the reverse side of the *Index to Map Sheets.*

- soil boundaries and symbols
- slope
- erosion status
- cultural features (e.g., cemeteries, airports, roads, dams, etc.)
- water features (e.g., drainage ways, lakes, ponds, rivers, marshes, etc.)
- special features (e.g., wet spots, sandy spots, steep slopes, etc.)

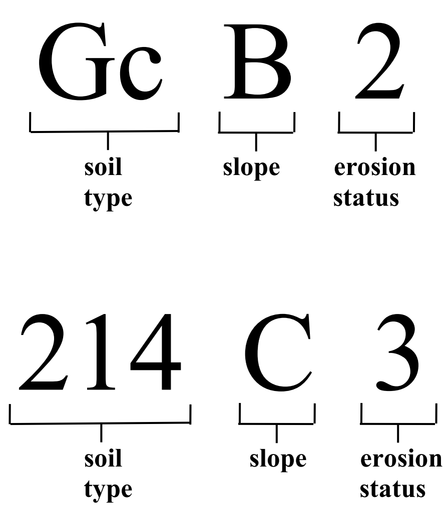
See Appendix F for an example of a soils map.

Soil symbols & other features on map sheets

Soil types

On map sheets, boundaries of soil types are shown by lines with a number or two-letter symbol (of the latter type of symbol, the second letter is lower case) inside the lines (see Figure 6).

Figure 6
Soil symbols



Slope

Slope is the vertical rise or fall over a given horizontal distance. Slope is represented by a capital letter immediately after the symbol for soil type (recall that symbols for soil type can be letters or numbers). Symbols for slope generally range from **A** to **F**, with **A** being the flattest (has the least slope) and **F** being the steepest (has the most slope). If the symbol contains either **A** or no letter at all, it indicates that the slope of the land is less than 2%. The slope range is usually given in the *Soil Legend*.

In the examples in Figure 6 the capital letters **B** and **C** indicate slope. For an example of the soil legend used in the Chisago County soil survey, see Appendix F.

Erosion

Biosolids managers must consider the extent of erosion when determining if a site is suitable for biosolids application. A one-digit number found immediately after the slope designation shows the extent of soil erosion. In the example, the **2** of **GcB2** and the **3** of **214C3** indicates that the surface of the soil has been eroded in both of these soils. Following is a key to erosion designations:

Number		**Amount of erosion**
(blank)	→	no significant erosion has occurred on soil surface
2	→	soil surface has been eroded
3	→	soil surface has been severely eroded

There is no number 1 to indicate the amount of soil erosion.

Cultural & physical features

The symbols for cultural and physical features are usually in the *Conventional and Special Symbols Legend* of soil surveys. See Appendix F for an example of this legend used in the Chisago County soil survey.

If you're not using this manual in class or do not have a soil survey, a set of sheets from a survey is in Appendix F.

Soils information tables

Soils information tables contain most of the information necessary to evaluate a soil for biosolids recycling. These tables are normally provided at the end of the text of most soil surveys. Some soil surveys contain this information in one table; others use several tables.

See Appendix F for examples of soils information tables from the Chisago County soil survey. Soils information tables contain lists of symbols for the soil types found in the county. These lists are either alphabetical or numerical. Each soils information table provides detailed information about the soil property featured in the table.

Example table		Gives information about:
Engineering Index Properties	→	thickness and texture of soil horizon
Physical and Chemical Properties of the Soils	→	soil permeability
Soil and Water Features	→	depth to water tables and bedrock

Chapter

9 Site restrictions & management

The previous chapter focuses on how to identify a site in a soil survey and where to go in the survey to find soil information. This chapter focuses on using the soil survey to determine if the site is suitable because of its physical features such as slope, surface water, and cultural features such as parks or residences. The applier must understand the restrictions of these features to delineate (outline) the correct boundaries of the application site.

Requirements for site suitability and management practices protect public health, surface water and ground water from components of concern in biosolids, such as nutrients, pathogens and metals. The requirements accomplish this through:

- Restrictions on slope and depth to the water table allow biosolids to contact soil long enough so that the soil can act as a physical, chemical and biological filter (see Chapter 3).
- Slope restrictions and separation distances help prevent biosolids from moving into surface waters or wetlands.
- Slope restrictions help keep biosolids where they are applied. This is necessary to ensure biosolids are applied at agronomic rates across the application site.
- Separation distances and public access controls help prevent the public from coming into contact with biosolids.

Separation distances and slope restrictions

MN Rules Chapter 7041: Basic requirements for slopes and separation distances

🕮 When biosolids are applied to **agricultural land,** the suitable slopes and separation distances in Table 10 must be met**.**

🕮 When biosolids are applied to **non-agricultural land,** the conditions in Table 10 must also be met, unless approved by the MPCA.

If non-agricultural land does not meet all the requirements in Table 10, the applier may request modifications to the suitable soil, slope or separation distances. In the application form, the applier must describe the conditions that could be modified and the intended environmental benefits.

MN Rules Chapter 7041: Applying biosolids near wetlands or surface waters

🕮 Do not apply bulk biosolids less than 33 feet (10 meters) from all surface waters or wetlands, unless allowed by permit. Thirty-three feet is also the absolute minimum separation distance to surface waters and wetlands specified in the federal regulations. As shown in Table 10 however, separation distances to surface water and Types 3, 4, and 5 wetlands ranges from 50 to 200 feet. All the remaining types of wetlands not included in Table 10 require the minimum separation distance of 33 feet.

Generally, soils close to wetlands are not suitable for land application because they have high seasonal water tables. Because of this condition, a setback naturally occurs by applying biosolids only to those soils that meet the 3-foot separation distance from the zone of application to the water table.

Sometimes a wetland can be in a depression and the soil right up to the edge of this depression may be suitable for biosolids. An example of such a situation is a prairie pothole where the elevation between the wetland and the surrounding landscape is very different. In this case, the operator must determine the correct separation distance, depending upon the wetland type.

How to identify types of wetlands

When using Table 10, an applier may need to distinguish between types of wetlands to determine the correct separation distance. Wetlands are classified into 8 types — Types 1 through 8. As already discussed, Types 3, 4 and 5 wetlands generally contain water all the time. However, the applier can positively identify the type of wetland by using the following:

Table 10

Allowable separation distances and slopes for applying bulk biosolids

Minnesota's rules specify the percentage of slope allowed at a site on which biosolids are applied, as well as the minimum separation distances from the applied biosolids to the features listed in this table. All allowable slopes and separation distances depend upon the method used to apply the biosolids.

Criteria	If surface applied...	If incorporated within 48 hours...	If injected...
For all land types			
Allowable slopes	0% - 6%	0% - 12%	0% - 12%
Depth to bedrock	3 ft. [1]	3 ft. [1]	3 ft. [1]
Depth to seasonal high water table[2] or drain tile[3]	3 ft. [1]	3 ft. [1]	3 ft. [1]
Distance to wells:			
Private supply	200 ft.	200 ft.	200 ft.
Public supply	1000 ft.	1000 ft.	1000 ft.
Irrigation	50 ft.	25 ft.	25 ft.
Distance to residences[4]	200 ft.	200 ft.	100 ft.
Distance to residential development[4]	600 ft.	600 ft.	300 ft.
Distance to public contact site[4] (public parks, ball fields, cemeteries, golf courses etc.)	600 ft.	600 ft.	300 ft.
Distances to down gradient[5] lakes, rivers, streams, Types 3, 4, & 5 wetlands, intermittent streams[6], or tile inlets connected to these surface waters, and sinkholes			
Slope 0%-6%	200 ft.	50 ft.	50 ft.
Slope > 6%-12%	N/A	100 ft.	100 ft.
Distances to grassed waterways[7]			
Slope 0%-6%	100 ft.	33 ft.	33 ft.
Slope 6%-12%	N/A	33 ft.	33 ft.

[1]Depth is calculated from the zone of biosolids application. The separation distance for highly permeable soils is 5 feet. The zone of application is where the biosolids are placed, such as on the surface or injected 8 inches.

[2]A perched water condition is not considered a seasonal high water table.

[3]The depth to subsurface drainage tiles is the depth to the seasonal high water table for sites with tile drainage systems designed according to (or equivalent to) Natural Resources Conservation Service engineering standards and criteria.

[4]Separation distances may be reduced with written permission from all persons responsible for residential developments and places of recreation and all persons inhabiting within the otherwise protected distance. Residential development means ten or more places of habitation concentrated within ten acres of land and also includes schools, churches, hospitals, nursing homes, businesses, offices and apartment buildings or complexes with ten or more living units.

[5]If down gradient surface water does not receive runoff from a bermed site, separation distances can be reduced to 33 feet.

[6]Intermittent stream means a drainage channel with definable banks that provides for runoff flow to a perennial stream, lake or wetland during snowmelt or rainfall.

[7]Separation distances are from the centerline of grassed waterways. For grassed waterways that are wider than these separation distances, biosolids can be applied up to the edge of the grass. Grassed waterways are natural or constructed, typically broad and shallow, and seeded with grass to help prevent erosion.

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- National Wetlands Inventory Maps
- Fish and Wildlife Service Circular 39: *Wetland Types and Definitions*
- Wetland Identification Sheet

First identify your site on a National Wetlands Inventory Map. You can do this at your local Soil and Water Conservation District (SWCD) office. They are actually overlays of the U.S.G.S. quadrangle maps, so you need to know the name of the U.S.G.S. quadrangle map on which the site is located. Also, you can purchase National Wetland Inventory maps from the Minnesota Bookstore for approximately $5.00 (again, you must know the name of the U.S.G.S. quadrangle map). Contact:

Minnesota Bookstore
Ford Building, 117 University Ave., St. Paul, MN 55155
Phone: (651) 297-3000, toll free 1 (800) 657-3757
Fax: (651) 296-2265

Secondly, locate any wetlands shown on the National Wetlands Inventory map. Compare their lettered designation (i.e., PUBF) to the descriptions on the Wetland Identification Sheet, Table 11, to determine what types they are.

Information similar to that provided by National Wetlands Inventory Maps but not as detailed, is shown on the Fish and Wildlife Service Circular 39, *Wetland Types and Definitions*, which is included for reference. Pictures in this circular will give you an idea of what Types 1-8 wetlands look like.

Example: Using a National Wetlands Inventory Map

The example site is located in the N 1/2 of the NW 1/4 of section 36, township 33 N, range 20 W (see Figure 7). To use a National Wetlands Inventory Map to find the correct separation distance, follow these steps:

1 The SWCD indicates that this site is on the Scandia quadrangle map (a portion of this map is shown on the next page). Find Section 36 and delineate the legal description on it.

2 Three areas are mapped as part of the wetland inventory on this site. They are PEMC, PUBG and PEMB. Match these designations to the types of wetlands listed on the Wetland Identification Sheet (see Table 11) PEMB is Type 8, PUBG is Type 5, and PEMC is a Type 3 wetland. Notice that PEMB is also listed as a Type 2.

3 Determine the separation distances. Since Type 2 and Type 8 wetlands require the same separation distance, so either classification gives the correct separation distance.

4 Open Circular 39 to get an idea what these types of wetlands look like and to read detailed descriptions of them.

Figure 7
National Wetlands Inventory Map

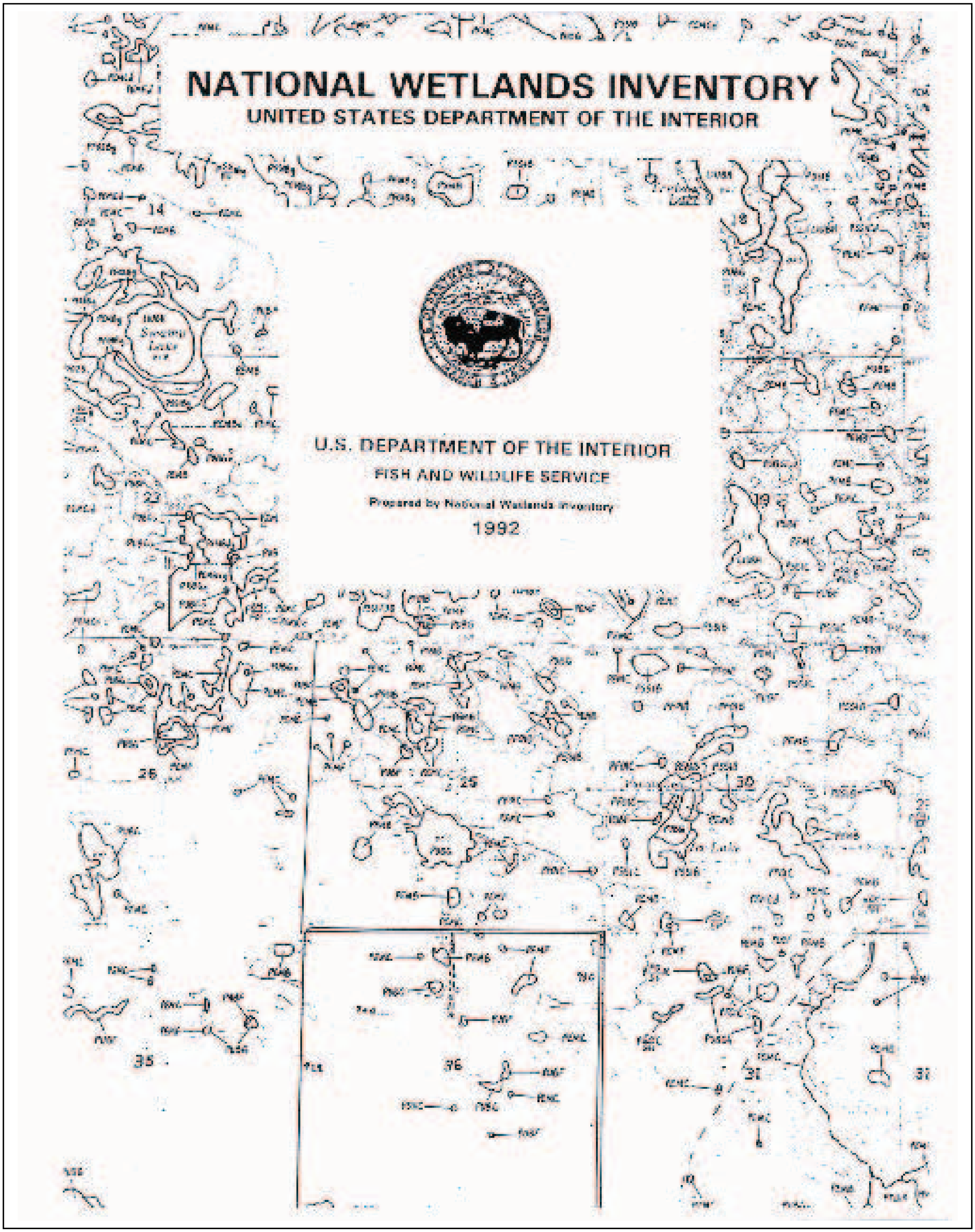


Table 11

Wetland Identification Sheet:

Conversion of wetland habitats to Circular 39 Wetland Types

It is important to note that there is not a one to one conversion or crossover — for example, a PEMF wetland could be a type 3 or type 4 wetland and PABG and PUBG could be a type 4 or type 5 wetland. Water regimes denoted with a ([1]) may be reported as type 3, 4 or 5.

Circular 39	Wetland Designations
Type 1	PEMA PEM1A PEM1J PFOA PF01A PFO1J PUS
Type 2	PEMB PEM1B
Type 3	PEMC and F[1] PEM1C PSSH PEM1F PUBA and C
Type 4	L2ABF L2EM2F, G and H L2EMF[1] and G[1] PEMF L2US L2ABG L2ABH PABF and G[1] PEMG and H PUBB PUBF PUBG
Type 5	L1 L1UBH PABG L2ABG[1] and H L2RS PABH L2UB, G, and H PUBG[1] and H L2EMA, B, and H
Type 6	PSSA, C, F, and G PSS1, 2, 3, 4, 5, or 5A, B, C, F, J, and G and PSS6B
Type 7	PFO1, 2, 4, 5, and 6B PFOC AND F PFO5A, B, C, F, J
Type 8	PFO2, 4, and 7B PMLB PEMB PSS2, 3, 4, and 7B PSS1, 2, 3, 4, or 5B PFO1, 2, 4, or 5B

MN Rules Chapter 7041: Applying biosolids on land that is subject to flooding

📖 On land that is subject to flooding, biosolids must be injected or incorporated within 48 hours of surface application.

It is unlikely that a flooded area would meet other soil or site requirements. However, if the site is suitable, this requirement prevents biosolids from directly entering surface water or wetlands.

MN Rules Chapter 7041: Applying biosolids on frozen and snow-covered land

📖 On frozen and snow covered land:

- Apply biosolids on 0 - 2 % slopes only.
- For liquid biosolids, the maximum hydraulic loading rate is 15,000 gallons per acre.
- For liquid biosolids, the separation distance to surface water is 600 feet.

The minimum federal and state requirement for frozen and snow-covered land is that biosolids do not run off the land and enter surface waters or wetlands. The MPCA does not prohibit applying biosolids on frozen or snow-covered land, but if attempted, specifies how it should be done. EPA informally recommends that biosolids applied in winter be put on areas with little slope.

Because liquid biosolids can melt snow, this minimum requirement is particularly important. The added liquid from melted snow increases the chance that biosolids will run off the area to which biosolids are applied. This, in turn, can cause ponding. To address problems associated with ponding, state requirements also limit the hydraulic loading rate to a frozen or snow-covered site and call for a greater separation distance to surface waters. The minimum separation distance to other features, such as wetlands, are shown in Table 10.

MN Rules Chapter 7041: Applying biosolids near threatened or endangered species or critical habitat

📖 Biosolids must not be applied to land if it is likely to adversely affect a threatened or endangered species or their critical habitat.

In general, if biosolids are applied to cultivated land, you can be reasonably sure that the biosolids will not adversely affect endangered species. This generalization may not hold true, however, for forested land or unusual habitats. If you have questions about a site, contact the DNR Natural Heritage and Nongame Research Program before proposing the site for biosolids application.

If threatened or endangered species are identified within or near a potential application site, the DNR may suggest solutions to alleviate the problem. For example, a buffer zone can increase the distance between the biosolids and the endangered specie's critical habitat. The applier must include such possible solutions on the Site Application form.

To the best of their knowledge, operators must keep a record of meeting the above requirement as a signed certification statement (see Chapter 13).

Because most sites are on cultivated farm fields, checking with the U.S. Fish and Wildlife Service on each site would be time consuming. The MPCA is working with the Department of Natural Resources (DNR) and the U.S. Fish and Wildlife Service to develop a way to assure biosolids appliers that they are complying with this requirement without having to contact them about every site.

Staking a site and calculating acreage

MN Rules Chapter 7041: Marking boundaries of application sites

📖 The boundary of a land application site must be identified prior to and during application using conspicuous flags placed to achieve a clear and positive identification of the suitable site boundary unless apparent boundaries, such as fence rows, roads, tree lines, type of vegetation or steep slopes exist.

Many sites contain pockets of unsuitable soils or are located near features that require the applier to maintain a certain distance from these features. Separation distances and unsuitable acres must be marked for or by the applier. Make sure this delineation appears on the soil map submitted with the Site Application.

The applier must be realistic when determining the area of application. This makes it easier to calculate site acreage and give the farmer correct information.

How to calculate areas

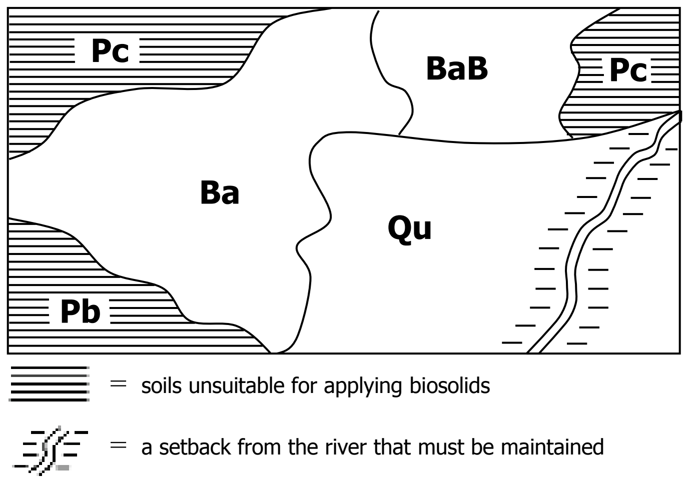
To calculate the number of acres in a designated area, multiply the length by the width of the area and divide by 43,560 (there are 43, 560 sq. ft. in an acre). For calculating areas of other shapes (i.e.; triangular), see the Wastewater Formulas Book available from a course instructor.

$$\frac{\text{Length (ft) x width (ft.)}}{\text{43,560 sq. ft.}} = \text{acres}$$

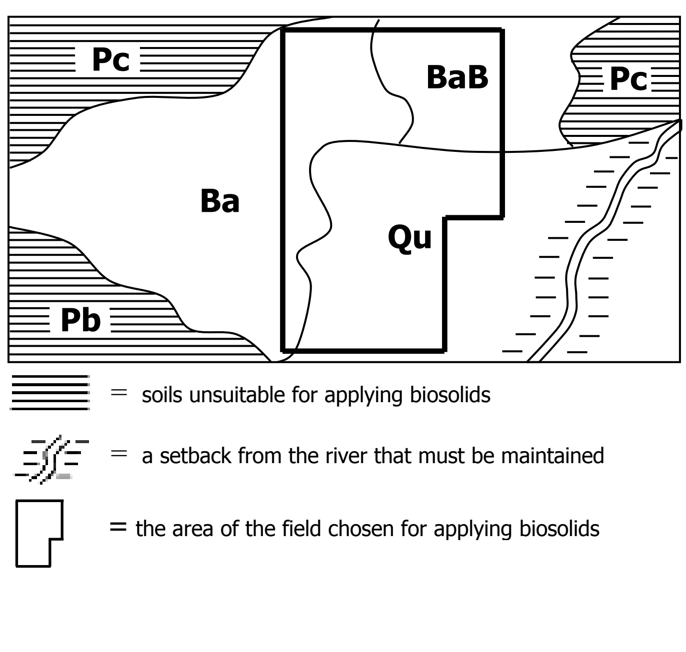
If a site contains all suitable soils and no setbacks occur, the acreage for a particular field is usually available from the Farm Service Agency (formerly the Agricultural Stabilization and Conservation Service) on aerial photographs. Copies of these official USDA aerial photographs are available to anyone and show detailed field acreage. Another way to find acreage is by using U.S.G.S. aerial photographs. Although these aerial photographs do not show acreage, you can calculate the acreage based on the map scale. U.S.G.S. aerial photographs throughout the U.S. can be found on the following Web site: **terraserver.microsoft.com**

Example: Delineating a site and calculating acreage

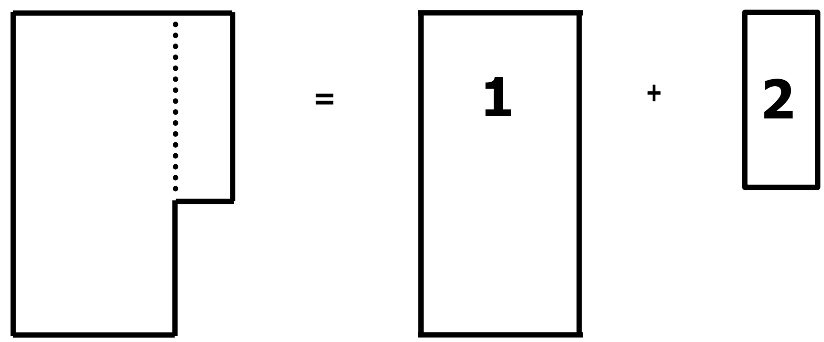
1 **Consider the characteristics of the following field:**



2 **Determine a suitable site.** After determining the suitable areas and setbacks, consider how the application site should be set up — discuss this with the farmer. Farmers are likely to drive equipment in straight rows or on contours, so it is important to stake out an application site with the farmer's needs in mind. This is particularly important if the site contains soils unsuitable for biosolids, creating an irregular area for application. The flip side of having an irregular area for application is that it may be difficult for the farmer to apply fertilizer to the remaining odd-shaped areas. In addition, it is difficult to calculate acreage on an irregular site. For this example, a reasonable area for site application might be:



3 **Calculate the total acreage of the application site.** In this example, the site can be divided into two rectangles to calculate the site's total acreage. First you'll need the dimensions (length and width) of each rectangle — you'll have to measure each "rectangle" in the field. Then to calculate total acreage, you'll have to calculate the area of each rectangle and then add these two values.



Area (# of acres) chosen for biosolids = **Area of Rectangle 1** + **Area of Rectangle 2**

$$= \frac{\text{Length x width (feet)}}{\text{43,560 sq. ft.}} + \frac{\text{Length x width (feet)}}{\text{43,560 sq. ft.}}$$

= ______ + ______

= ______ acres

Sampling and analyzing soil

When the site is properly located with respect to other land features, and the soil characteristics are researched using the soil survey, a soil analysis is also needed to determine if the site can be used for biosolids application. To conduct soil tests, collect soil samples and analyze them through a laboratory.

MN Rules Chapter 7041: Soil analyses

📖 Soil must be analyzed at least once in the three-year period before biosolids are applied, unless stipulated otherwise in a site approval letter, and always when applying for site approval. The analysis must include:

- ❑ soil texture (USDA)
- ❑ organic matter (%)
- ❑ extractable phosphorus (ppm)
- ❑ exchangeable potassium (ppm)
- ❑ pH
- ❑ soluble salts (mmhos/cm) — sometimes called specific conductance

Chapter 8 discusses limits and using information from these parameters.

How to collect soil samples

Analytical results are only as reliable as the methods used to collect the sample. Samples must be **representative** of the field being sampled. The following is a list of **do's** and **don'ts** to get a representative sample.

To get a representative sample, do the following:

- ❑ Collect a minimum of one composite sample per 40 acres on relatively flat fields; more samples may be needed based on how many soil types are on the site, previous fertilization, liming, crops grown, land management and soil texture.
- ❑ Stay at least 300 feet from roadways.
- ❑ Scrape away all surface vegetation.
- ❑ Sample only the top 6 to 9 inches.
- ❑ Break up soil clods.
- ❑ Sample soil at 15 to 20 random locations, mix samples, take an adequate quantity, air dry, and send the **composite sample** for analysis.

To get a representative sample, don't sample the following:

- ❑ dead furrows
- ❑ terraces, fence rows, roads
- ❑ animal droppings, urine spots
- ❑ eroded knolls or low spots

When to sample

As already mentioned, the operator must sample when applying for site approval. This analysis must be done within 6 months of submitting a Site Application. Other than this, soil may be sampled any time of year when weather permits and before the farmer applies fertilizers or other soil amendments.

Other sampling details

- ❑ Use clean sampling equipment (spade, auger, pails)
- ❑ Dry the sample at room temperature before sending it to the lab.
- ❑ Fill out a lab sheet from the lab you choose to use. This should accompany the sample so that all the necessary parameters are done. For example, a routine soil analysis does not include the soluble salt test. See Appendix F for two examples of lab sheets.

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Chapter 10

How to calculate

Application rates of biosolids

The effects of biosolids on crops and the environment rely on the biosolids manager's ability to accurately calculate the amount of biosolids to apply to a particular parcel of land. Nitrogen and metals are two important components of biosolids, and calculations concerning these components are some of the most important that biosolids managers must make. Inaccurate calculations can lead to over-applying nutrients and metals, which can harm the environment. Incorrect calculations could also result in under-applying nutrients, which can result in poorer crop yields than expected.

The operator's ability to accurately calculate the amount of biosolids to apply to a parcel of land relies, in part, on the operator's knowledge of taking truly representative samples of the biosolids (see Chapter 5).

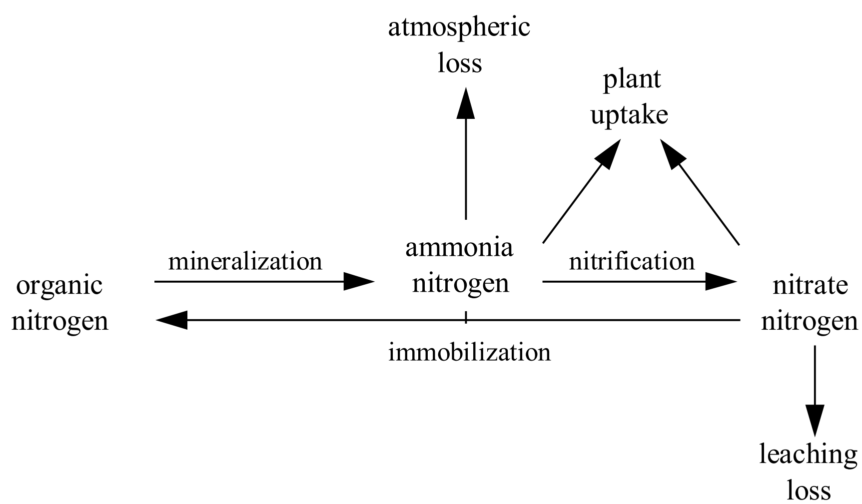
Concepts of applying nitrogen to the land

In Minnesota, biosolids should be applied to land at the rate at which it supplies no more available nitrogen than the vegetation or crop can use during the growing season. This is called the **agronomic rate for nitrogen**. Then, if biosolids are used to supply the agronomic rate of nitrogen (as opposed to the agronomic rate for phosphorus, potassium or lime, for example), this rate can be referred to as the **agronomic rate of biosolids**.

Nitrogen processes in soil

Before discussing how to calculate the agronomic application rate of biosolids, one should first understand the soil processes that affect nitrogen. Most of the nitrogen in biosolids is in two forms — ammonia nitrogen and organic nitrogen. Figure 8 shows the nitrogen cycle of land-applied biosolids.

Figure 8
Nitrogen cycle of biosolids



Ammonia nitrogen

The ammonia nitrogen in biosolids is immediately available for plant uptake. When biosolids are applied to the surface of the land, a portion of the ammonia nitrogen present in the biosolids can volatilize into the atmosphere and be lost. For calculations, we assume the loss of ammonia nitrogen is 50%, unless the biosolids are injected or incorporated within 48 hours.

In the soil, ammonia nitrogen is firmly held in the root zone by cation exchange processes and will not leach. However, when soil temperature and moisture conditions are right, ammonia nitrogen will convert to nitrate nitrogen by soil microorganisms in a process called **nitrification**. Like ammonia nitrogen, plants can also take up nitrate nitrogen immediately. Unlike ammonia nitrogen, nitrate nitrogen is very mobile in soils and can leach below the root zone if not taken up by plants.

Organic nitrogen

The other form of nitrogen in biosolids is organic nitrogen. Plants cannot use organic nitrogen. Soil microorganisms must mineralize it into the ammonia form before plants can take it up.

The mineralization rate depends primarily on the type of biosolids, soil temperature and soil moisture content. The more rigorous the process that is used to stabilize the biosolids at the treatment plant, the slower the mineralization rate of the organic nitrogen once it is applied to soil. In other words, if microorganisms have had a long time to decompose the biosolids at the treatment plant (as in digesters or compost piles), then the soil microorganisms will get "fed" biosolids that are not easily decomposed or degraded. Therefore, the mineralization process in the soil will be slower compared to being "fed" raw (undigested) biosolids.

As will be pointed out later when calculating the agronomic application rate of biosolids, each stabilization process has a different factor for organic nitrogen mineralization. The annual mineralization rates and corresponding calculation factor for the various biosolids stabilization methods are shown in Table 12.

Table 12

Nitrogen mineralization rates & calculation factors for biosolids treatment methods

	Treatment method			
Application history	**Anaerobic digestion**	**Aerobic digestion**	**Stabilized primary & waste activated**	**Composted**
The year biosolids are applied:				
Mineralization rate	20%	30%	40%	10%
Calculation Factor II	4	6	8	2
First year carryover N:				
Mineralization rate	10%	15%	20%	5%
Calculation Factor I	1.6	2.1	2.4	0.9
Second year carryover N:				
Mineralization rate	5%	8%	10%	3%
Calculation Factor III	—	1	1	—

Nitrogen mineralization is most rapid in summer. Because of this, it is important that a crop or some type of vegetation is present to use the available nitrogen that is produced during the warm months before it leaches past the root zone. Several regulations pertain to vegetation present during the summer months at application sites — see the following section.

Rules on agronomic rates of biosolids

Following are two summaries of rules concerning the timing of applying biosolids. Some of these are repeated elsewhere in this manual.

MN Rules Chapter 7041: Time of year restrictions

📖 Biosolids must not be applied to the land during June, July and August unless a crop is growing on the land or a crop is seeded within 14 days following biosolids application.

📖 Biosolids must not be applied to fallow land. **Fallow land** is land that is uncropped and kept cultivated throughout a growing season and has a vegetative cover of less than 25 percent. Any land that is uncropped and cultivated during September through May where a crop will be grown the following growing season is not considered fallow land.

📖 For highly permeable soils, biosolids must not be applied to the land during June, July, August or September unless a crop is growing on the land or a crop is seeded within 14 days following biosolids application.

📖 For highly permeable soils, biosolids applied in October shall be surface applied or applied with a nitrification stabilizer that extends the time the nitrogen remains in the soil in the ammonia form.

MN Rules Chapter 7041: Calculating the agronomic rate of biosolids

They following definitions and limitations pertain to the agronomic rate for applying biosolids:

Biosolids must be applied to land at an application rate that is equal to or less than the agronomic rate, unless the MPCA approves a higher rate, such as for a reclamation site

The method for calculating **the Maximum Allowable Nitrogen Application Rate** or **MANA rate** shall be provided by the MPCA and be based on all of the following:

- realistic yield goals. The **realistic yield goal** is the most recent five-year average of crop yields, excluding the worst year, or the most recent three- to five-year average yield increased by ten percent. If the crop has never been grown or records are not available, the county NRCS, county extension agent or crop consultants can recommend a realistic yield goal based on soil productivity and level of management.
- soil organic matter content
- previously grown crops

For alfalfa and clovers, none of which have recommended nitrogen application rates, the MANA rate must meet **one** of the following requirements:

- the MANA rate must not exceed 200 pounds per acre for alfalfa and 100 pounds per acre for clover, alfalfa grass and clover grass mixtures.
- MANA rates may be calculated for the crops above based on realistic yield goals based on actual measured yields in tons per acre multiplied by 50 pounds of nitrogen per ton.

For soybeans, calculate the MANA rate by multiplying the realistic yield goal in bushels per acre times 3.5 pounds of nitrogen per bushel.

The MANA rate after the second cutting of a hay crop must be no more than 50 percent of the recommended nitrogen application rate for the current cropping year.

Steps & calculations used to determine the application rate

Listed below are the major steps the biosolids manager must take to determine the proper amount of biosolids to apply to a particular parcel of land. Detailed instructions for these steps are on the pages listed below.

Table 13
Steps to determine application rate

How to calculate application rates for septage regulated under MN Rules Chapter 7041

See Chapter 14.

Step 1: How to determine the realistic yield goal

The **realistic yield goal** is the most recent five-year average of crop yields, excluding the worst year, or the most recent three- to five-year average yield increased by ten percent.

If the crop has never been grown or records are not available, the county NRCS, county extension agent or crop consultants can recommend a realistic yield goal based on soil productivity and level of management.

Step 2: How to determine the MANA rate

The biosolids manager must determine the Maximum Allowable Nitrogen Application Rate, or MANA rate, to determine the rate at which to apply biosolids.

The **Maximum Allowable Nitrogen Application Rate (MANA rate)** is the maximum allowable amount of available nitrogen that can be applied to a biosolids application site and is equivalent to the amount of nitrogen required by the crop or vegetation grown at the application site during a growing season. This rate is measured in pounds of nitrogen per acre (lbs N/acre).

The rule specifies that the MPCA should provide the biosolids manager with the method to determine the MANA rate. However, because MPCA staff is not always available, biosolids managers should learn the method approved by the MPCA to determine the MANA rate for the crop to be grown at the application site.

MANA rates are either fixed or must be calculated

Table14 lists the MANA rates for some crops and identifies the crops for which the operator must use a bulletin from the University of Minnesota to look up or calculate the rate. A copy of this bulletin, *Fertilizer Recommendations for Agronomic Crops in Minnesota,* is in the pocket of this manual.

Table 14
MANA rates
(Maximum Allowable Nitrogen Application Rates)

Crop	Examples	MANA rate
legume hay*	alfalfa	200 lbs N/acre ***or*** Yield goal (tons/acre) x 50 lbs N/acre
legume/grass hay*	clover alfalfa/grass mix clover/grass mix	100 lbs N/acre ***or*** Yield goal (tons/acre) x 50 lbs N/acre
grass hay*	brome grass orchard grass timothy	75 lbs N/acre ***or*** Yield goal (tons/acre) x 30 lbs N/acre
soybeans	—	Yield goal (bu/acre) x 3.5 lbs N
cover crops	small grains or other close growing vegetation not grown for harvest	50 lbs N/acre
other crops	corn oats sunflowers wheat	Use U of M bulletin: *Fertilizer Recommendations for Agronomic Crops in Minnesota,* BU-6240-E

**Reduce MANA rate 50% after the second cutting of hay.*

How to calculate the MANA rate

1 **Collect crop information.** For the biosolids manager to determine the MANA rate using the *Fertilizer Recommendations for Agronomic Crops in Minnesota*, first collect information related to the crop to be grown. This information includes:

- ❑ type of crop to be grown
- ❑ realistic yield goal
- ❑ soil organic matter content
- ❑ type of crop grown last year
- ❑ type of crop grown two years ago

2 **Determine the MANA rate.** With all the necessary information in hand, it is relatively easy to determine the MANA rate using the U of M fertilizer bulletin. Consider the following examples:

Crop information	Example A	Example B
Crop to be grown	corn	corn
Realistic yield goal	160 bushels/acre	160 bushels/acre
Soil organic matter content	medium	medium
Crop grown last year	corn	corn
Crop grown 2 yrs ago	corn	alfalfa (> 4 plants/ft.)

Example A

For this example, find the *Fertilizer Recommendations for Agronomic Crops in Minnesota* in the pocket of this manual. Use Table 18 on page 12. This table indicates a MANA rate of 160 pounds per acre.

Example B

Example B is a little more complicated. Use Tables 18 and 19 on page 12 of the University of Minnesota bulletin, *Fertilizer Recommendations for Agronomic Crops in Minnesota.* Table 18 shows a MANA rate of 160 pounds per acre. Table 20 of this bulletin shows a second year nitrogen credit of 75 pounds per acre from the alfalfa. Subtract the second year nitrogen credit (75 lbs/acre) from the MANA rate (160 lbs/acre). The result is 85 pounds of nitrogen per acre (85 lbs N/acre).

Step 3: How to determine the agronomic rate of biosolids(dry tons/acre)

Biosolids should be applied to land at the rate at which it supplies no more available nitrogen than the vegetation or crop can use during the growing season. The **agronomic rate of biosolids** is the term used in this manual for the rate intended to provide the correct amount of nitrogen to the crop while minimizing pollution. This rate is based on the nitrogen content of the biosolids and about a dozen other factors. In the rules, this rate is simply called the **agronomic rate**.

Here's the full definition:

The **agronomic rate of biosolids** is the maximum allowable rate at which biosolids can be applied to a particular site. It is designed to do both of the following, and is measured in dry tons of biosolids per acre:

- provide no more than the allowable amount of nitrogen (via biosolids) needed by a crop or vegetation grown on the land to attain a desired yield
- minimize the amount of nitrogen that will pass below the root zone to ground water. Excess nitrogen applied to the site can result in nitrate contamination of the groundwater.

The agronomic rate of biosolids is the amount of biosolids that will supply the crops or vegetation with the correct amount of nitrogen (or in other words, will supply the MANA rate). Also, the agronomic rate of biosolids should supply no more nitrogen than the vegetation or crop can use during the growing season, as stated earlier. In short, the agronomic rate of biosolids is intended to provide the correct amount of nitrogen to the crop while minimizing pollution.

Let's take this concept of nitrogen being the basis of how much biosolids we apply to the land and put it into a larger picture. By rule, the application rate of biosolids in Minnesota is currently based on nitrogen for all circumstances. However, with the rising concern over phosphorus running off into lakes and streams, this rate in the future may be based on phosphorus for certain situations. Some states already have two agronomic rates of biosolids — one based on phosphorus and one based on nitrogen. The agronomic rate used depends upon environmental conditions at the site.

First collect the necessary information

To determine the agronomic rate of biosolids (dry tons/acre) the biosolids manager must first gather the following information:

- ❑ the previous year's application rates (dry tons/acre)
- ❑ the previous year's biosolids analysis
- ❑ the current year's biosolids analysis
- ❑ the biosolids treatment method
- ❑ the biosolids application method
- ❑ non-biosolids nitrogen credits
- ❑ the MANA rate

Next, use Worksheet 7*, How to determine the agronomic rate of biosolids***,** at the end of this chapter. Following is a step-by-step guide to using the worksheets.

Step 3A: How to determine second year carryover nitrogen

Possible shortcut...

You may skip Step 3A if either of the following are true:

- ❑ *Biosolids were not applied to a particular site two years ago (two cropping seasons).*
- ❑ *You do not land apply an aerobically digested or stabilized primary and waste-activated sludge.*

As mentioned previously, biosolids can supply available nitrogen for several years. Consequently, this residual amount of nitrogen should be estimated to determine an appropriate rate at which to apply biosolids. The calculation for second year carryover nitrogen provides the pounds of nitrogen per acre available to a crop grown two years after biosolids were applied.

This step is required only for aerobically digested and stabilized primary and waste activated biosolids if the biosolids application from two years ago provided 100 pounds per acre or more of available nitrogen.

Example

Aerobic digestion (192 lbs/acre available N applied in 1994)
1994 Biosolids analysis = 5.0% Kjeldahl N and 0.5% ammonia N
1994 Application rate = 6 dry tons per acre

Step 3A: Determine second year carryover nitrogen

Step 3A is only necessary for aerobically digested and stabilized primary and waste-activated sludge if the biosolids application from 2 years ago provided at least 100 lbs/acre of available nitrogen.

% Organic N =	5.0	-	0.5	=	4.5 (1)
	% Kjeldahl N*		% Ammonia N*		% Organic N
Carryover N = (lbs N/acre)	4.5	x	6.0	=	27 (2)
	% Organic N (1)		dry tons/acre**		Carryover N

* *Use analysis from 2 years ago.*
** *Use application rate from 2 years ago.*

Step 3B: How to determine first year carryover nitrogen

First year carryover nitrogen is the amount of nitrogen that becomes available, or is mineralized, during the current cropping year from last cropping year's application of biosolids. Regardless of treatment method or previous application rate, calculate the first year carryover nitrogen for all biosolids.

Possible shortcut...

The only time this step can be skipped is when either of the following circumstances is true:

- ❑ *biosolids have never been applied to the site*
- ❑ *the biosolids application occurred more than one year ago*

Calculation Factor I is found in the table below entitled *Calculation factors.* It is used to predict the mineralization rate of the nitrogen carried over from the first year. This calculation provides the pounds of nitrogen per acre available to a crop grown one year after the biosolids application.

Example

Aerobic digestion
1995 Biosolids analysis = 5.2% Kjeldahl N and 0.2% ammonia N
1995 Application rate = 4 dry tons per acre

Step 3B: Determine first year carryover nitrogen

% Organic N =	5.2	-	0.2	=	5.0 (3)		
	% Kjeldahl N*		% Ammonia N*		% Organic N		
Carryover N =	5.0	X	4.0	X	2.1	=	42 (4)
(lbs N/acre)	% Organic N (3)		dry tons/acre**		Factor I***		Carryover N

* *Use last year's analysis.*
** *Use last year's application rate.*
*** *Calculation factors are below.*

Calculation factors

	Factor I	Factor II	Factor III
Anaerobically digested	1.6	4	—
Aerobically digested	2.1	6	—
Stabilized primary & waste-activated	2.4	8	—
Composted	0.9	2	—
Surface application	—	—	10
Incorporated within 48 hrs. or injected	—	—	20

Step 3C: How to determine available nitrogen in current year's biosolids

To calculate this, the operator must use an analysis from a biosolids sample representative of the biosolids to be applied. Generally, this is the most recent analysis. Calculation Factor II is found in the table above entitled *Calculation factors.* It is used to predict the current year's nitrogen mineralization rate. In addition, Calculation Factor III, found in the same table above, is used to predict ammonia loss via volatilization. The result of this calculation provides the pounds of available nitrogen in a dry ton of solids.

Example

Aerobic digestion
Surface application
1996 biosolids analysis = 5.2% Kjeldahl N and 0.7% ammonia N

Step 3C: Determine available nitrogen in the current year's biosolids

% Organic N =	5.2	-	0.7	=	4.5	(5)
	% Kjeldahl N		% Ammonia N*		% Organic N	
	4.5	x	6	=	27	(6)
	% Organic N (5)		Factor II*			
	0.7	x	10	=	7	(7)
	% Ammonia N		Factor III*			
Available N = in biosolids (lbs N/dry ton)	27	+	7	=	34	(8)
	(6)		(7)		Available N	

* *Calculation factors are in previous table.*

Step 3D: How to determine nitrogen credits

Nitrogen credits are sources of nitrogen supplied to the current year's crop that are not coming from the current year's biosolids application. Typical sources of nitrogen credits are:

- ❑ manure
- ❑ starter fertilizer
- ❑ side-dress fertilizer
- ❑ carryover nitrogen from previous biosolids applications

Often farmers will apply some fertilizer when they plant the crop. If nitrogen is included in this "starter" fertilizer application, it must be considered a nitrogen credit. Many farmers will inject anhydrous ammonia when a corn crop is a few inches high. This fertilizer application is known as **side dressing**. The biosolids manager should discuss with the farmer if the corn crop will be side-dressed. If so, this amount of nitrogen should also be taken into account as a nitrogen credit. Appendix E contains information to help the biosolids manager determine nitrogen credits from various types of manure.

Example

Sidedress fertilizer = 50 pounds N per acre
Manure = none
2nd year carryover N = 27 pounds N per acre (from Step 3A)
1st year carryover N = 42 pounds N per acre (from Step 3B)

Step 3D: Determine crop nitrogen credits

Fertilizer N = (lbs/acre)	50 (9)				Manure N applied in lbs/acre	=	0 (10)
Nitrogen credits = (lbs N/acre)	27 Carryover N (2)	+	42 Carryover N (4)	+	50 Fertilizer N (9)	+	0 Manure N (10)
						=	119 (11) N Credits

Step 3E: How to determine the agronomic rate for biosolids

The last part of this process is to calculate the allowable biosolids application rate. In this calculation, simply divide the crop nitrogen need (in pounds of nitrogen per acre) by the available nitrogen in the biosolids (in pounds of nitrogen per dry ton). The answer is expressed in dry tons of solids per acre.

Example

Crop to be grown = corn
Realistic yield goal = 180 bushels per acre
Soil organic matter level = 2%
Crop grown last year = soybeans
Crop grown two years ago = corn
N credits = 119 pounds per acre (from Step 3D)
Biosolids available nitrogen = 34 pounds per dry ton of solids

Step 3E: Determine agronomic rate of biosolids (dry tons/acre)

Crop intended to be grown	corn	Realistic yield goal	180 bu/acre
Soil organic matter level	low	Crop grown last year	soybeans
MANA rate = (Maximum Allowable Nitrogen Application rate)	170 (12) lbs N/acre	Crop grown 2 years ago	corn

Additional crop N need = (dry tons/acre)	170 MANA rate (12)	-	119 N credits (11)	=	51 (13) Crop N need
Agronomic rate = (dry tons/acre)	51 Crop N need (13)	÷	34 Available N (8)	=	1.5 (14) Agronomic rate

Step 4: How to determine the application rate of biosolids (convert to wet tons or gal/acre)

The agronomic rate of biosolids calculated in the previous section is expressed as units of dry tons per acre (i.e., tons of solids per acre). Since no biosolids are ever completely dry, the agronomic rate must be converted to a unit that can be easily measured. For liquid biosolids, the unit of measure for application rates is usually gallons per acre. For dewatered or cake biosolids, the unit of measure is typically wet tons or cubic yards per acre.

Form of biosolids		Unit of measure		Step number
dewatered or cake biosolids	→	wet tons/acre or cubic yards/acre	→	4A
liquid biosolids	→	gallons/acre	→	4B

Step 4A: How to determine application rate for dewatered or cake biosolids (wet tons/acre)

Biosolids programs that produce dewatered or cake biosolids and have access to a scale or load cells can use this formula. In this situation, biosolids are typically loaded into a delivery truck or an application machine. The truck or machine is weighed empty and full to get the weight of the biosolids loaded. Consequently, the biosolids operator must first calculate the weight of biosolids in wet tons that are to be delivered to the application site. The operator then keeps track of the weights loaded to ensure that an excess amount is not delivered to the application site.

Example

Agronomic application rate = 1.2 dry tons per acre
Biosolids total solids content = 20%
Site acreage = 40 acres

Step 4A: Determine biosolids application rate for dewatered and cake biosolids (wet tons/acre)

Application rate = (wet tons/acre)	1.2	÷	0.20	=	6.0
	Agronomic rate (14)		% Total solids (as a decimal fraction)		wet tons/acre

After calculating the biosolids application rate in wet tons per acre, the biosolids manager must multiply this rate by the number of acres at the site to determine the total weight of biosolids that can be delivered to the site.

6 wet tons/acre x 40 acres = 240 wet tons

Step 4B: How to determine the application rate for liquid biosolids (gal/acre)

Biosolids programs that produce a liquid product can use this formula. Generally, the gallons of biosolids loaded into tank trucks or application machines can be measured using the volume of the tank into which the biosolids are loaded. The biosolids operator must first calculate the volume of biosolids that can be delivered to the application site in gallons. The operator then keeps track of the number of loads or gallons to ensure that excess is not delivered to the application site. All equipment should be calibrated or checked for volumes before being used.

Example

Agronomic application rate = 1.2 dry tons per acre
Biosolids total solids content = 2.0%
Applicator tank volume = 4000 gallons
Site acreage = 40 acres

Step 4B: Determine biosolids application rate for liquid biosolids (gal/acre)

Application rate = (gal/acre)	1.2	÷	0.02	x	240	=	14,400 (15)
	Agronomic rate (14)		% Total solids (as a decimal fraction)				gal/acre

After calculating the application rate in gallons per acre, the biosolids manager will multiply this rate by the number of acres at the site to determine the total volume of biosolids that can be delivered to the site (i.e., 14,400 gallons/acre x 40 acres = 576,000 gallons). Another way would be to just count tanker loads. In this case, the allowable number of gallons to be delivered is divided by the tanker volume (i.e., 576,000 gallons ÷ 4000 gallons/load = 144 loads).

Step 5: How to determine speed of application (MPH)

To apply biosolids at the correct rate, the operator must calculate the speed at which the application machine should travel across the application site. Moreover, biosolids must be spread uniformly to the application site. To accomplish this, the biosolids operator should try to maintain a constant speed when applying biosolids. We will assume that the application machine is pressurized and that it is discharging biosolids at a constant rate.

In some cases, the application machine's tank is emptied by gravity. Ideally in these situations, the biosolids operator should drive faster than the calculated application speed when beginning to discharge the tank, and slower near the end.

Following are two terms used in this section:

The **pumping rate** is the rate at which the application machine discharges the biosolids. This rate is in gallons per minute.

The **spreading width** is the width of the spray fan for surface-applied biosolids, and the distance between the outside knives for injected biosolids.

Example

Biosolids application rate = 14,400 gallons per acre
Spreading width = 10 feet
Pumping rate = 800 gallons per minute

To get the pumping rate, divide the size of the application tank by the number of minutes it takes to empty the tank:

4000 gallon tank ÷ 5 minutes to empty = 800 gallon per minute pumping rate.

Step 5: Determine vehicle speed for applying liquid biosolids (MPH)

Tank volume (gal)	=	4,000 (16)				
Spreading width (ft.)	=	10 (17)				
Pumping rate (gal/min)	=	800 (18)				
Spread rate = (gal/ft)	14,400 gal/acre (15)	x	10 Spreading width (17)	÷ 43,560	=	3.3 (19) Spread rate
Vehicle speed = (MPH)	800 Pumping rate (18)	÷	3.3 Spread rate (19)	x 0.011	=	2.7 (20) MPH

How to determine application rate for dewatered or cake biosolids(cubic yards/acre)

This series of calculations is typically done by biosolids programs producing a dewatered or cake biosolids product that don't have access to weigh scales or load cells. Consequently, the only way to measure the biosolids delivered to a site is to count the number of loader buckets loaded into a delivery truck or application machine. In this situation, the biosolids operator must know the volume of the loader bucket. Typically, a Bobcat-type loader has a 1/2 cubic yard bucket. Buckets of front-end loaders generally hold from 2 to 5 cubic yards.

The first task is to determine the density (i.e., weight per unit volume) of biosolids. We suggest you use a procedure that is included in Worksheet 8, *How to determine application rates for dewatered or cake biosolids,* which uses a standard five-gallon pail. Then, convert the weight of a five-gallon volume to tons per cubic yard. Lastly, use the agronomic application rate (dry tons per acre) to determine the allowable application rate in cubic yards per acre.

Example

5-gallon pail weight, empty = 2 pounds
5-gallon pail weight, full = 42 pounds
Total solids of biosolids in pail = 20%
Agronomic application rate = 1.2 dry tons per acre

1. Determine the weight of a pail of moist biosolids.

a. Weigh an empty 5-gallon pail.

b. Fill the pail with biosolids. We suggest you fill the pail using the same equipment that is used to load the applicator or delivery truck. For example, if a Bobcat is used to fill a manure spreader with biosolids, use the loader to fill the 5-gallon pail.

c. Scrape the surface of the loaded pail so that the level of the biosolids is even with the top of the pail.

d. Weigh the loaded pail.

Weight of moist biosolids (lbs)	=	42.0	-	2.0	=	40.0 (a)
		Weight of full pail (lbs)		Weight of empty pail (lbs)		Weight of biosolids (lbs)

2. Determine % total solids of biosolids.

Take a representative sample of biosolids from the filled 5-gallon pail and analyze for % total solids.

% Total solids	=	20% (b)
		% Total solids

3. Determine dry weight of solids in 5-gallon pail.

Dry weight of biosolids (lbs)	=	40.0	x	0.20	=	8.0 (c)
		Weight of biosolids (a)		Total solids (b) (as a decimal fraction)		dry weight of biosolids

4. Determine dry weight of solids per cubic yard of biosolids.

Dry weight of biosolids (dry tons/cu yd)	=	8.0	x	0.02	=	0.16 (d)
		dry weight (c)				dry tons/cu yd

5. Determine application rate of biosolids in cubic yards/acre.

Application rate of biosolids (cu yd/acre)	=	1.2	÷	0.16	=	7.5 (c)
		Agronomic rate of biosolids (14)*		dry tons/cu yd (d)		cu yd/acre

* *This value can be determined by using* ***Worksheet 1, How to determine the agronomic rate of biosolids.***

Calculations made *after* application: How to determine actual amounts of solids, nutrients and metals applied

Often, actual application rates of nutrients and metals are calculated **after** biosolids are applied. This is generally done in two situations:

- When the biosolids manager samples the biosolids as the application machines or delivery vehicles are being loaded. This provides a biosolids manager with a sample that is extremely representative of the biosolids that are being applied. After the sample is analyzed, the biosolids manager, knowing the actual application rate, can **back-calculate** the amounts of solids (dry tons), nitrogen, phosphorus, potassium and trace metals actually applied to a site.
- When the biosolids manager knows, based on experience or previous analytical history, that the amount of biosolids being applied to a site will not exceed any requirements. In other words, the biosolids manager realizes that it may take 100,000 gallons per acre to exceed the MANA rate. The manager also knows that the program never exceeds an application rate of 20,000 gallons per acre. In this situation, the biosolids manager is confident that actual amounts of solids (dry tons), nitrogen, phosphorus, potassium and trace metals applied to a site can be calculated **after** the application occurs, and no regulatory limits will be exceeded.

We provide Worksheet 9 to help the biosolids manager calculate, or **back-calculate**, the actual amounts of solids (dry tons), nitrogen, phosphorus, potassium and trace metals actually applied to a site. Worksheets are found at the end of this chapter.

How to determine amounts of solids actually applied (dry tons/acre)

To accomplish this step, the operator must choose the appropriate formula from the three provided. How the operator measures the biosolids when loading into the application machine or delivery vehicle determines the formula to use. For instance, if the operator measures biosolids in gallons, use the first formula. If the operator measures in cubic yards, use the last formula.

Example

Actual application rate = 22,500 gallons/acre
Total solids content = 3.2%

Amounts of solids actually applied (dry tons/acre)

Choose one of the following equations:

Equation 1

Biosolids applied = (dry tons/acre)	22,500	x	0.032	÷	240	=	3.0 (1)	
	gal/acre applied		% total solids (as a decimal fraction)				Biosolids applied	

Equation 2

Biosolids applied = (dry tons/acre)		x		=	(1)
	wet tons/acre applied		% total solids (as a decimal fraction)		Biosolids applied

Equation 3

Biosolids applied = (dry tons/acre)		x		=	(1)
	cu yd/acre applied		dry tons/cu yd		Biosolids applied

How to determine amounts of available nitrogen actually applied (lbs/acre)

The first step of this determination is to calculate the amount of available nitrogen in a dry ton of biosolids. This procedure is identical to the one discussed previously in *Step 3C: How to determine available nitrogen in current year's biosolids*. In this calculation, the biosolids manager must use the Kjeldahl nitrogen and ammonia nitrogen contents of the biosolids applied, as well as the method of biosolids treatment and application. The next step is simply multiplying the actual biosolids application rate (in dry tons per acre) by the pounds of available nitrogen in a dry ton of biosolids.

Example

Kjeldahl nitrogen = 4.2%
Ammonia nitrogen = 0.2%
Actual biosolids application rate = 3.0 dry tons per acre
Treatment method = lime stabilization
Application method = injection

1. Determine amount of available nitrogen in biosolids applied (lbs/dry ton)

% Organic N =	4.2	-	0.2	=	4.0	(a)
	% Kjeldahl N		% Ammonia N		% Organic N	
	4	x	8	=	32	(b)
	% Organic N (a)		Factor II*			
	0.2	x	20	=	4	(c)
	% Ammonia N (a)		Factor III*			
Available N in biosolids = (lbs N/dry ton)	32	+	4	=	36	(d)
	(b)		(c)		Available N	

* *Calculation factors are below.*

Calculation factors

	Factor I	Factor II	Factor III
Anaerobically digested	1.6	4	—
Aerobically digested	2.1	6	—
Stabilized primary & waste-activated	2.4	8	—
Composted	0.9	2	—
Surface application	—	—	10
Incorporated within 48 hrs. or injected	—	—	20

2. Determine available nitrogen in biosolids actually applied (lbs/acre)

Available N applied = (lbs N/acre)	3	x	36	=	108
	Biosolids applied (1)		Available N (d)		Available N applied

How to determine amounts of phosphorus & potassium actually applied (lbs/acre)

This calculation is straightforward and is the same for both macronutrients. The biosolids manager must remember to convert the nutrient concentration, usually in percentage, to a decimal fraction.

Example

Actual biosolids application rate = 3.0 dry tons per acre
Phosphorus content = 2.4%
Potassium content = 0.2%

Amounts of phosphorus actually applied (lbs P/acre)

Phosphorus applied = (lbs P/acre)	3.0 Biosolids applied (1)	x	0.024 % Phosphorus (as a decimal fraction)	x	2000	=	144 P applied

Amounts of potassium actually applied (lbs/K acre)

Potassium applied = (lbs K/acre)	3.0 Biosolids applied (1)	x	0.002 % Potassium (as a decimal fraction)	x	2000	=	12 K applied

How to determine amounts of trace metals actually applied (lbs/acre)

This calculation is straight-forward using the dry tons per acre of biosolids actually applied multiplied by the metal concentration times a conversion factor of 0.002. Perform this calculation for each of the metals that have cumulative loading rate limits.

Example

Actual biosolids application rate = 3.0 dry tons per acre
Zinc concentration = 1000 mg/kg

Amounts of trace metals actually applied (lbs/acre)

Trace metal applied = (lbs metal/acre)	3.0 Biosolids applied (1)	x	1000 Metal concentration (mg/kg)	x	0.002	=	6.0 Trace metal applied

How to track trace metal cumulative additions

The previous formula is used to determine the amount of trace metal actually applied to an application site during one cropping year. This calculation should be made for each of the nine metals that have cumulative loading rate limits. Once this determination is complete, the metal loading rates are added to the previous year's cumulative metal loading rate. In other words, a running total of trace metal additions is determined for each application site annually. To assist the biosolids operator with this, see Worksheet 10, *How to determine metal loading rates,* at the end of this chapter.

The first part of this worksheet contains formulas to determine the annual trace metal addition for each trace metal. After this is done, add those numbers to the past cumulative loading rate in the second part of the worksheet. Insert the site name and cropping year on the worksheet. The following example is for only one metal.

Example

Site number = 5201
Cropping year = 1996
Actual biosolids application rate = 3.0 dry tons per acre
Arsenic concentration = 50 mg/kg (dry weight basis)
Past cumulative loading rate for arsenic = 16.4 pounds/acre
Cadmium concentration = 10 mg/kg (dry weight basis)
Past cumulative loading rate for cadmium = 3.2 pounds/acre

Determine annual metal loading rates

Site number 5201

Crop year 1996

1. Determine annual metal loading rates.

	Metal concentration (mg/kg)		Actual application rate of biosolids (dry tons/acre)				Actual metal loading rate (lbs/acre)
Arsenic (As)	50	x	3.0	x	0.002	=	0.3
Cadmium (Cd)	10	x	3.0	x	0.002	=	0.06

2. Add to past cumulative metal loading rates.

	Actual metal loading rate (lbs/acre)		Past cumulative loading rate (lbs/acre)		New cumulative loading rate (lbs/acre)
Arsenic (As)	0.3	+	16.4	=	16.7
Cadmium (Cd)	0.06	+	3.2	=	3.26

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How to determine the agronomic rate of biosolids (dry tons/acre)

This worksheet corresponds to Steps 3-5 of text.

1. Determine second year carryover nitrogen

Corresponds to Step 3A of text.

This step is only necessary for aerobically digested and stabilized primary and waste-activated sludge if the biosolids application from 2 years ago provided at least 100 lbs/acre of available nitrogen.

% Organic N =	______	-	______	=	______ (1)
	% Kjeldahl N*		% Ammonia N*		% Organic N
Carryover N = (lbs N/acre)	______	x	______	=	______ (2)
	% Organic N (1)		dry tons/acre**		Carryover N

* *Use analysis from 2 years ago.*
** *Use application rate from 2 years ago.*

2. Determine first year carryover nitrogen

Corresponds to Step 3B of text.

% Organic N =	______	-	______	=	______ (3)		
	% Kjeldahl N*		% Ammonia N*		% Organic N		
Carryover N = (lbs N/acre)	______	X	______	X	______	=	______ (4)
	% Organic N (3)		dry tons/acre**		Factor I***		Carryover N

* *Use last year's analysis.*
** *Use last year's application rate.*
*** *Calculation factors are below.*

3. Determine available nitrogen in the current year's biosolids

Corresponds to Step 3C of text.

% Organic N =	______	-	______	=	______ (5)
	% Kjeldahl N*		% Ammonia N*		% Organic N
	______	x	______	=	______ (6)
	(5)		Factor II**		
	______	x	______	=	______ (7)
	% Ammonia N		Factor III**		
Available N = in biosolids (lbs N/dry ton)	______	+	______	=	______ (8)
	(6)		(7)		Available N

* *Use current year's analysis.*
** *Calculation factors are below.*

Calculation factors

	Factor I	Factor II	Factor III
Anaerobically digested	1.6	4	—
Aerobically digested	2.1	6	—
Stabilized primary & waste-activated	2.4	8	—
Composted	0.9	2	—
Surface application	—	—	10
Incorporated within 48 hrs. or injected	—	—	20

4. Determine crop nitrogen credits

Corresponds to Step 3D of text.

Fertilizer N (lbs/acre) = ______ (9)

Manure N applied in lbs/acre = ______ (10)

Nitrogen credits (lbs N/acre) = ______ Carryover N (2) + ______ Carryover N (4) + ______ Fertilizer N (9) + ______ Manure N (10)

= ______ (11) N Credits

5. Determine agronomic rate of biosolids (dry tons/acre)

Corresponds to Step 3E of text.

Crop intended to be grown ______

Realistic yield goal ______

Soil organic matter level ______

Crop grown last year ______

MANA rate = ______ (12) lbs N/acre
(Maximum Allowable Nitrogen Application rate)

Crop grown 2 years ago ______

Additional crop N need (lbs N/acre) = ______ MANA rate (12) - ______ N credits (11) = ______ (13) Crop N need

Agronomic rate (dry tons/acre) = ______ Crop N need (13) ÷ ______ Available N (8) = ______ (14) Agronomic rate

Choose either 6A or 6B.

6A. Determine biosolids application rate for dewatered and cake biosolids (wet tons/acre)

Corresponds to Step 4A of text.

Application rate (wet tons/acre) = ______ Agronomic rate (14) ÷ ______ % Total solids (as a decimal fraction) = ______ wet tons/acre

6B. Determine biosolids application rate for liquid biosolids (gallons)

Corresponds to Step 4 B of text.

Application rate (gal/acre) = ______ Agronomic rate (14) ÷ ______ % Total solids (as a decimal fraction) x 240 = ______ (15) gal/acre

7. Determine vehicle speed for applying liquid biosolids (MPH)

Corresponds to Step 5 of text.

Tank volume (gal) = ______ (16)

Spreading width (ft.) = ______ (17)

Pumping rate (gal/min) = ______ (18)

Spread rate (gal/ft) = ______ gal/acre (15) x ______ Spreading width (17) ÷ 43,560 = ______ (19) Spread rate

Vehicle speed (MPH) = ______ Pumping rate (18) ÷ ______ Spread rate (19) x 0.011 = ______ (20) MPH

How to determine application rates for dewatered or cake biosolids (cubic yards/acre)

1. Determine the weight of a pail of moist biosolids.

a. Weigh an empty 5-gallon pail.

b. Fill the pail with biosolids. We suggest you fill the pail using the same equipment that is used to load the applicator or delivery truck. For example, if a Bobcat is used to fill a manure spreader with biosolids, use the loader to fill the 5-gallon pail.

c. Scrape the surface of the loaded pail so that the level of the biosolids is even with the top of the pail.

d. Weigh the loaded pail.

Weight of moist biosolids (lbs) = [ ] Weight of full pail (lbs) - [ ] Weight of empty pail (lbs) = [(a)] Weight of biosolids (lbs)

2. Determine % total solids of biosolids.

Take a representative sample of biosolids from the filled 5-gallon pail and analyze for % total solids.

% Total solids = [(b)] % Total solids

3. Determine dry weight of solids in 5-gallon pail.

Dry weight of biosolids (lbs) = [ ] Weight of biosolids (a) x [ ] Total solids (b) (as a decimal fraction) = [(c)] dry weight of biosolids

4. Determine dry weight of solids per cubic yard of biosolids.

Dry weight of biosolids (dry tons/cu yd) = [ ] dry weight (c) x 0.02 = [(d)] dry tons/cu yard

5. Determine application rate of biosolids in cubic yards/acre.

Application rate of biosolids (cu yd/acre) = [ ] Agronomic rate of biosolids (14)* ÷ [ ] dry tons/cu yd (d) = [(c)] cu yd/acre

* *This value can be found by using* ***Worksheet 1, How to determine the agronomic rate of biosolids.***

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After application:

How to determine amounts actually applied

(solids, nutrients and metals)

Solids: amounts actually applied (dry tons/acre)

Choose one of the following equations:

Equation 1

Biosolids applied (dry tons/acre) = ______ gal/acre applied x ______ % total solids (as a decimal fraction) ÷ 240 = ______ (1) Biosolids applied

Equation 2

Biosolids applied (dry tons/acre) = ______ wet tons/acre applied x ______ % total solids (as a decimal fraction) = ______ (1) Biosolids applied

Equation 3

Biosolids applied (dry tons/acre) = ______ cu yd/acre applied x ______ dry tons/cu yd = ______ (1) Biosolids applied

Nitrogen: amounts actually applied (lbs/acre)

1. Determine amount of available nitrogen in biosolids applied (lbs/dry ton)

% Organic N = ______ % Kjeldahl N - ______ % Ammonia N = ______ (a) % Organic N

______ % Organic N (a) x ______ Factor II* = ______ (b)

______ % Ammonia N x ______ Factor III* = ______ (c)

Available N in biosolids (lbs N/dry ton) = ______ (b) + ______ (c) = ______ (d) Available N

2. Determine available nitrogen in biosolids actually applied (lbs/acre)

Available N applied (lbs N/acre) = ______ Biosolids applied (1) x ______ Available N (d) = ______ Available N applied

* *Calculation factors are below.*

Calculation factors

	Factor I	Factor II	Factor III
Anaerobically digested	1.6	4	—
Aerobically digested	2.1	6	—
Stabilized primary & waste-activated	2.4	8	—
Composted	0.9	2	—
Surface application	—	—	10
Incorporated within 48 hrs. or injected	—	—	20

Phosphorus: **amounts actually applied (lbs P/acre)**

Phosphorus applied = (lbs P/acre)	______ Biosolids applied (1)	x	______ % Phosphorus (as a decimal fraction)	x	2000	=	______ P applied

Potassium: **amounts actually applied (lbs K/acre)**

Potassium applied = (lbs K/acre)	______ Biosolids applied (1)	x	______ % Potassium (as a decimal fraction)	x	2000	=	______ K applied

Trace metals: **amounts actually applied (lbs/acre)**

Trace metal applied = (lbs metal/acre)	______ Biosolids applied (1)	x	______ Metal concentration (mg/kg)	x	0.002	=	______ Trace metals applied

After application:

How to track trace metal cumulative additions and determine metal loading rates

Site number ________________

Crop year ________________

1. Determine annual metal loading rates.

	Metal concentration (mg/kg)		Actual application rate of biosolids (dry tons/acre)				Actual metal loading rate (lbs/acre)
Arsenic (As)		x		x	0.002	=	
Cadmium (Cd)		x		x	0.002	=	
Copper (Cu)		x		x	0.002	=	
Mercury (Hg)		x		x	0.002	=	
Molybdenum (Mo)		x		x	0.002	=	
Nickel (Ni)		x		x	0.002	=	
Lead (Pb)		x		x	0.002	=	
Selenium (Se)		x		x	0.002	=	
Zinc (Zn)		x		x	0.002	=	

2. Add to past cumulative metal loading rates.

	Actual metal loading rate (lbs/acre)		Past cumulative loading rate (lbs/acre)		New cumulative loading rate (lbs/acre)
Arsenic (As)		+		=	
Cadmium (Cd)		+		=	
Copper (Cu)		+		=	
Mercury (Hg)		+		=	
Molybdenum (Mo)		+		=	
Nickel (Ni)		+		=	
Lead (Pb)		+		=	
Selenium (Se)		+		=	
Zinc (Zn)		+		=	

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Chapter

11

Harvest restrictions & farmer cooperation

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Good communication between biosolids managers and biosolids users is one of the most important aspects of a successful biosolids recycling program. Communication is not only important in knowing when and where to deliver and apply biosolids, it is also essential to be able to comply with state and federal biosolids regulations. As a biosolids manager, good communication with your farmers is in your best interests because:

the biosolids manager is ultimately responsible to ensure that all rules and regulations are followed in the land application process.

Harvest restrictions

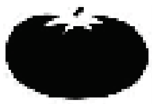
Whenever Class B biosolids are applied to land, the biosolids manager must observe several harvest restrictions, which really are waiting periods. These restrictions are necessary because Class B biosolids contain low levels of pathogens. The waiting periods before harvesting crops or grazing animals allow enough time for pathogens to die-off from environmental conditions. The harvest restrictions apply to different types of crops and animal grazing. Table 15 is a summary of the harvest restrictions.

Table 15

Harvest restrictions for Class B biosolids

Type of crop	Examples	Timeframe within which the crop cannot be harvested:
Above ground crops	melon squash tomatoes cucumbers	The part of the plant that will be harvested and which may touch biosolids in the soil cannot be harvested within 14 months of applying biosolids.
Below-ground crops	potatoes carrots onions	• If biosolids remain on soil surface for $\geq$4 months, cannot harvest crop less than 20 months after applying biosolids • If biosolids are incorporated into the soil within 4 months, cannot harvest crop less than 38 months after applying biosolids.
Feed crops	hay silage corn small grains	Cannot harvest within 30 days of applying biosolids
Fiber crops	flax cotton hemp	Cannot harvest within 30 days of applying biosolids
Other food crops	field corn sweet corn soybeans small grains	Cannot harvest within 30 days of applying biosolids
Pastureland	Pasture used for grazing cattle or sheep	Livestock may not graze on land within 30 days of applying biosolids

Above ground crops



The part of food crops that will ultimately be harvested **and** which may touch the soil-biosolids mixture may not be harvested within 14 months after biosolids are applied.

Melons, squash, tomatoes and cucumbers are examples of this type of food crop.

Below-ground crops

Food crops whose harvested parts grow underground may not be harvested within 20 months of application **if** the biosolids stay on the soil surface for at least four months before being incorporated into the soil. If the biosolids are incorporated within four months of application, these food crops may not be harvested within 38 months of application.

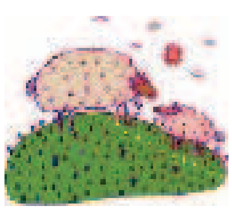
Potatoes, carrots and onions are examples of this type of food crop.

Other food crops, feed crops and fiber crops

Certain other food crops and crops used to feed animals cannot be harvested within 30 days of applying biosolids.

Examples of these crops include feed crops (e.g., hay, silage, corn, small grains), other food crops (e.g., field corn, sweet corn, soybeans, small grains) and fiber crops (e.g., flax, cotton, hemp).

Pastureland



Livestock may not graze on land within 30 days of applying biosolids.

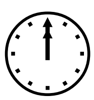
Farmer cooperation and obligations

In addition to the harvest restrictions, the farmer or landowner must be aware of, cooperate with, and enforce the biosolids regulations listed below. Some of these have been discussed in other chapters of this manual. If a farmer does not cooperate with the program, the biosolids manager should consider dropping the farmer from the biosolids recycling program. An example is a farmer who consistently applies more nitrogen than the MANA rate. The regulations where farmer cooperation is generally needed are:

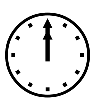
- Cannot exceed the maximum available nitrogen application (MANA) rate for the crop.

- For 30 days, control public access to land with a low potential for public contact. This is land that the public uses infrequently, such as agricultural land, forested land and reclamation sites in unpopulated areas.

- For one year, control public access to land with a high potential for public contact. A public contact site is land with a high potential for contact with the public and includes public parks, ball fields, cemeteries, golf courses, turf farms, plant nurseries and reclamation sites in populated areas (i.e., an urban construction site).



- Incorporate biosolids within the 48 hour limit for land that has over a 6% slope or within certain separation distances from surface waters, wetlands, tile inlets, intermittent streams and grassed waterways (see Chapter 9).



- Incorporate biosolids within the six-hour limit when used as the method of controlling vector attraction.

Information for farmers on land-applying biosolids

To ensure that farmers and landowners are aware of their roles in complying with biosolids regulations, an example information sheet, *Biosolids Quality and Nutrient Information Sheet***,** is in Appendix G. Biosolids managers may use this information sheet or develop an information sheet tailored to their own biosolids recycling programs.

MN Rules Chapter 7041: Relaying biosolids rules to the farmer

Whether biosolids managers develop their own information sheets or use the one in this manual, they should be aware that the biosolids regulations require the following:

📖 The biosolids manager, whether a preparer or an applier, is responsible for notifying and providing to the users of biosolids the necessary information for complying with the biosolids rules by specifying appropriate agronomic rates, site restrictions and other management practices.

The biosolids manager **must** relay to the farmer the following information:

- ❑ harvest restrictions
- ❑ MANA rates and the amount of nitrogen supplied by biosolids
- ❑ public access control periods
- ❑ immediate incorporation requirements

In addition, MPCA staff **recommends** that the biosolids manager also provide the farmer with:

- ❑ the amount of other macro- and micro-nutrients supplied by biosolids
- ❑ the number of acres applied
- ❑ cumulative metal additions compared to allowable limits
- ❑ biosolids treatment information, such as pathogen reduction and vector attraction reduction methods

Supervising the farmer during application

In Minnesota, farmers need not be certified operators to apply biosolids **to their own land**. Occasionally a biosolids program asks the cooperating farmer to apply the biosolids. In these situations, a certified operator should supervise the application because the biosolids manager is ultimately responsible for ensuring that all rules and regulations are followed. If a certified operator cannot supervise the land application, the biosolids manager **must** provide the farmer with the rules for agronomic rates, site restrictions and management practices.

As discussed in Chapter 9, suitable areas for biosolids recycling must be staked out before land application. Generally, the farmer is not familiar enough with the rules to be able to stake out the area. Consequently, the certified land applicator is responsible for staking.

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Chapter 12

How to request Site approval

MPCA staff approves or denies sites that operators target for applying biosolids. Biosolids managers must take the following three basic steps to request site approval:

1 **Complete the Site Application form (Figure 9).** Before applying biosolids, the operator must get approval for the site from the MPCA. *Site Application forms* must be completed and signed by a Type IV certified operator or inspector. A Type IV certified operator or inspector is someone certified (according to Minnesota Rules Chapter 7048) to land-apply biosolids or inspect biosolids land application sites.

2 **Prepare a Notification letter.** Persons who manage biosolids (the permittees) must prepare a *Notification letter* for appropriate persons. Figure 10 is an example notification letter.

3 **Send the Site Application form and Notification letters with the proper attachment to the appropriate persons.** By rule, *Notification letters* and *Site Application forms* must go into the mail **on the same date.** Persons applying for site approval must notify those on the list below that they are requesting approval from MPCA staff for that site:

- the site's owner
- the site's occupier, if applicable
- the city or township where the site is located (send a COPY of this letter to the MPCA)
- the county official responsible for solid waste management (send a COPY of this letter to the MPCA)
- any person known to be interested in the use of biosolids on the site

If MPCA staff grants approval for the site, the approval is valid for the conditions stated in the document, which may include some management practices.

Step 1: Complete a Site Application form

MN Rules Chapter 7041: Obtain approval from MPCA before applying biosolids

Before applying biosolids (aside from exceptional quality biosolids), persons who prepare biosolids must obtain approval of the sites on which bulk biosolids are intended to be applied.

Notification for Exceptional Quality Biosolids (EQB)

Those who prepare exceptional quality biosolids must determine if notification is necessary, and if so, what type of notification is necessary for their product and land application program. Public relations are extremely important in biosolids application, and we strongly recommend that persons producing EQB communicate with the public on these issues.

How to complete the Site Application form

Fill out the *Site Application form* completely or MPCA staff will return it.

Page 1: Site information

Each form has room for up to three proposed biosolids application sites. The first page asks for site information.

1. Site code: Give the site a code, ideally one that helps you easily identify a site. One example of a site code is **JD-1**. If a site is divided into subsites, list those as well (sites can be divided into subsites when a small acreage is needed each year, provided the smaller parcels have the same delineation each or any year that they are used). Delineate subsites on the soil map, as discussed in #5.

The following is an example of a site that is divided into subsites. A farmer has a 35-acre field to which he wants biosolids applied. The quantity of biosolids produced covers only a 5-acre strip of the field each year. For convenience, the operator requests and receives approval to apply biosolids to that 35-acre field. Consequently, the farmer allows the operator to cover a 5-acre strip by moving across the field in rotation each year. Fortunately, one soil analysis can be used for the 35-acre site.

2 & 3. Landowner and occupier's name and address. Make sure the landowner's and occupier's address is complete. In many areas, the postal service will not deliver to a simple RR address — usually a box number is also necessary. The MPCA sends the approval or denial letter to the landowner and occupier, if applicable.

4. Legal description. Give the legal description, down to the quarter section, of the site to which biosolids are intended to be applied. The operator must consider all setbacks and unsuitable soils on or near the site when calculating acreage — include only **suitable** site acreage on the Site Application form.

5. Include a soil map of the site. Include a soil map with the *Site Application form*. On the map, the operator must **DELINEATE** the following areas:

a) the site that the operator has determined is suitable for applying biosolids. To show a number of features, enlarge the map so you can clearly mark features and setbacks.

b) any short-term or long-term storage areas, if applicable (see the definitions below). For details on managing short and long-term storage, see Minnesota Rules Chapter 7041.1200 subparts 7 and 8. For long-term storage, fill out the last page of this form.

Short-term storage areas are for storing dewatered biosolids for less than 30 days at the site where applied.

Long-term storage areas are for storing dewatered biosolids for more than 30 days but less than 7 months at the site where applied.

c & d) all tile lines and tile inlets and separation distances around tile inlets.

e) all areas that are not suitable for biosolids — crosshatch or color those areas. Be sure the map clearly shows the features for which the setbacks occur.

6. Highly permeable soils. List any highly permeable soils on the site. To find out if any highly permeable soils exist on the site, request from the county NRCS (formerly SCS) such a list. Ask for the list of soils whose leaching potentials are rated as severe, poor filter for soil pesticide loss (this is determined by the procedure that the NRCS uses).

7. Tile drainage. Provide the tile spacing and depth of any tile lines on the site. When determining site suitability, the minimum depth to seasonally high ground water for tiled sites is the depth of the tile.

8. Soil analysis. Enter the date of the soil analysis (the soil sample must be taken within 6 months of submitting the *Site Application form*. Include the results of the following tests:

- ❑ Texture — requirements are associated with texture and a maximum daily hydraulic loading rate for liquid biosolids applied to the soil surface.
- ❑ Organic matter content — needed for calculating nitrogen application rates.
- ❑ Extractable phosphorus — required because of the potential special management practices that may be associated with levels of over 200 ppm (400 pounds per acre).
- ❑ Exchangeable potassium — you must inform the farmer of this.
- ❑ pH — the pH limit is 5.5. If the soil pH is near 5.5, expect the site approval to require yearly sampling.
- ❑ Soluble salts — look closely at the soluble salts results (conductivity is given in millimhos/centimeter). If soils are at 4 mmhos/cm or greater, application is prohibited. When sending in soil for analysis, be sure to request that the soluble salt test is run — it is not a normal soil test parameter.

Page 2: Site management

Enter the site codes used on Page 1 of the *Site Application form*.

9. Application methods. List the methods you intend to use when applying biosolids.

- When you specify that biosolids will be incorporated within 6 hours, the MPCA will interpret this as your chosen method of meeting vector attraction reduction requirements (VAR).
- If the site has slopes greater than 6%, the biosolids must be injected or incorporated within 48 hours.

10. Public access. Describe the access control. Is the site fenced, surrounded by agricultural fields, or is it simply remote?

11 & 12. Short-term and long-term storage. See instruction #5 for page 1 of this form.

13. Other waste products applied to site. Are any other waste products applied to the site? Include the information requested for any other waste products, manure, or biosolids currently applied to the site or approved to be applied to the site. Take all sources of nitrogen into account when calculating application rates. Discuss your rates of biosolids application, explaining how the amounts of nitrogen or other constituents were taken into consideration. If you need more space, attach a sheet to the form.

14. Non-agricultural use. If applying for approval for a non-agricultural site (i.e., mineland reclamation or forest), and the site doesn't meet the requirements for soil conditions, slope or separation distances, the operator may still be able to use the site. In this case, the operator must attach a request to the *Site Application form* that describes the following:

- ❑ the requirements that the operator cannot meet at the proposed site
- ❑ the environmental benefits the operator expects if granted approval to carry out their plans
- ❑ the precautions, if necessary, that the operator will take during or after application to protect the environment

15. Applier's name and phone number. This will usually be the same as the applicant. If you use contract appliers, record their contact information.

16. Type IV certified operator or inspector. The *Site Application form* must be completed and signed by a Type IV certified operator or inspector. Include this person's phone number and Type IV certification number.

Page 3: Cropping and site management

Enter the site codes used on Page 1 of the *Site Application form*.

List all the crops that are likely to be grown on the site. This information is necessary to calculate allowable application rates. For example, in a corn - corn - soybean rotation, the maximum rate for corn following corn is more than corn following soybeans. To calculate the MANA rate, use U of M extension bulletins and the organic matter content of the soil and previously grown crops (see Chapter 10). The rates on this page can be compared later to the site's annual reports.

Circle the months you expect to apply biosolids. Remember that if applying biosolids when the ground is frozen or snow-covered, more management is needed. For example, if you are applying for a site that has slopes of 2 to 6%, January should not be circled because surface application is not permitted when the ground is frozen or snow-covered unless all slopes are less than or equal to 2%.

Page 4: Request for long-term storage of biosolids

This page must be filled out only if you are requesting long-term storage of biosolids at the same site where the biosolids are intended to be applied. Include all the information requested and make sure the map is large enough to delineate the storage areas. Remember to submit with your annual report the location of the stockpile. As a reminder, some of the requirements for long-term storage are listed at the bottom of the page.

Figure 9

Site Application form

(for Minnesota's biosolids program)

Page 1 of 4: Site information

Complete this form in full or MPCA staff will return it. Each form can be used for up to 3 sites.

		Site code	Site code	Site code
1	**Site information**			
2	**Landowner's name**			
	Address			
3	**Land occupier's name**			
	Address			
4	**Legal description:**			
	Quarter/Section			
	Township coordinate			
	Range coordinate			
	Township name			
	County			
	Total approvable acreage			

5 **Attach a soils map from the Natural Resources Conservation Service (NRCS) or a comparable map prepared by a soil scientist. Delineate the following on the map (enlarge the map, if necessary):**

- **a. Boundaries of each proposed site (approvable acreage)**
- **b. Locations of any long-term dewatered biosolids storage areas**
- **c. Location of all tile lines (transfer tile location data to the soil map)**
- **d. Locations of all tile inlets**
- **e. Areas that will not be used for biosolids application. Identify these areas by coloring or crosshatching. Be sure the map shows the features for which setbacks occur.**

6 **List highly permeable soils on the site (obtain from the NRCS):**

7	**Tile drainage? (yes, no)**			
	List tile spacing			
	List tile depth			
8	**Soil analysis:**			
	Sampling date			
	Texture (USDA)			
	Organic matter (%)			
	Extractable phosphorus (ppm)			
	Exchangeable potassium (ppm)			
	pH			
	Soluble salts (mmhos/cm)			

Figure 9 Site Application form
Page 2 of 4: Site management

Site management	Site code	Site code	Site code
9 Biosolids will be (check all that apply):			
Injected			
Surface applied			
Surface applied & incorporated:			
- within 48 hours			
- within 6 hours			
10 How will public access to each site be controlled?			
11 Will biosolids be stored onsite short-term (less than 30 days)?			
12 Must biosolids be stored long-term (greater than 30 days but less than 7 months)?			

If long-term storage of biosolids is proposed, fill out page 4 of this form.

13 List any other waste materials currently applied to this site, including manure or other biosolids. Describe the materials and include a copy of any contracts or agreements the landowner holds for each material that is land applied. If permits or approval are required for land applying these materials, list the name, address and telephone number of each regulatory contact.

How will your proposed application rate be affected by other waste materials applied to the site?

14 *For non-agricultural use:* If modifications of soil conditions, slope or separation distances are requested for a non-agricultural site, attach a description of the proposed modifications and the environmental benefits expected from applying biosolids under the proposed conditions.

15 Applier's name

Address

Phone number

16 Form prepared by:

Address

Phone number

Type IV Certification number

Expiration date

Cropping & site management

Figure 9 Site Application form, page 3 of 4

For each proposed site, fill in the information for crop rotations and application rates. Identify crops that are most likely to be grown, realistic yield goals, maximum available nitrogen application (MANA) rates and the agronomic rate that correlates to the MANA rate. Provide the analysis used in calculating these agronomic rates in percentages:

Kjeldahl-N ________ NH_3N ________ Total solids ________

---

1 **Site code** ____________

2

Crop types	Realistic yield goal (give units)	MANA rate (lbs/acre)	Allowed agronomic rate: dry tons/acre	Allowed agronomic rate: gal. or wet tons/acre

3 **Circle the months that the site is intended to be used for application:**

January February March April May June July August September October November December

---

1 **Site code** ____________

2

Crop types	Realistic yield goal (give units)	MANA rate (lbs/acre)	Allowed agronomic rate: dry tons/acre	Allowed agronomic rate: gal. or wet tons/acre

3 **Circle the months that the site is intended to be used for application:**

January February March April May June July August September October November December

---

1 **Site code** ____________

2

Crop types	Realistic yield goal (give units)	MANA rate (lbs/acre)	Allowed agronomic rate: dry tons/acre	Allowed agronomic rate: gal. or wet tons/acre

3 **Circle the months that the site is intended to be used for application:**

January February March April May June July August September October November December

Request to store biosolids long-term

Figure 9 Site Application form, page 4 of 4

1 **Site code** ________ **(site where biosolids are proposed to be stored)**

2 **Describe why long-term storage is needed.**

3 **List the dimensions of each storage area (in square feet).** ____________

4 **List the maximum quantity of biosolids proposed to be stored at each location at any one time (in dry tons).** ____________

5 **List the maximum length of time biosolids are proposed to be stored at this location prior to land application (in days).** ____________

6 **Describe how storage will be managed to control any leachate or runoff.**

7 **Attach boring logs that provide all of the following information (at least 2 soil borings are required to a depth of 10 feet at the perimeter of the proposed storage area):**

- ☐ **texture and thickness of each soil horizon encountered**
- ☐ **color and presence or absence of mottling for each soil horizon encountered**
- ☐ **depth to seasonal high water table, if encountered**
- ☐ **depth to bedrock, if encountered**

Separation distances required for long-term storage areas

1 **Long-term storage of biosolids intended for application areas of 40 acres or less must not take place within 400 feet of any residence. This separation distance increases 100 feet for every additional 10 acres of land application area, or portion thereof, up to a maximum of 1,000 feet. Separation distances may be reduced if all persons residing within the otherwise protected distance give written permission.**

2 **Long-term storage of biosolids must not take place within 1,000 feet of any residential development or public contact site.**

3 **Long-term storage of biosolids must not take place within 1,000 feet of any downgradient surface waters, unless measures are taken to control runoff, in which case the separation distance may be reduced to 200 feet.**

Step 2: Prepare the Notification letter

Format of Notification letter

The person applying for site approval may create a *Notification letter* based on the rules or use our example (see Figure 10). The example *Notification letter* contains all the information required for public participation when requesting site approval (the *Notification letter* can be used as a template). When creating a *Notification letter*, **include all information listed in the next section.** Applicants may include additional information to describe their land application program in more detail.

Parts of Notification letter

The *Notification letter* must include **all** of the information listed below. Providing this information gives interested persons meaningful information on which they can comment.

- ❑ **A.** that the purpose of the *Notification letter* is to inform local officials of the preparer's intent to apply for MPCA approval to land apply biosolids on a particular site.
- ❑ **B**. site ownership and location and the name of the lessee, renter or occupier of the site, if applicable
- ❑ **C**. the preparer's name and how they can be contacted for information about their program.
- ❑ **D**. a one-page attachment, *General Management Requirements for Agricultural Sites* (see Table 16) or a similar attachment prepared specifically for your site (agricultural, forest or reclamation) and approved by the MPCA
- ❑ **E**. that a Type IV operator or inspector certified by the MPCA in handling biosolids has reviewed the sites for compliance with the rules
- ❑ **F.** that the *Site Application form* is being mailed on the same date to the MPCA for a final determination on site suitability and site management for those sites
- ❑ **G**. that if interested persons have comments or questions about the approval process, contact the MPCA's biosolids coordinator within 30 days of the date on the *Notification letter*.
- ❑ **H.** that the MPCA will approve or deny the site in writing after the 30-day comment period
- ❑ **I.** that the MPCA reviews land application reports submitted annually by those who prepare biosolids

Figure 10

Sample Notification letter

to interested persons of possible biosolids land application site

(to be put on requestor's letterhead)

[name of city or township official]
[title]
[address]

[name of county solid waste official]
[title]
[address]

Dear *[Mr./Ms. name]:*

This is to notify you that we are requesting approval from the Minnesota Pollution Control Agency (MPCA) to apply biosolids on the property of *[owner's name]* located in the *[give legal description(s) of property(ies)].* This site is currently farmed by *[name, if applicable].*

Biosolids are reclaimed through wastewater treatment and benefit crops and soil because of their value as fertilizer and as organic matter.

[name of Type IV operator or inspector], certified by the MPCA as a Type IV *[operator or inspector]* for biosolids, prepared the *Site Application form*. This person has reviewed the site characteristics and determined acceptable management practices for complying with Minnesota's rules for land applying biosolids. For your information, enclosed is a table of general management practices and conditions that apply to the land application of biosolids. In addition, we submit reports on our land application program to the MPCA annually. If you have any questions or want additional information about our biosolids application program, please contact *[permittee's contact]* at *[phone number].*

The MPCA will approve or deny our request after the 30-day comment period, which starts the day this letter and *Site Application form* is sent to the MPCA. You will receive a copy of that approval or denial letter. This letter was also mailed on the same date to the persons listed on the CC below, including the MPCA contact person.

If you have comments or questions about the approval process, please contact *[MPCA biosolids coordinator]* at *[phone number*] within 30 days of the date on this letter.

Sincerely,

[signature of applicant]
[typed name of applicant]

Enclosure

cc: *[Landowner and occupier, if different]*
[MPCA contact listed in letter]
[Any other interested persons]

Table 16
General Management Requirements for Agricultural Sites

Minnesota's rules specify the percentage of slope allowed at a site on which biosolids are applied, as well as the minimum separation distances from the applied biosolids to the features listed in this table. All allowable slopes and separation distances depend upon the method used to apply the biosolids.

For all land types			
Criteria	**If surface applied...**	**If incorporated within 48 hours...**	**If injected...**
Allowable slopes	0% - 6%	0% - 12%	0% - 12%
Depth to bedrock	3 ft.	3 ft.	3 ft.
Depth to seasonal high water table or drain tile	3 ft.	3 ft.	3 ft.
Distance to wells:			
Private supply	200 ft.	200 ft.	200 ft.
Public supply	1000 ft.	1000 ft.	1000 ft.
Irrigation	50 ft.	25 ft.	25 ft.
Distance to residences[1]	200 ft.	200 ft.	100 ft.
Distance to residential development[1]	600 ft.	600 ft.	300 ft.
Distance to public contact site[4]	600 ft.	600 ft.	300 ft.
Distances to down gradient[2] lakes, rivers, streams, Types 3, 4, & 5 wetlands, intermittent streams[3], or tile inlets connected to these surface waters, and sinkholes			
Slope 0%-6%	200 ft.	50 ft.	50 ft.
Slope > 6%-12%	Not allowed	100 ft.	100 ft.
Distances to grassed waterways[4]			
Slope 0%-6%	100 ft.	33 ft.	33 ft.
Slope 6%-12%	Not allowed	33 ft.	33 ft.

[1]Separation distances may be reduced with written permission from all persons responsible for residential developments and places of recreation and all persons inhabiting within the otherwise protected distance.

[2]If down gradient surface water does not receive runoff from a bermed site, separation distances can be reduced to 33 feet.

[3]Intermittent stream means a drainage channel with definable banks that provides for runoff flow to a perennial stream, lake or wetland during snowmelt or rainfall.

[4]Separation distances are from the centerline of grassed waterways. For grassed waterways that are wider than these separation distances, biosolids can be applied up to the edge of the grass. Grassed waterways are natural or constructed, typically broad and shallow, and seeded with grass to help prevent erosion.

When applying on frozen or snow-covered ground:

- Biosolids can be applied on frozen or snow-covered land only if the slope of the land is between 0 and 2%.
- Applying liquid biosolids is restricted to a maximum rate of 15,000 gallons per acre.
- The separation distance to surface water features in the table above increases to 600 ft. for liquid biosolids.

Public access: Control public access to agricultural application sites for 30 days of applying biosolids. The MPCA considers private farmland inaccessible to the general public because of the Minnesota Trespass Law. However, if public access to the site cannot be easily controlled, signs or fences may be necessary.

Application rates: The application rate of biosolids is based on the nitrogen needs of the crop to be grown on the site. All other forms of nitrogen fertilizers that may be applied to the same crop must be considered when determining the biosolids application rate. This ensures that excess nitrogen, which could impact our water resources, is not applied.

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Step 3: Send Site Application form & Notification letters

MN Rules Chapter 7041: Notification of intent to apply biosolids

By mail and on the same date as mailing the *Site Application form* to the MPCA, persons applying for site approval must notify (in writing) those on the list below that they are requesting approval from MPCA staff for that site:

- the site's owner
- the site's occupier
- the city or township where the site is located (send a **copy** of this letter to the MPCA)
- the county official responsible for solid waste management (send a **copy** of this letter to the MPCA)
- any person known to be interested in the site

30-day comment period

A 30-day comment period starts the day the operator sends the *Notification letters* and *Site Application form*. Anyone with questions on the proposed site should contact the MPCA's biosolids coordinator within 30 days of the date on the *Notification letter*.

Who must receive the Notification letter and Site Application form?

Table 17
Distribution list for Notification letters & Site Application form

Party to receive document	Must receive:	When should applicant send it?
MPCA	• a copy of each *Notification letter* sent to local units of government • completed *Site Application form* *(remember to date both documents)*	Send the *Site Application form* and the *Notification letters* (or copies of letters, as appropriate) to all persons on the same day.
Landowner or occupant	• a copy of the *Notification letter (remember to date it)* • a copy of the *General Management Requirements for Agricultural Sites*[1] provided by MPCA (see Table 16)	See top box.
Local units of government: • County official responsible for solid waste management • Township official • If site is within city limits (instead of a township), address to city and county • If site is within an unorganized territory, address to county only	• the **original** *Notification letter (remember to date it)* • a copy of the *General Management Requirements for Agricultural Sites*[1] provided by MPCA (see Table 16)	See top box.
Other interested persons	• a copy of the *Notification letter (remember to date it)* • a copy of the *General Management Requirements for Agricultural Sites*[1] provided by MPCA (see Table 16)	See top box.
Operator applying for site approval	• Keep a copy of the *Site Application form* • Keep a copy of each *Notification letter* sent	N/A

[1]If the proposed site is on non-agricultural land and not all of the requirements in the General Management Requirements for Agricultural Sites apply, the MPCA will provide the applicant with a different management sheet. To get this, contact the MPCA biosolids coordinator before preparing the Notification letters.

Receiving (or being denied) site approval

MN Rules Chapter 7041:

📖 No sooner than 30 days after the applicant initiates the comment period, the MPCA will approve or deny the site in writing. If the MPCA denies the site, it will explain why. Approval is valid for the conditions stated in the approval, including any management practices.

Changing acreage after receiving site approval

If an operator proposes a change in acreage, the site approval process must be carried out again.

Changing site management practices after receiving site approval

If an operator proposes a change in site management, request the change in writing to the MPCA only. Then wait for written approval before making the change.

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Chapter

13 Records & annual reports

Recordkeeping and reporting requirements for biosolids vary with the quality of biosolids produced and how it is distributed. All Class B and non-exceptional quality Class A biosolids have the same recordkeeping and reporting requirements. (see MN Rules Chapter 7041.1600, subp. 3 and Chapter 7041.1700). Recordkeeping and reporting requirements for exceptional quality biosolids are found in MN Rules Chapter 7041.1600, subp.2 and Chapter 7041.1700 subp.1. These requirements may also be included in your permit if your product has been permitted for reduced regulation. Consult your permit for specific requirements.

Type of biosolids		**Recordkeeping & reporting requirements are found in MN Rules:**
Class B biosolids **and** Non-exceptional quality Class A biosolids	→	Ch. 7041.1600, subp. 3 **and** Ch. 7041.1700
Exceptional quality biosolids	→	Ch. 7041.1600, subp.2 **and** Ch. 7041.1700, subp.1

Who must keep records for biosolids programs?

Persons who prepare biosolids are responsible for developing and maintaining a recordkeeping system for their biosolids program. The system should allow operators and inspectors to easily access the records. Records must be kept to show compliance with the requirements for all of the following:

- ❑ monitoring
- ❑ management practices
- ❑ site restrictions
- ❑ vector attraction reduction (VAR) requirements
- ❑ pathogen reduction requirements

In Minnesota, some records may initially be generated by an applier when that person is different than the preparer. During application, the applier is likely to create records used later to determine compliance with management practices, site restrictions or vector attraction reduction (VAR) requirements. For example, contract appliers are responsible for certifying that the proper management practices (such as injection and maintaining separation distances) are carried out because they witness these events or situations in the field. However, the preparer is responsible for getting and maintaining these records, or a copy of them.

MN Rules Chapter 7041: Recordkeeping for non-exceptional quality biosolids

Some records of biosolids programs must be kept for at least 5 years. Others must be kept indefinitely.

It seems logical that if the annual report is kept on file with the operator, the recordkeeping requirements would also be met because that information is included on the annual report. Indeed this is the case with many things, such as the certification statements, concentration of pollutants, agronomic rates, soil test data, number of acres, etc. However, this is not necessarily enough information to show compliance with other requirements, such as for vector attraction reduction. Interpretations of some of these more complicated recordkeeping requirements are in following sections.

Records to keep for 5 years

The preparer must keep the following records for at least 5 years:

- ❑ concentration of analytical parameters — metals, nutrients and solids content
- ❑ a signed certification statement for meeting pathogen and vector attraction reduction requirements
- ❑ a description of how the pathogen reduction requirements are met
- ❑ a description of how the vector attraction reduction requirements are met
- ❑ records of soil test data
- ❑ Maximum Available Nitrogen Application (MANA) rates for specific crops
- ❑ the known amount of available nitrogen applied to the crops for a cropping year
- ❑ the record of the applier's certification statement (whether the preparer or a different party applies the biosolids) used to determine compliance with management practices, site restrictions and vector attraction reduction requirements (if injection or incorporation are used to meet the requirement). Preparers must keep as part of their records a description of how those requirements are met. (The certification statement that applies to management practices is number 4 on page 4 of the annual report.)

Records to keep indefinitely

The preparer must keep the following records indefinitely (this is how it is stated in the rule; however, more detail is needed to actually determine compliance, as discussed later in this chapter):

- ❑ the location of land application and stockpile sites on a U.S.G.S. quadrangle or soil map
- ❑ the legal descriptions of the sites
- ❑ the amount of bulk biosolids applied for the cropping year and cumulatively in tons/acre
- ❑ the amount of metals applied for the cropping year and cumulatively in pounds/acre
- ❑ the date of biosolids application
- ❑ a signed certification statement for contacting the EPA to see if a site has reached it cumulative pollutant loading rate
- ❑ a description of how the information to determine if a site has reached the cumulative pollutant loading rate was obtained

Monitoring records — details

To determine compliance with monitoring requirements, records must show both of the following:

- that the samples were representative of biosolids going to the field
- that the sampling frequency was correct.

This can be done by simply keeping a copy of the *Record of biosolid sampling events* found in Chapter 5 (the original form goes to the lab with the sample). A similar form containing all of the following sampling information could also be used:

- ❑ sample ID
- ❑ parameteres analyzed
- ❑ name of sampler
- ❑ date & time sample collected
- ❑ sampling location
- ❑ sample volumes
- ❑ holding times
- ❑ sample type (grab, composite)
- ❑ sample container
- ❑ preservation method
- ❑ name of lab doing analyses
- ❑ date & time analyzed
- ❑ analytical methods for each parameter

Pathogen and Vector Attraction Reduction (VAR) records — details

The operator must document the name of the alternatives used for pathogen and vector attraction reduction. The operator must also describe the method used. Tables 18 and 19 list the records that must be kept for the various alternatives for Class A and Class B pathogen reduction. Table 20 lists the records to be kept for vector attraction reduction.

Records for management practices, site restrictions and VAR (injection or incorporation)

To review from Chapter 11, the operator must give the farmer information on site restrictions and the nutrient value of the biosolids applied (see *Information for farmers on land-applying biosolids* in Chapter 11). Aside from the certification statement and a description of how these items are met, operators should keep a record of the information they give to the farmer. The operator does not need to submit (with the annual report) a copy of the information given to the farmer. However, this record must be kept on hand to show compliance with 7041.1000, subpart 2 regarding notice and necessary information.

Overall, some of the most important records that are used to determine compliance are those that document the application itself. This includes records of the amounts applied and those from calibrating the application equipment. If records on application are inaccurate, the calculations for agronomic rates and cumulative metals will be incorrect. In addition, the farmer will *not* get the correct information. Incorrect recordkeeping and reporting can lead to inappropriate enforcement actions. Remember to cover sites evenly with biosolids and record only the acreage covered.

Table 18

Recordkeeping requirements for Class A pathogen reduction alternatives

Alternative A1: Time and temperature

- Analytical results for density of Salmonella sp. bacteria or fecal coliform (most probable number)
- Biosolids temperature (either continuous chart or two readings per day, at least one per shift)
- Time (days, hours, minutes) temperature maintained

Alternative A2: Alkaline treatment

- Analytical results for density of Salmonella sp. bacteria or fecal coliform (most probable number)
- Biosolids pH (beginning, middle and end of treatment)
- Time (hours) pH maintained above 12 (at least 72 hours)
- Biosolids temperature (beginning, middle and end of treatment and hourly to demonstrate 12 hours above 52°C)
- Percent solids in biosolids after drying (at least 50 percent)

Alternative A3: Analysis and operation

- Analytical results for density of Salmonella sp. bacteria or fecal coliform (most probable number)
- Analytical results for density of enteric viruses (plaque forming unit/4 grams total solids) prior to pathogen reduction and, when appropriate, after treatment
- Analytical results for density of viable helminth ova (number/4 grams total solids) prior to pathogen reduction and, when appropriate, after treatment
- Values or ranges of values for operating parameters to indicate consistent pathogen reduction treatment

Alternative A4: Analysis only

- Analytical results for density of Salmonella sp. bacteria or fecal coliform (most probable number)
- Analytical results for density of enteric viruses (plaque forming unit/4 grams total solids)
- Analytical results for density of viable helminth ova (number /4 grams total solids)

Alternative A5: Processes to Further Reduce Pathogens (PFRP)

- Heat drying
  - Analytical results for density of Salmonella sp. bacteria or fecal coliform (most probable number)
  - Moisture content of dried biosolids <10 percent
  - Logs documenting temperature of biosolids particles or wet bulb temperature of exit gas exceeding 80°C (either continuous chart or two readings per day, at least one per shift)
- Thermophilic Aerobic Digestion
  - Analytical results for density of Salmonella sp. bacteria or fecal coliform (most probable number)
  - Dissolved oxygen concentration in digester $\leq$ 1 mg/L
  - Logs documenting temperature maintained at 55-60°C for 10 days (either continuous chart or two readings per day, at least one per shift)
- Heat treatment
  - Analytical results for density of Salmonella sp. bacteria or fecal coliform (most probable number)
  - Logs documenting biosolids heated to temperatures greater than 180° C for 30 minutes (either continuous chart or three readings at 15 minute intervals)
- Pasteurization
  - Analytical results for density of Salmonella sp. bacteria or fecal coliform (most probable number)
  - Temperature maintained at or above 70°C for at least 30 minutes (either continuous chart or two readings per day, at least one per shift)
- Composting
  - Analytical results for density of Salmonella sp. bacteria or fecal coliform (most probable number)
  - Description of composting method
  - Logs documenting temperature maintained at or above 55°C for 3 days if within vessel or static aerated pile composting method (either continuous chart or two readings per day, at least one per shift)
  - Logs documenting temperature maintained at or above 55°C for 15 days if windrow compost method (minimum of two readings per day, at least one per shift)
  - Logs documenting compost pile turned at least five times per day, if windrow compost method
- Gamma ray irradiation
  - Analytical results for density of Salmonella sp. bacteria or fecal coliform (most probable number)
  - Gamma ray isotope used
  - Gamma ray dosage at least 1.0 megarad
  - Ambient room temperature log (either continuous chart or two readings per day, at least one per shift
- Beta ray irradiation
  - Analytical results for density of Salmonella sp. bacteria or fecal coliform (most probable number)
  - Beta ray dosage at least 1.0 megarad
  - Ambient room temperature log (either continuous chart or two readings, at least one per shift)

Alternative A6: PFRP Equivalent

- Operating parameters or pathogen levels as necessary to demonstrate equivalency to the PFRP
- Analytical results for density of Salmonella sp. bacteria or fecal coliform (most probable number)

Table 19

Recordkeeping requirements for Class B pathogen reduction alternatives

Alternative B1: Fecal Coliform Count
• Number of samples collected during each monitoring event • Analytical results for density of fecal coliform for each sample collected
Alternative B2: Processes to Significantly Reduce Pathogens (PSRP)
• Aerobic digestion - Dissolved oxygen concentration - Volatile solids content before and after digestion - Mean residence time of biosolids in digester - Logs showing temperature was maintained for sufficient period of time (ranging from 60 days at 15° C to 40 days at 20° C) (continuous charts or two readings per day, at least one per shift) • Air drying - Description of drying bed design - Depth of biosolids on drying bed - Drying time in days - Daily average ambient temperature • Anaerobic digestion - Volatile solids content before and after digestion - Mean residence time of biosolids in digester (between 15 days at 35° C to 55° C and 60 days at 20° C) - Temperature logs of biosolids in digester (continuous charts or two readings per day, at least one per shift) • Composting - Description of composting method - Daily temperature logs documenting biosolids maintained at 40° C for 5 days (either continuous chart or two readings per day, at least one per shift) - Hourly readings showing temperature exceeding 55° C for 4 consecutive hours • Lime stabilization - pH of biosolids immediately and then 2 hours after addition of lime
Alternative B3: PSRP Equivalent
• Operating parameters or pathogen levels as necessary to demonstrate equivalency to PSRP

Table 20

Recordkeeping requirements for biosolids processing options for vector attraction reduction

Option 1: Volatile Solids (VS) Reduction	Option 5: Aerobic Processing (Thermophilic Aerobic Digestion/Composting)
• Volatile solids concentration of raw and final solids streams (mg/kg) • Calculations showing 38 percent reduction in volatile solids	• Biosolids detention time in digester/composting • Temperature logs (at least two readings per day) showing average temperature above 45° C and minimum temperature above 40°C for 14 consecutive days
Options 2 & 3: Bench scale vs. Reduction	**Option 6: Alkaline treatment**
• One-time description of bench-scale digester • Time (days) that sample was further digested in bench-scale digester (30 days for aerobically and 40 days for anaerobically digested biosolids) • Temperature logs (at least two readings per day) showing temperature maintained at 20° C for aerobically or between 30°C and 37°C for anaerobically digested biosolids • Volatile solids concentration of biosolids (mg/kg) before and after bench-scale digestion	• Logs demonstrating hours pH of biosolids/alkaline mixture was maintained (12 for 2 hours and 11.5 for an additional 22 hours) • Amount of alkaline added to biosolids (lbs or gals) • Amount of biosolids treated
Option 4: Specific Oxygen Uptake Rate	**Options 7 & 8: Drying**
• Dissolved oxygen readings for biosolids sample over 15-minute intervals (mg/L) • Temperature logs at beginning and end of DO readings showing test was conducted at 20°C • Total solids for biosolids sample (g/L) • SOUR calculations (mg/g)	• Results of percent solids (dry weight) test • Presence of unstabilized solids generated during primary treatment

MN Rules Chapter 7041: Annual reports

Regarding annual reports, the following are required by rule:

- Annual reports are due to the MPCA by **December 31** following a cropping year. An annual report form and directions are at the end of this chapter.
- All this information is required on a form provided by or approved by the MPCA (not having to use the MPCA's paper form allows an operator to create or duplicate the form on a computer.)
- If bulk biosolids are applied, a Type IV certified operator or inspector employed by the person who prepares the biosolids must complete the annual report or supervise those who complete it.
- All records required for biosolids programs must be submitted with the annual report except for the following:
  - the legal description of the site, if the biosolids are applied in Minnesota
  - a signed certification statement for contacting the EPA to see if a site has reached it cumulative pollutant loading rate
  - a description of how the information was obtained to determine if a site has reached its cumulative pollutant loading rate
  - the month, instead of the date, that biosolids were applied
- The preparer of non-exceptional quality biosolids is required to notify both the MPCA and EPA in writing when 90% or more of any of the cumulative pollutant loading rates are reached. In the rule, this is referred to as *Special Reporting Requirements (MN Rules Chapter 7041.1700, subp. 2).*

How to complete the annual report

Report form designed for data entry

The MPCA's annual report form is designed so that persons not familiar with the biosolids program can easily enter the information into a database. Because of this, the operator must fill in all the blanks on the form. For example, where the form asks for analytical results, fill in all the blanks instead of simply attaching a lab sheet. Even though the rules allow you to use a form approved or provided by the MPCA, the form you use must look like the MPCA's annual report form.

Page 1 of Annual Report: Basic information, pathogen reduction & VAR

Basic information

The first part of the form is self-explanatory. Simply fill out the information about the reporting year, facility, contact person and permit number.

Quantities applied

If biosolids were not applied during the reporting year, check the box. The rule does not require you to report if you do not land apply. However, the requirement to report quantities of biosolids that have not been applied or those that have been transferred, will be included in your permit when it is reissued (the MPCA is required to track all generators and their yearly production of biosolids.)

The next three items refer to the quantity of biosolids (in dry tons) that were applied. The first item asks for the gallons or wet tons applied (enter the appropriate quantity) **and** dry tons. Wet tons refer **only** to facilities that dewater their biosolids. If you transfer a small quantity and do not have the percent solids, you may report the amount transferred in gallons. Be sure to include the facility to which it was transferred as well as the contact person at that facility. Remember, the dry tons applied determine the minimum sampling frequency for land application.

Pathogen reduction

First indicate which option or options were used to meet Class B or Class A pathogen reduction requirements. For Class B biosolids, check the alternative(s) you used. If Class A biosolids are produced, refer to the rule or Appendix C for the correct number for the Class A options.

Secondly, write a short description of how pathogen reduction was met. To describe pathogen reduction, indicate the information that was used to determine compliance.

Example 1: For digestion processes where the solids retention time (SRT) and temperature are used to determine compliance, indicate that daily temperature readings were recorded and that volumes of biosolids flowing into and out of the digester (necessary to calculate SRT) were measured. Then indicate what the operating conditions were, such as "The temperature was kept at 95° F for 30 days".

Example 2: For limed solids, describe what material was used to raise the pH and how and when pH measurements were taken. Indicate what action was taken if the pH was not high enough during the process. For example, "The pH was measured after 2 hours, and more lime was added because the pH was not 12 or greater. Then the pH was taken in another 2 hours."

Vector attraction reduction (VAR)

First indicate which option or options your program used during the reporting year to meet the VAR requirements. Next, to describe how your program met the VAR requirements, indicate what information was used and how it was evaluated to determine compliance. Regarding calculations for volatile solids reduction, indicate which equation was used (such as the VanKleek or Approximate Mass Balance Equations) and why by describing the operating mode of digestion. The information used to determine compliance should support the type of VSR equation used. (See Chapter 4 for details on vector attraction reduction.)

Page 2 of Annual Report: Biosolids analysis

Record biosolids analyses here. The last column is for average results. The average is used to determine if a greater sampling frequency for metals is necessary. It may also be used in other calculations, such as for nitrogen and cumulative metals, if it is representative of the biosolids applied.

However, when biosolids quality varies greatly, especially the nitrogen values, use analytical data for biosolids that were actually applied when doing calculations. If different sets of analytical data are used in calculations for different times of year or sites, assign that column of data a **sample number** at the top of the column in which the data is reported. Then, place the **sample number** that was used in calculations for a specific site on the first line under *Application Rates & Methods* (page 3).

At the bottom of this page, record a reminder about which parameters need to be sampled at a greater frequency the next reporting year.

Page 3 of Annual Report: Site-specific information

Site code

Site Code: The Site Code is the code that the preparer gives each site on a site application. The MPCA also uses this code in the site approval letter. Up to 3 sites can fit on a form.

Actual acreage receiving biosolids: Report **only** the number of acres that actually received biosolids. This number may be less than the total suitable acreage of the site, as listed in the site approval letter.

Crop grown this year: Indicate the crop grown during the year on which you are reporting.

Realistic yield goal: Indicate yield units such as bushels/acre for the crop grown this year.

Crop grown previous year: Indicate the crop grown the year previous to the one on which you are reporting.

Soil organic matter*: Indicate the organic matter content in either percent or in one of the following categories: low, medium, or high. Use the last soil test value. As noted under the asterisk, soil testing is required only once during the 3-year period prior to land application unless stipulated otherwise in a site approval letter. The organic matter content is used to determine the Maximum Allowable Nitrogen Application (MANA) rate.

MANA rate: Indicate the allowable MANA rate in pounds of nitrogen per acre for the *Crop Grown This Year*, based on the realistic yield goal, previous crop grown, and soil organic matter content.

Which months biosolids were land applied: For the months that biosolids were applied, indicate by using either the month name or number. Examples are October or 10, and November or 11. When land applying during the fall, also record the year. This gives you and the reviewer a way to check if land application occurred during the cropping year on which you are reporting.

Soil test

Report soil test data here. Soils do not have to be sampled each year that biosolids are applied, unless the site approval letter stipulates to do so. If no soil samples were taken during the reporting year, you can leave this section blank. Otherwise, you can enter the last available soil test data, even though it's old, to serve as a reminder of when to take the next sample.

Application rates & methods

Sample #: This refers to the analysis you used to calculate nitrogen and metal application rates. As mentioned above, this sample number refers back to the top of the columns on page 2 for individual analyses. If an average value was used, indicate the values (dates or sample numbers) used to calculate the average.

Gallons or wet tons applied <u>per acre</u> this year: Indicate how many gallons or wet tons (whichever is applicable) were applied **per acre** during the cropping year.

Dry tons applied <u>per acre</u> this year: Convert the previous value to dry tons, and report that on the per acre basis also. Please pay close attention to the units — all are reported on a **per acre** basis.

Method: Indicate how the biosolids were applied. The application method affects the calculation for available nitrogen. It may also show compliance with certain requirements such as those for meeting vector attraction reduction or separation distance to the water table.

Nitrogen applied: Once again pay particular attention to the units. Nitrogen applied is reported in **pounds of nitrogen per acre**. Enter all the various sources of nitrogen applied to the site. Under certain circumstances, you must account for nitrogen applied 2 years ago (see Chapter 10, How to calculate application rates).

Metals applied this year & cumulative totals

Report the metal loading rates (this equation is on the annual report form).

Page 4 of Annual Report: Certification Statements

All four certification statements must be signed. Certification Statements #2, 3 and 4 are on the annual report form. Certification Statement # 1 is in Figure 12 for you to copy. Also, Certification Statement #4 is repeated in Figure 13; it is provided separately from the annual report for those times when the applier (versus the preparer) must sign it.

If you apply septage regulated by this program, see Chapter 14 for information on regulations and reporting.

Statement #1: Certification that preparer has checked if site has reached cumulative pollutant loading rate

Three copies of this certification statement are found in Figure 12. Clip these certification statements, make copies, sign them yearly and keep them as records. They do not need to be included with the annual report.

Statement #2: Certification that a Type IV operator or inspector prepared the annual report

In Minnesota, a Type IV certified operator or inspector is required to prepare the annual report. This certification is found on page 4 of the annual report.

Statement #3: Certification that pathogen reduction (for all facilities) and one of the vector attraction reduction Options A through H (if chosen) were used — signed by biosolids preparer

Certification Statement #3 applies to all means of determining pathogen reduction and for Options A through H for Vector Attraction Reduction (see page 1 of the annual report for a list of options) for treatment processes. If you do not use these VAR options, you may leave the space blank or put *N/A* for *Not applicable*. The biosolids preparer must sign this certification statement.

Tell me why again...

Purpose of Certification Statements 3 and 4: *By signing Certification Statement #3 or 4, the person certifies only that the information that will be used to determine compliance was prepared under the signer's (preparer's) supervision. It does not require the signer to certify that the requirements have actually been met, as originally written in the federal rule.*

Statement #4: Certification that management practices and vector attraction reduction Options I or J (if chosen) were used — signed by biosolids applier

This certification statement covers the requirements for a number of management practices, including the following:

- records of maintaining setbacks
- field operations, such as injecting or incorporating biosolids

Certification Statement #4 can be signed by the applier or preparer, or both, depending on preference and who was assuring the referenced items (the events in the field) were met. This certification statement is geared toward the applier because management practices involve work done in the field. It is also possible that the applier has records of site approval and has completed all of the other management practices. In this case, it is acceptable for the applier alone to sign the certification.

If the applier signs the certification statement, the applier must give the preparer the certification statement (or a copy of it) for recordkeeping and reporting purposes. When the applier is different than the preparer, you can use Figure 13. Figure 13 contains two copies of Certification Statement #4 to copy and give to appliers to sign.

On the other hand, there are advantages to the preparer signing this certification statement, and they are as follows:

- The preparer should have records of the actual application of biosolids (Minnesota requires the preparer to keep all records, including those of the applier when different than the preparer).
- The preparer should have on record, in addition to the records of application, the site approval by the MPCA.
- The preparer is responsible for ensuring that the farmer received information about site restrictions for harvesting crops, grazing and public access.

On the other hand, under circumstances of shared responsibility for management practices, both the preparer and applier may simply prefer to sign the certification statement on the annual report.

To fill out the certification statement, first, insert ***I, J*** or ***N/A*** on the line, whichever applies for VAR. Then, as with all the certification statements, simply check the boxes for the appropriate descriptions of how the biosolids management practices were met, or when appropriate, add your own description, such as for mineland reclamation.

This is how the descriptions correspond to rule requirements:

- ❑ Biosolids were applied on sites approved by the MPCA according to MN Rules Chapter 7041.0800. If a site has been approved by the MPCA, you can assume that the requirement for protection of endangered species has been met.
- ❑ Biosolids were applied according to the soil, slope and separation distance requirements of MN Rules Chapter 7041.1200. If you have applied biosolids according to these requirements, biosolids should not run off into surface water or wetlands, and the minimum 33-foot separation distance has been met. On the line, describe how surface water and wetlands are protected if the soil, slope or separation distances are not met (i.e. for mineland reclamation).
- ❑ A detailed description of how agronomic rates are met is on page 3 of this form.
- ❑ The farmer was notified of the applicable site restrictions for harvesting crops, grazing and public access. This description insures that the site restrictions in 7041.1300 subp. 3, item D cited in the certification statement are met.

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Minnesota Pollution
Control Agency
520 Lafayette Road North
St. Paul, MN 55155-4194

Biosolids Annual Report

Minnesota's Biosolids Program
Figure 11

The yearly completion and submittal of this form, including the certification statements, will fulfill the requirements of Minn. R. Chapter 7041 for annual reporting of biosolids landspreading activities. This form must be submitted to the Minnesota Pollution Control Agency (MPCA) at the address above **by December 31 following the cropping year**. *When bulk biosolids are applied, this form must be prepared by, or under the supervision of, a Type IV certified operator or inspector.*

Reporting period: September 1, ____________________ **through August 31,** _________________

Facility Information

Facility name: ____ **NPDES or SDS Permit number:** _________________________

Contact person: ____ **Phone number:** _________________________

Work address: ____

Check here if biosolids were not **land applied during this cropping year:** ☐

Total quantity of biosolids land applied as bulk material: ______________ Gallons or _______ Wet tons **and** ______Dry tons

Total quantity of Class A biosolids sold or given away in bags or other containers: ________________Dry tons

Total quantity of biosolids transferred to another facility: ______________ Dry tons **or** ______________Gallons

Transferred to what facility: __________________ Contact person/phone # of facility: ________________ / _______________

Reporting of Biosolids Information

Pathogen reduction

Select the option/s used to meet pathogen reduction requirements:

Class B Options:

1. ☐ Geometric mean of fecal coliform determined
2. Process to Significantly Reduce Pathogens (PSRP) monitored:
   ☐ Aerobic ☐ Anaerobic ☐ Air dry ☐ Compost ☐ Lime
3. ☐ Process determined equivalent to a PSRP process monitored

Class A Options: (1 - 6 listed under 7041.1300, subp. 2, C)

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6

Describe how the Class A or Class B pathogen reduction requirement is met. For example, indicate what information was used and how it was evaluated to determine compliance.
(Do not submit daily data.)

____
____
____
____
____
____

Vector attraction reductions

Select the option/s by which vector attraction reduction was met: (For a detailed description of these options, see your Biosolids Manual or Minn. R. Chapter 7041.1400, subp. 2)

- ☐ A. 38% Volatile Solids Reduction (VSR)
- ☐ B. Bench Scale - Anaerobically Digested
- ☐ C. Bench Scale - Aerobically Digested
- ☐ D. SOUR Test: $\leq$ 1.5 mg oxygen/hour at 20 C
- ☐ E. Composted (aerobic/high temperature)
- ☐ F. Lime or Alkaline Stabilization
- ☐ G. Dried to 75% - for Stabilized Solids
- ☐ H. Dried to 90% - for Unstabilized Solids
- ☐ I. Injected
- ☐ J. Incorporated within six hours of application

For options A through H only, describe how the option was met. If VSR is calculated, indicate which equation was used, i.e. Van Kleek.

____
____
____
____

Biosolids Analysis

	Sample #	Sample #	Sample #	Sample #	Sample #	Sample #	Average
Date/s of Sampling							
Date Sent to Lab							
Total Solids (%)							
Total Volatile Solids (%)							
Kjeldahl Nitrogen (%)							
Ammonia Nitrogen (%)							
Phosphorus (%)							
Potassium (%)							
pH							
Arsenic (mg/kg)							
Cadmium (mg/kg)							
Copper (mg/kg)							
Lead (mg/kg)							
Mercury (mg/kg)							
Molybdenum (mg/kg)							
Nickel (mg/kg)							
Selenium (mg/kg)							
Zinc (mg/kg)							

Parameter	**Concentration (mg/kg)**
Arsenic	38
Cadmium	43
Copper	2150
Lead	420
Mercury	28
Molybdenum	38
Nickel	210
Selenium	50
Zinc	3750

Greater sampling frequency

Compare your average biosolids values with those in the table on the left. List any parameters that have average values greater than the values in the table.

__________ __________ __________ __________

__________ __________ __________ __________

These parameters must be analyzed two times their minimum sampling frequency during **next year's cropping season**. Your minimum sampling frequency depends on the quantity of biosolids land applied.

Your minimum biosolids sampling frequency = __________

Two times minimum biosolids sampling frequency = __________

Site Specific Information

Site Code (each site follows column down):			
Landowner:			
Actual Acreage Receiving Biosolids:			
Crop Grown This Year:			
Realistic Yield Goal (yield /acre):			
Crop Grown Previous Year:			
Soil Organic Matter*:			
MANA Rate (lbs./acre):			
Which Months Biosolids Were Land Applied:			

*Use last soil test taken for organic matter content. Soil testing is required once in the three-year time period prior to land application unless stipulated otherwise in a permit or site approval letter. If soil tests were required to be taken for this reporting year, complete the following:

Soil Test Date Sampled:			
Texture:			
Organic Matter:			
Phosphorus:			
Potassium:			
pH:			
Soluble Salts:			

Application rates and methods:

Sample # or average used in following calculations:			
Gallons **or** wet tons applied **per acre** this year:			
Dry tons applied **per acre** this year:			
Method: Surface/Inject/Incorporate (0 to 48 hrs.):			
Nitrogen applied ***(pounds/acre)***			
Available nitrogen applied in biosolids this year:			
Carry-over nitrogen from 1 year ago:			
Carry-over nitrogen from 2 years ago:			
Nitrogen applied from other sources:			
Total nitrogen applied:			

Metals applied this year and cumulative *(pounds/acre)*

Concentration (mg/kg) X .002 X Dry tons/acre = pounds/acre of metal.

For cumulative metals, add all past metal loadings together.

Parameter	This Year	Cumulative	This Year	Cumulative	This Year	Cumulative
Arsenic						
Cadmium						
Copper						
Lead						
Mercury						
Molybdenum						
Nickel						
Selenium						
Zinc						

Certification Statements for managing biosolids

Statement #1: Certification that preparer has checked if site has reached cumulative pollutant loading rate

This certification statement is not included on the annual report form. Copies are found in Figure 12 of the Land Application of Biosolids manual (see Minn. R. ch. 7041.1000, subp. 2, item B, for the requirement and 7041.1600, subp. 3, item M, for the certification statement.) Keep these signed certification statements in your records, but you do not need to include them with the annual report.

Statement #2: Certification that a Type IV operator or inspector prepared the annual report

I certify that the attached forms were prepared by myself or under my supervision.

____ ________________________

Signature of Type IV Certified Operator or Inspector *Date*

Statement #3: Certification that pathogen reduction (for all facilities) and vector attraction reduction Options A through H (if chosen) were used — signed by biosolids preparer

Plain language: I have supervised preparing information that is used to determine if our biosolids program complies with the pathogen reduction and vector attraction reduction (VAR) requirements of the biosolids rules. Specifically, Item _____ *[insert one of items A through H — see page 1 of annual report for a list of options]* of Minn. R. ch. 7041.1400, subp. 2, was used to meet VAR requirements. In addition, those who gathered and evaluated this information are qualified to do so. I understand that I may be penalized for false certification.

Actual statement from rule: I certify, under penalty of law, that the information that will be used to determine compliance with the Pathogen Requirements in Minn. R. ch. 7041.1300, subp. 2, or 7041.1300, subp. 3, and the VAR requirement in _____ *[insert one of the vector attraction reduction requirements in Minn. R. ch. 7041.1400, subp. 2, A-H, if one of those requirements is met]* has been prepared under my direction and *supervision* in accordance with the system designed to ensure that qualified personnel properly gather and evaluate the information used to determine that the pathogen requirements (and vector attraction reduction requirements, if applicable) have been met. I am aware that there are significant penalties for false certification, including the possibility of fine and imprisonment.

____ ________________________

Signature of Type IV Certified Operator or Inspector *Date*

Statement #4: Certification that management practices and vector attraction reduction Options I or J (if chosen) were used — signed by biosolids applier

Plain language: I supervised preparing information that is used to determine if our biosolids program complies with the management practices, site restrictions and VAR requirements of the biosolids rules. Specifically, Item _____ *[insert I for injection or J for incorporating within 6 hours of application]* of Minn. R. ch. 7041.1400, subp. 2, was used to meet VAR requirements. In addition, those who gathered and evaluated this information are qualified to do so. I understand that I may be penalized for false certification.

Actual statement from rule: I certify, under *penalty* of law, that the information that will be used to determine compliance with the Management Practices in Minn. R. ch. 7041.1200, the Site Restrictions in Minn. R. ch. 7041.1300, subp. 3, item D, and the VAR requirement in _____ *[insert Minn. R. ch. 7041.1400, subp. 2, I or J, if applicable]* for each site on which bulk biosolids is applied has been prepared under my direction and supervision according to the system designed to ensure that qualified personnel properly gather and evaluate the information used to determine that the management practices and site restrictions have been met. I am aware that there are significant penalties for false certification including the possibility of fine and imprisonment.

____ ________________________

Signature of Type IV Certified Operator or Inspector *Date*

Management practices were met by: (Check appropriate boxes for compliance descriptions, or if needed, add your own description. *For example, mineland reclamation may not follow all agricultural site practices, such as those for slope.)*

☐ Biosolids were applied on sites approved by the MPCA according to Minn. R. ch. 7041.0800.
☐ Biosolids were applied according to the soil, slope, and separation distance requirements of Minn. R. ch. 7041.1200.

____

____

☐ A detailed description of how agronomic rate requirements were met is on page 3 of this Annual Report.
☐ The farmer was notified of the applicable site restrictions for harvesting crops, grazing and public access.

Figure 12

Statement 1: Certification that preparer has checked if site has reached cumulative pollutant loading rate

Statement #1: Certification that preparer has checked if site has reached cumulative pollutant loading rate

Directions: Sign this and keep it on record — you do not have to report this is applying to sites in Minnesota.

Plain language: Before biosolids were applied to this site, either I or those whom I supervise checked with the MPCA to determine if cumulative pollutant loading rates for the site had been reached. If the MPCA reported that pollution concentrations applied to the site since July 20, 1993 were greater than those listed in the biosolids rules (MN Rules 7041.1100, Subp. 4, item C) and the cumulative amount was not known, we applied no additional biosolids to the site. In addition, those who gathered and evaluated this information are qualified to do so. I understand that I may be penalized for false certification.

Actual statement from rule: I certify, under penalty of law, that the information that will be used to determine compliance with the requirements to obtain information in Minn. R., part 7041.1000, subpart 2, item B, has been prepared for each site on which bulk sewage sludge is applied under my direction and supervision according to the system designed to ensure that qualified personnel properly gather and evaluate the information used to determine that the requirements to obtain information have been met. I am aware that there are significant penalties for false certification including fine and imprisonment.

____________________________________ __________________
Signature *Date*

Statement #1: Certification that preparer has checked if site has reached cumulative pollutant loading rate

Directions: Sign this and keep it on record — you do not have to report this is applying to sites in Minnesota.

Plain language: Before biosolids were applied to this site, either I or those whom I supervise checked with the MPCA to determine if cumulative pollutant loading rates for the site had been reached. If the MPCA reported that pollution concentrations applied to the site since July 20, 1993 were greater than those listed in the biosolids rules (MN Rules 7041.1100, Subp. 4, item C) and the cumulative amount was not known, we applied no additional biosolids to the site. In addition, those who gathered and evaluated this information are qualified to do so. I understand that I may be penalized for false certification.

Actual statement from rule: I certify, under penalty of law, that the information that will be used to determine compliance with the requirements to obtain information in Minn. R., part 7041.1000, subpart 2, item B, has been prepared for each site on which bulk sewage sludge is applied under my direction and supervision according to the system designed to ensure that qualified personnel properly gather and evaluate the information used to determine that the requirements to obtain information have been met. I am aware that there are significant penalties for false certification including fine and imprisonment.

____________________________________ __________________
Signature *Date*

Statement #1: Certification that preparer has checked if site has reached cumulative pollutant loading rate

Directions: Sign this and keep it on record — you do not have to report this is applying to sites in Minnesota.

Plain language: Before biosolids were applied to this site, either I or those whom I supervise checked with the MPCA to determine if cumulative pollutant loading rates for the site had been reached. If the MPCA reported that pollution concentrations applied to the site since July 20, 1993 were greater than those listed in the biosolids rules (MN Rules 7041.1100, Subp. 4, item C) and the cumulative amount was not known, we applied no additional biosolids to the site. In addition, those who gathered and evaluated this information are qualified to do so. I understand that I may be penalized for false certification.

Actual statement from rule: I certify, under penalty of law, that the information that will be used to determine compliance with the requirements to obtain information in Minn. R., part 7041.1000, subpart 2, item B, has been prepared for each site on which bulk sewage sludge is applied under my direction and supervision according to the system designed to ensure that qualified personnel properly gather and evaluate the information used to determine that the requirements to obtain information have been met. I am aware that there are significant penalties for false certification including fine and imprisonment.

____________________________________ __________________
Signature *Date*

Figure 13

Additional copies of Statement 4: Certification that management practices and vector attraction reduction Options I or J (if chosen) were used — signed by biosolids applier

Statement #4: Certification that management practices and vector attraction reduction Options I or J (if chosen) were used — signed by biosolids applier

Plain language: I supervised preparing information that is used to determine if our biosolids program complies with the management practices, site restrictions and vector attraction reduction (VAR) requirements of the biosolids rules. Specifically, Item ____ *[insert I for injection or J for incorporating within 6 hours of application]* of MN Rules Chapter 7041.1400, Subp. 2 was used to meet VAR requirements. In addition, those who gathered and evaluated this information are qualified to do so. I understand that I may be penalized for false certification.

Actual statement from rule: I certify, under penalty of law, that the information that will be used to determine compliance with the Management Practices in 7041.1200, the Site Restrictions in 7041.1300, subp. 3, item D, and the Vector Attraction Reduction Requirement in ____ *[insert 7041.1400, subp. 2, I or J, if applicable]* for each site on which bulk biosolids is applied has been prepared under my direction and supervision according to the system designed to ensure that qualified personnel properly gather and evaluate the information used to determine that the management practices and site restrictions have been met. I am aware that there are significant penalties for false certification including the possibility of fine and imprisonment.

_______________________________ *Signature* _______________________ *Date*

Management practices were met by: *[Check appropriate boxes for compliance descriptions, or if needed, add your own description. For example, mineland reclamation may not follow all agricultural site practices, such as those for slope.]*

☐ Biosolids were applied on sites approved by the MPCA according to MN Rules Ch. 7041.0800.
☐ Biosolids were applied according to the soil, slope, and separation distance requirements of MN Rules Ch. 7041.1200.

____

____

☐ A detailed description of how agronomic rate requirements were met is on page 3 of this Annual Report.
☐ The farmer was notified of the applicable site restrictions for harvesting crops, grazing and public access.

Statement #4: Certification that management practices and vector attraction reduction Options I or J (if chosen) were used — signed by biosolids applier

Plain language: I supervised preparing information that is used to determine if our biosolids program complies with the management practices, site restrictions and vector attraction reduction (VAR) requirements of the biosolids rules. Specifically, Item ____ *[insert I for injection or J for incorporating within 6 hours of application]* of MN Rules Chapter 7041.1400, Subp. 2 was used to meet VAR requirements. In addition, those who gathered and evaluated this information are qualified to do so. I understand that I may be penalized for false certification.

Actual statement from rule: I certify, under penalty of law, that the information that will be used to determine compliance with the Management Practices in 7041.1200, the Site Restrictions in 7041.1300, subp. 3, item D, and the Vector Attraction Reduction Requirement in ____ *[insert 7041.1400, subp. 2, I or J, if applicable]* for each site on which bulk biosolids is applied has been prepared under my direction and supervision according to the system designed to ensure that qualified personnel properly gather and evaluate the information used to determine that the management practices and site restrictions have been met. I am aware that there are significant penalties for false certification including the possibility of fine and imprisonment.

_______________________________ *Signature* _______________________ *Date*

Management practices were met by: *[Check appropriate boxes for compliance descriptions, or if needed, add your own description. For example, mineland reclamation may not follow all agricultural site practices, such as those for slope.]*

☐ Biosolids were applied on sites approved by the MPCA according to MN Rules Ch. 7041.0800.
☐ Biosolids were applied according to the soil, slope, and separation distance requirements of MN Rules Ch. 7041.1200.

____

____

☐ A detailed description of how agronomic rate requirements were met is on page 3 of this Annual Report.
☐ The farmer was notified of the applicable site restrictions for harvesting crops, grazing and public access.

Chapter 14 Septage

Although the federal rule (40 CFR 503) regulates domestic septage from individual septic tanks, Minnesota rules do not. However, MN Rules Chapter 7041 does regulate certain types of septage, as outlined in this chapter.

Septage regulated under MN Rules Chapter 7041

MN Rules Chapter 7041 regulates the following types of septage:

- septage generated by municipalities that are required to have a permit from the MPCA
- septage generated by sanitary districts that are required to have a permit from the MPCA
- all septage storage or treatment facilities that receive domestic septage from multiple sources. The septage storage or treatment facilities are required to have a permit from the MPCA.

Important note...

In general, the categories of septage listed immediately above are regulated much the same as for biosolids (rules on septage are found in MN Rules Chapter 7041.1800). In fact, this type of regulated septage must comply with *all* the biosolids rules for site approval and management practices.

Some differences do, however, exist between this category of septage and biosolids. The major differences are how this type of septage meets pathogen and vector attraction reduction requirements and how agronomic rates are calculated. In addition, sometimes the metals analysis is not necessary for septage. Because of this, cumulative pollutant loading rates may not be recorded or reported for septage and a different certification statement must be used for annual reporting.

Meet pathogen and vector attraction reduction requirements for septage by using one of the following methods:

- ❑ The pH of the septage must be raised to 12 or higher for 30 minutes by adding alkali and, without adding more alkali, shall remain at 12 or higher for 30 minutes.
- ❑ The septage is injected, and no significant amount of septage is present on the land surface within one hour after it is injected.
- ❑ The septage is incorporated below the surface of the land within 6 hours of application unless specified otherwise by the EPA.

Use the following equation to calculate agronomic rates for septage, unless the MPCA requires it to be based on an actual analysis:

$$AR = \frac{N}{0.0026}$$

AR = Application rate (gallons per acre) for the cropping year
N = The maximum allowable nitrogen application rate (pounds per acre) per cropping year required by the crop that is based on realistic yield goals or nitrogen uptake by vegetation grown on the land minus the amount supplied by other sources, such as manure or fertilizer.

For details, refer to your permit or MN Rules part 7041.1800 or call the MPCA biosolids coordinator for help.

How to Complete Annual Reports for Septage

To complete an annual report for septage, use the first three pages of Figure 11 in Chapter 13 (Biosolids Annual Report) and substitute Figure 14 for page 4.

Figure 14

Certifications for biosolids from septic tanks

Statement #1 for Septage	**Certification that a Type IV operator or inspector prepared the annual report**

I certify that the attached forms were prepared by myself or under my supervision.

______________________________________ ____________________

Signature of Type IV Certified Operator or Inspector *Date*

Statement #2 for Septage	**Certification that pathogen reduction, vector attraction reduction, management practices and site restrictions were used**

Plain language: I have supervised preparing information that is used to determine if our program complies with all of the following parts of the biosolids rules: the pathogen reduction and vector attraction reduction (VAR) requirements, the management practices, and the site restrictions. Specifically, Item ____ *[insert A, B or C — see box below]* of MN Rules Chapter 7041.1800, Subp. 3 was used to meet pathogen reduction and VAR requirements. In addition, those who gathered and evaluated this information are qualified to do so. I understand that I may be penalized for false certification.

Actual statement from rule: I certify, under penalty of law, that the information that will be used to determine compliance with the pathogen and vector attraction reduction requirements in subpart 3, item A, B, or C, ____ *[insert either subpart 3, item **A, B, or C,** see subp. 3 below]* the management practices in part 7041.1200, and the site restrictions in part 7041.1300, subpart 3, item D, has been prepared under my direction and supervision according to the system designed to ensure that qualified personnel properly gather and evaluate the information used to determine that the pathogen and vector attraction reduction requirements have been met. I am aware that there are significant penalties for false certification including the possibility of fine and imprisonment.

______________________________________ ____________________

Signature *Date*

MN Rules Chapter 7041.1800 Subpart 3: Pathogen and vector attraction reduction

To meet pathogen and vector attraction reduction requirements, fulfill the site restrictions in MN Rules Chapter 7041.1300, subpart 3, item D ***and*** use one of the following methods:

A. The pH of the septage must be raised to 12 or higher for 30 minutes by adding alkali and, without adding more alkali, shall remain at 12 or higher for 30 minutes.

B. The septage is injected, and no significant amount of septage is present on the land surface within one hour after it is injected.

C. The septage is incorporated below the surface of the land within 6 hours of application unless specified otherwise by the EPA.

Management practices were met by: *[Check appropriate boxes for compliance descriptions, or if needed, add your own description. For example, mineland reclamation may not follow all agricultural site practices, such as those for slope.]*

☐ Biosolids were applied on sites approved by the MPCA according to MN Rules Chapter 7041.0800.
☐ Biosolids were applied according to the soil, slope and separation distance requirements of MN Rules Chapter 7041.1200.

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☐ A detailed description of how agronomic rate requirements were met is on page 3 of this Annual Report.
☐ The farmer was notified of the applicable site restrictions for harvesting crops, grazing and public access.

CHAPTER 7041, SEWAGE SLUDGE MANAGEMENT

MINNESOTA POLLUTION CONTROL AGENCY

7041.0100 DEFINITIONS.

Subpart 1. Scope. For the purpose of this chapter, the following terms have the meanings given them.

Subp. 2. Agency. "Agency" means the Minnesota Pollution Control Agency.

Subp. 3. Agricultural land. "Agricultural land" means land on which a food crop, feed crop, cover crop, or fiber crop is grown as well as land managed for the production of hay, pastureland for grazing of livestock, or rangeland.

Subp. 4. Agronomic rate. "Agronomic rate" means the sewage sludge application rate (dry weight basis) designed to:

A. provide the amount of nitrogen which can be utilized by the food crop, feed crop, fiber crop, cover crop, or vegetation grown on the land; and

B. minimize the amount of nitrogen in the sewage sludge that passes below the root zone of the crop or vegetation grown on the land to the groundwater.

Subp. 5. Annual pollutant loading rate. "Annual pollutant loading rate" means the maximum amount of a pollutant that can be applied to a unit area of land during a 365-day period.

Subp. 6. Apply sewage sludge or sewage sludge applied to the land. "Apply sewage sludge" or "sewage sludge applied to the land" means applying sewage sludge by spraying or spreading sewage sludge on the surface of the land, injecting sewage sludge below the surface of the land or incorporating sewage sludge into the soil for beneficial use.

Subp. 7. **Available nitrogen.** "Available nitrogen" means nitrogen which is present in inorganic forms and the amount of organic nitrogen that can be mineralized to plant available forms.

Subp. 8. **Beneficial use.** "Beneficial use" means any application of sewage sludge to the land to improve soil physical and chemical properties by supplying nutrients, organic matter, and other components of this material.

Subp. 9. **Bulk sewage sludge.** "Bulk sewage sludge" means sewage sludge that is not sold or given away in a bag or other container for application to the land.

Subp. 10. **Cave.** "Cave" means any naturally formed, subterranean open area or chamber, or series of chambers.

Subp. 11. **Commissioner.** "Commissioner" means the commissioner or other designated representative of the Minnesota Pollution Control Agency.

Subp. 12. **Cover crop.** "Cover crop" means a small grain or other close growing vegetation not grown for harvest such as vegetation growing on land set aside for conservation purposes.

Subp. 13. **Cropping year.** "Cropping year" means a year beginning on September 1 of the year prior to the growing season and ending August 31 the year the crop is harvested. For example, the 1994 cropping year began September 1, 1993, and ended August 31, 1994.

Subp. 14. **Cumulative pollutant loading rate.** "Cumulative pollutant loading rate" means the maximum amount of an inorganic pollutant that can be applied to an area of land.

Subp. 15. **Dewatered sewage sludge.** "Dewatered sewage sludge" means any sewage sludge with a total solids content of 20 percent or greater or which can be transported and handled as a solid material.

Subp. 16. **Domestic septage.** "Domestic septage" means either liquid or solid material removed from a septic tank, cesspool, portable toilet, Type III marine sanitation device, or similar treatment works that receives only domestic sewage. Domestic septage does not include liquid or solid material removed from a septic tank, cesspool, or similar treatment works that receives either commercial wastewater or industrial wastewater and does not include grease removed from a grease trap at a restaurant.

Subp. 17. **Domestic sewage.** "Domestic sewage" means waste and wastewater from humans or household operations that is discharged to or otherwise enters a treatment works.

Subp. 18. **Dry weight basis.** "Dry weight basis" means calculated on the basis of having been dried at 105 degrees Celsius until reaching a constant mass, or essentially 100 percent solids content.

Subp. 19. **EPA.** "EPA" means the United States Environmental Protection Agency.

Subp. 20. **Exceptional quality sewage sludge.** "Exceptional quality sewage sludge" means sewage sludge which has been prepared to meet one of the Class A pathogen reduction requirements in part 7041.1300, subpart 2; the pollutant concentrations in part 7041.1100, subpart 4, item C; and one of the vector attraction reduction requirements in part 7041.1400, subpart 2, items A to H.

Subp. 21. **Feed crops.** "Feed crops" means crops produced primarily for consumption by animals.

Subp. 22. Food crops. "Food crops" means crops consumed by humans. These include, but are not limited to, fruits, vegetables, and tobacco.

Subp. 23. Forest. "Forest" means a tract of land thick with trees and underbrush.

Subp. 24. Groundwater. "Groundwater" means water below the land surface in the saturated zone.

Subp. 25. Highly permeable soils. "Highly permeable soils" means soils whose soil leaching potentials are rated as severe, poor filter for soil pesticide loss, by the Natural Resources Conservation Service using the procedure found in part 620, Soil Interpretation Rating Guides of the United States Department of Agriculture-Natural Resources Conservation Service National Soil Survey Handbook.

Subp. 26. Industrial wastewater. "Industrial wastewater" means wastewater generated in a commercial or industrial process.

Subp. 27. Land application site. "Land application site" means an area of land which receives application of sewage sludge for beneficial use.

Subp. 28. Long-term storage. "Long-term storage" means the storage of dewatered bulk sewage sludge for a period greater than 30 days but not exceeding seven months at a land application site.

Subp. 29. Material derived from sewage sludge. "Material derived from sewage sludge" means sewage sludge received from a treatment works whose quality is changed either through treatment or mixing with a nonhazardous material prior to being applied to the land.

Subp. 30. Mine. "Mine" means an excavation for minerals.

Subp. 31. NPDES permit. "NPDES permit" means a national pollutant discharge elimination system permit issued by the agency that authorizes under certain conditions the discharge of pollutants to surface waters of the state. Combined NPDES/SDS permits issued by the agency will be considered NPDES permits under this chapter.

Subp. 32. Natural Resources Conservation Service. "Natural Resources Conservation Service" means the Natural Resources Conservation Service of the United States Department of Agriculture, formerly known as the Soil Conservation Service.

Subp. 33. Other container. "Other container" means either an open or closed receptacle. This includes, but is not limited to, a bucket, box, carton, or vehicle or trailer with a load capacity of one metric ton (2205 pounds) or less.

Subp. 34. Pathogens. "Pathogens" means organisms that are capable of producing an infection or disease in a susceptible host.

Subp. 35. Perched water condition. "Perched water condition" means the soil is saturated with water in one or more layers within 200 centimeters (78.7 inches) of the mineral soil surface and has one or more unsaturated layers, with an upper boundary above 200 centimeters (78.7 inches) in depth, below the saturated layer. The zone of saturation, i.e., the water table, is perched on top of a relatively impermeable layer. The Natural Resources Conservation Service also classifies this as "epi-saturation."

Subp. 36. Permitting authority. "Permitting authority" means either the EPA or a state with an EPA-approved sewage sludge management program.

Subp. 37. Person. "Person" has the meaning given it in Minnesota Statutes, section 116.06, subdivision 17.

Subp. 38. Person who prepares sewage sludge. "Person who prepares sewage sludge" means the person who generates sewage sludge during the treatment of domestic sewage in a treatment works or the person who derives a material from sewage sludge.

Subp. 39. pH. "pH" means the logarithm of the reciprocal of the hydrogen ion concentration measured at 25 degrees Celsius or measured at another temperature and then converted to an equivalent value at 25 degrees Celsius.

Subp. 40. Pollutant. "Pollutant" means an organic substance, an inorganic substance, a combination of organic and inorganic substances, or a pathogenic organism that, after discharge and upon exposure, ingestion, inhalation, or assimilation into an organism either directly from the environment or indirectly by ingestion through the food chain, could, on the basis of information available to the administrator of EPA, cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions including malfunction in reproduction, or physical deformations in either organisms or offspring of the organisms.

Subp. 41. Pollutant limit. "Pollutant limit" means a numerical value that describes the amount of a pollutant allowed per unit amount of sewage sludge, such as milligrams per kilogram of total solids, or the amount of a pollutant that can be applied to a unit area of land, such as pounds per acre.

Subp. 42. Public contact site. "Public contact site" means land with a high potential for contact by the public. This includes, but is not limited to, public parks, ball fields, cemeteries, and golf courses.

Subp. 43. Quarry. "Quarry" means a surficial mine used to obtain building stone, limestone, gravel, or sand.

Subp. 44. Realistic yield goal. "Realistic yield goal" means the most recent five-year average of crop yields, excluding the worst year, or the most recent three- to five-year average yield increased by ten percent or if the crop has never been grown, the realistic yield goal based on soil productivity and level of management as determined by the county Natural Resources Conservation Service, county extension agent, or a crop consultant.

Subp. 45. Reclamation site. "Reclamation site" means drastically disturbed land that is reclaimed using sewage sludge. This includes, but is not limited to, strip mines and construction sites.

Subp. 46. Residential development. "Residential development" means ten or more places of habitation concentrated within ten acres of land. The term also includes schools, churches, hospitals, nursing homes, businesses, offices, and apartment buildings or complexes having ten or more living units.

Subp. 47. SDS permit. "SDS permit" means a state disposal system permit issued by the agency that authorizes under certain conditions the subsurface disposal or on-land disposal of pollutants and the operation of a disposal system.

Subp. 48. Seasonal high water table. "Seasonal high water table" means the highest level the water table reaches during a given year. Methods of determining the seasonal high water table are given in part 7041.3400, subpart 3.

Subp. 49. Sewage sludge. "Sewage sludge" means solid, semisolid, or liquid residue generated during the treatment of domestic sewage in a treatment works. Sewage sludge includes but is not limited to, scum or solids removed in primary, secondary, or advanced wastewater treatment processes; and a material derived from sewage sludge. Sewage sludge does not include ash generated during the firing of sewage sludge in a sewage sludge incinerator or grit and screenings generated during preliminary treatment of domestic sewage in a treatment works. Sewage sludge that is acceptable and beneficial for recycling on land as a soil conditioner and nutrient source is also known as biosolids.

Subp. 50. Short-term storage. "Short-term storage" means the storage of dewatered bulk sewage sludge for a period of less than 30 days at a land application site.

Subp. 51. Sinkhole. "Sinkhole" means a closed depression in an area of Karst topography that is formed either by solution of surficial limestone or by collapse of underlying caves.

Subp. 52. Soil horizon. "Soil horizon" means a layer of soil that is approximately parallel to the soil surface and has some set of properties that have been produced by soil-forming processes, and has some properties that are not like those of the layers above and beneath it. These properties include color, structure, texture, consistency, and bulk density.

Subp. 53. Soil texture. "Soil texture" means the relative portion of the soil separates sand, silt, and clay. It can be measured using methods described in part 7041.3400, subpart 1. Coarse texture is United States Department of Agriculture textural classifications sand, loamy sand, and sandy loam. Medium texture is United States Department of Agriculture classifications loam, silt, silt loam, and sandy clay loam. Fine texture is United States Department of Agriculture classifications clay loam, silty clay loam, sandy clay, silty clay, and clay.

Subp. 54. Specific oxygen uptake rate (SOUR). "Specific oxygen uptake rate (SOUR)" means the mass of oxygen consumed per unit time per unit mass of total solids (dry weight basis) in the sewage sludge.

Subp. 55. Surface waters. "Surface waters" means waters of the state including streams, lakes, ponds, marshes, watercourses, waterways, springs, reservoirs, and all other bodies or accumulations of water, natural or artificial, public or private, which are contained within, flow through, or border upon the state.

Subp. 56. Total solids. "Total solids" means the materials in sewage sludge that remain as residue when the sewage sludge is dried at 103 to 105 degrees Celsius.

Subp. 57. Treatment works. "Treatment works" means either a federally owned, publicly owned, or privately owned device or system used to treat, recycle, or reclaim either domestic sewage or a combination of domestic sewage and industrial waste of a liquid nature. This includes a septage treatment or septage storage facility which receives domestic septage from multiple sources. For the purpose of this chapter, a treatment works does not include septic tanks unless they are part of a wastewater treatment facility operated by a municipality or sanitary district which is required by the agency to have a NPDES or SDS permit.

Subp. 58. Type IV certified operator or inspector. "Type IV certified operator or inspector" means a person certified according to chapter 7048 for the land application of sewage sludge or the inspection of sewage sludge land application sites.

Subp. 59. Unstabilized solids. "Unstabilized solids" means organic materials in sewage sludge that have not been treated in either an aerobic or anaerobic treatment process.

Subp. 60. Vector attraction. "Vector attraction" means the characteristic of sewage sludge that attracts rodents, flies, mosquitoes, or other organisms capable of transporting infectious agents.

Subp. 61. Volatile solids. "Volatile solids" means the amount of the total solids in sewage sludge lost when the sewage sludge is combusted at 550 degrees Celsius in the presence of excess air.

Subp. 62. Wetland. "Wetland" means those areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. Constructed wetlands designed for wastewater treatment are not waters of the state. Wetlands must:

A. have a predominance of hydric soils;

B. be inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support a prevalence of hydrophytic vegetation typically adapted for life in a saturated soil condition; and

C. under normal circumstances, support a prevalence of such vegetation.

Statutory Authority: *MS s 116.07*

History: *21 SR 1642*

Published Electronically: *October 27, 2003*

7041.0200 PURPOSE AND POLICY.

The purpose of this chapter is to establish requirements for the storage and land application of sewage sludge that protect public health and the environment. The policy of the agency is to encourage the beneficial use of sewage sludge as a fertilizer or soil conditioner.

Statutory Authority: *MS s 116.07*

History: *21 SR 1642*

Published Electronically: *October 27, 2003*

7041.0300 APPLICABILITY AND EXCLUSIONS.

Subpart 1. Applicability. Except as provided in subpart 2, item I, the requirements of this chapter apply to any person who prepares sewage sludge that is applied to the land, to any person who applies sewage sludge to the land, to sewage sludge applied to the land (including sewage sludge remaining in a treatment works that is a wastewater treatment pond when the pond is emptied or ceases to be used to receive wastewater), and the land on which sewage sludge is applied.

Subp. 2. Exclusions. This chapter does not establish requirements for:

A. processes used to treat domestic sewage or for processes used to treat sewage sludge such as thickening, stabilization, and dewatering prior to final application to the land, except as provided in parts 7041.1300 and 7041.1400. Treatment processes do not include storage;

B. the use or disposal of sludge generated at an industrial facility during the treatment of industrial wastewater, including sewage sludge generated during the treatment of industrial wastewater combined with domestic sewage;

C. the use or disposal of sewage sludge determined to be hazardous according to Code of Federal Regulation, title 40, part 261;

D. the use or disposal of sewage sludge with a concentration of polychlorinated biphenyls (PCBs) equal to or greater than 50 milligrams per kilogram of total solids (dry weight basis);

E. the use or disposal of ash generated during the firing of sewage sludge in a sewage sludge incinerator;

F. the use or disposal of grit, for example, sand, gravel, cinders, or other materials with a high specific gravity, or screenings, for example, relatively large materials such as rags, generated during preliminary treatment of domestic sewage in a treatment works;

G. the use or disposal of sludge generated during the treatment of either surface water or groundwater used for drinking water;

H. a material derived from exceptional quality sewage sludge; and

I. the land application or storage of domestic, commercial, industrial septage, a mixture of domestic septage and commercial septage, or a mixture of domestic septage and industrial septage unless the domestic septage or mixture is generated or stored at a treatment works, in which case it is subject to the requirements of this chapter.

Statutory Authority: *MS s 116.07*

History: *21 SR 1642*

Published Electronically: *October 27, 2003*

7041.0400 EXCEPTIONAL QUALITY SEWAGE SLUDGE.

Subpart 1. Conditions. The conditions in subpart 2 for exceptional quality sewage sludge do not apply until they are included in a permit or approved management plan as required in part 7041.0600.

Subp. 2. General requirements and management practices. The general requirements in part 7041.1000 and the management practices in part 7041.1200 do not apply to exceptional quality sewage sludge which is applied to the land, except as follows:

A. the management practices in part 7041.1200, subpart 2, item B, for liquid bulk sewage sludge applied to frozen or snow covered ground apply to liquid bulk exceptional quality sewage sludge; and

B. the total nitrogen, phosphorus, and potassium content must be supplied by the person who prepares the sewage sludge to the person who applies or distributes the sewage sludge for that person's use in recommending application rates.

Subp. 3. Storage. The requirements in part 7041.1200, subpart 8, items D and E, apply to the storage of dewatered bulk exceptional quality sewage sludge on agricultural land, forest, or a reclamation site and the storage must not exceed seven months. Persons who prepare sewage sludge shall inform in writing persons who receive the bulk exceptional quality sewage sludge of these storage requirements.

Statutory Authority: *MS s 116.07*

History: *21 SR 1642*

Published Electronically: *October 27, 2003*

7041.0500 BASIC PROVISIONS.

Subpart 1. Responsibility. Persons who prepare sewage sludge are responsible for ensuring that the applicable requirements in this chapter are met when the sewage sludge is prepared, distributed, or applied to the land.

Subp. 2. Direct enforceability. No person shall use or dispose of sewage sludge through any practice for which requirements are established in this chapter except in accordance with such requirements.

Subp. 3. Additional or more stringent requirements. When necessary to protect the public health or the environment from a potentially adverse effect of a pollutant in sewage sludge, the commissioner may include in a permit or site approval additional or more stringent requirements than established in this chapter.

Subp. 4. Variance. Any person may apply for a variance from requirements of this chapter in accordance with chapter 7000, Minnesota Statutes, section 116.07, subdivision 5, and other applicable statutes and rules; however, the agency shall not grant a variance from any federal requirement.

Subp. 5. [Repealed, L 2012 c 272 s 98]

Subp. 6. [Repealed, L 2012 c 272 s 98]

Subp. 7. [Repealed, L 2012 c 272 s 98]

Statutory Authority: *MS s 116.07*

History: *21 SR 1642; L 2012 c 272 s 98*

Published Electronically: *August 3, 2012*

7041.0600 REQUIREMENT TO OBTAIN PERMITS AND SITE APPROVAL.

Subpart 1. Permits for inclusion of the sewage sludge requirements. A NPDES or SDS permit which includes sewage sludge requirements must be applied for and obtained from the agency by persons specified in items A to C. Persons who do not have a permit must apply for and obtain a permit before land applying or distributing sewage sludge for application to the land. Permit application requirements are set out in part 7041.0700.

A. Persons who prepare sewage sludge in Minnesota. For persons who have NPDES or SDS permits issued by the agency, the requirements for sewage sludge shall be incorporated into those permits when they are reissued unless the requirements are included in a separate permit or modification of a permit at the request of a permittee. Information required in part 7041.0700 shall be submitted with an application to obtain, renew, or modify a permit.

B. Persons who prepare sewage sludge in another state which is applied to the land or distributed for application to the land in Minnesota, unless the person who prepares the sewage sludge produces exceptional quality sewage sludge or sewage sludge that is sold or given away in a bag or other container and has a permit issued by another state or EPA which includes the requirements for its preparation.

If a permit from the agency is not required, the person who prepares the sewage sludge must obtain written approval of a management plan from the commissioner before the sewage sludge is distributed or applied to the land. The plan must include the information in part 7041.0700, item I. An approved management plan shall be enforceable to the same extent and the same manner as a permit.

C. Persons who prepare sewage sludge which is applied to the land or distributed for application to the land in Minnesota who propose methods to utilize sewage sludge which are not addressed by this chapter.

Subp. 2. **Permits for sewage sludge storage.** Persons who store bulk sewage sludge or construct storage for bulk sewage sludge at locations other than at a permitted wastewater treatment facility must apply for and obtain a NPDES or SDS permit from the agency prior to storage or construction. Persons who have permits may apply to have their permits modified to include conditions for storage or construction of storage. Permit application requirements are set out in part 7041.0700. A permit is not required for:

A. short-term or approved long-term storage of dewatered bulk sewage sludge at a land application site; or

B. storage of dewatered bulk exceptional quality sewage sludge when:

(1) (1) the storage meets the requirements in part 7041.0400, subpart 3;

(2) (2) the storage is at a facility permitted under Minnesota Statutes, section 18C.305, for fertilizer;

(3) (3) the storage is located at public contact sites, plant nurseries, turf farms, or other locations where it is used for landscaping or horticultural purposes; or

(4) (4) it is stored by persons using it for landscaping or horticultural purposes.

Subp. 3. **Site approval.** Persons who prepare bulk sewage sludge must obtain approval of the sites on which bulk sewage sludge is applied before it is applied unless it is exceptional quality sewage sludge. Application procedures are set out in part 7041.0800.

Statutory Authority: *MS s 116.07*

History: *21 SR 1642*

Published Electronically: *October 27, 2003*

7041.0700 APPLICATION REQUIREMENTS FOR NPDES AND SDS PERMITS.

The agency's procedural and permitting rules, chapters 7000 and 7001, apply to all permits required by this chapter. In addition to information required by part 7001.1050, permit applications must include the information listed in items A to L, except that items I and J need only be included when applicable, on a form provided by the commissioner. Information in item I is required when exceptional quality sewage sludge or sewage sludge which is sold or given away in a bag or other container is prepared. Item J is required when the application is for storage or construction of a storage facility for bulk sewage sludge.

A. A description of the process used to meet Class A or Class B pathogen and vector attraction reduction requirements, including any information needed to make these determinations including temperatures, retention times, salmonella, virus, and viable helminth data, volatile solids reduction calculations and management practices.

B. Sewage sludge chemical characteristics determined from a sample or samples taken within one year of application submittal, analyzed, at a minimum, for the parameters listed in part 7041.1500, subpart 2, items A to E, unless the sewage sludge is generated from septic tanks in which case an analysis is not necessarily required. The commissioner shall determine and notify the permit applicant if an analysis is required to protect human health or the environment after review of the permit application. In order to make this determination, the permit application must include information on the size and location of the septic tanks and a description of any commercial (such as a restaurant) or industrial discharges to the treatment works.

C. A description of how and when representative samples of sewage sludge applied to the land will be taken.

D. Information necessary to evaluate the laboratory quality assurance and quality control procedures including analytical methods, detection limits, and holding times of the laboratory doing the analysis in item B and the sampling techniques, preservation method, and shipping technique used by the preparer.

E. Any groundwater monitoring data, with a description of the well locations and approximate depth to groundwater for land application sites if this data is not already on file at the agency.

F. A description of the applicant's sewage sludge use, disposal, or distribution practices.

G. The location to which sewage sludge is transferred and the names of applicators, contractors, or distributors who will use or dispose of the sewage sludge, if applicable.

H. Annual sewage sludge production.

I. A management plan that describes how the person who prepares the sewage sludge will ensure that the proposed distribution or land application of the sewage sludge meets the requirements of this chapter. The following items shall be included or addressed in the plan:

(1) a copy of any permits issued to the applicant which contain conditions for the treatment of sewage sludge which are not issued by the agency;

(2) a certification statement appropriate to the type of sewage sludge prepared as required in part 7041.1600;

(3) a copy of the analysis of the sewage sludge as required by part 7041.1500;

(5) (4) the proposed method of use and distribution of the sewage sludge;

(6) (5) a copy of any labels or information sheets to be supplied to users or distributors of the sewage sludge, if applicable;

(7) (6) the quantity of sewage sludge to be transported and the transportation schedule; and

(8) (7) what information will be submitted on the annual report and when the annual report will be submitted.

J. Information describing storage or construction of storage which includes:

(1) the location on a topographic map depicting the area one mile beyond the proposed location;

(2) the size of the storage facility or area;

(3) the type of sewage sludge to be stored;

(9) (4) operating conditions for receiving and removing sewage sludge and handling spills if liquid sewage sludge is stored;

(10) (5) the type of storage structure or impermeable pad if proposed; and

(11) (6) the plans and specifications for constructed storage facilities.

K. Any information required to determine the appropriate standards for permitting under this chapter.

L. Any other information the commissioner may request and reasonably require to assess the sewage sludge land application practices, to determine whether to issue a permit, or to ascertain appropriate permit requirements such as detailed product description and proposed distribution.

Statutory Authority: *MS s 116.07*

History: *21 SR 1642*

Published Electronically: *October 27, 2003*

7041.0800 APPLICATION AND APPROVAL PROCEDURE FOR LAND APPLICATION SITES.

Subpart 1. Site application. Persons who are required by part 7041.0600, subpart 3, to obtain a site approval from the commissioner must apply for the approval as provided in this part. Applications for approvals must be completed and signed by a Type IV certified operator or inspector. An approval is only valid for the conditions stated in the approval, including management practices and acreage authorized. If a change in acreage is proposed, a new application must be submitted and approval obtained. If a change in management practices included in the site approval is proposed, the change shall be authorized by the commissioner through a letter to the person who applies for the change before the person initiates the change.

The application must include a copy of the notification described in subpart 6 and the specific information given in subparts 2 to 5 submitted on a site application form obtained from or approved by the commissioner.

Subp. 2. Site characterization. Site applications must contain site characterization that includes the following:

A. a copy of Natural Resources Conservation Service soil survey maps from the official soil survey, if available, or comparable soil maps prepared by a soil scientist with mapping experience, delineating the boundaries of the specific land application site, and:

(1) the depth, spacing, and location of tile lines;

(2) the location of tile inlets; and

(3) a list of soil types on the site that are highly permeable;

B. a legal description of the land application site, including township, range, section, quarter section, township or city name, and county;

C. the following characteristics of the soil determined from samples obtained within six months of site application submittal using collection and analysis procedures in parts 7041.3300 and 7041.3400:

(1) United States Department of Agriculture textural classification;

(2) percentage of organic matter;

(3) extractable phosphorus in parts per million;

(4) exchangeable potassium in parts per million;

(5) water pH; and

(6) soluble salts expressed in millimhos per centimeter;

D. the approvable acreage of the land application site;

E. the name and address of the landowner and a copy or description of any contracts or agreements the landowner has with persons other than the applicant for the land application of bulk sewage sludge or other waste products such as industrial sludge, wastewater, and animal manure, at the land application site; and

F. the name and address of any renter, lessee, or occupier of the land application site.

Subp. 3. Site management. Applications must include site management, including:

A. a description of the proposed method or methods of bulk sewage sludge application;

B. a description of the crops to be grown and realistic yield goals or dominant vegetation at the site and the intended use of the crops or vegetation;

C. the maximum available nitrogen application rate, in pounds of nitrogen per acre and the agronomic rate in dry tons of bulk sewage sludge solids per acre per cropping year; and

D. a description of how public access to the site is proposed to be controlled if necessary.

Subp. 4. Application requirements for long-term storage of dewatered bulk sewage sludge at the site at which the bulk sewage sludge is applied. Applications must include the following information if approval of long-term storage at the land application site is requested:

A. a description of the necessity for storage at the land application site;

B. the location of the storage area delineated on maps submitted according to subpart 2, item

C. the dimensions of the bulk sewage sludge storage area;

D. the quantity of bulk sewage sludge to be stored;

E. boring logs from at least two soil borings taken to a depth of ten feet at the perimeter of the proposed storage area. The boring logs must include:

(1) texture and thickness of each soil horizon encountered;

(2) color and presence or absence of mottling for each soil horizon encountered;

(3) depth to seasonal high water table, if encountered; and

(4) depth to bedrock, if encountered;

F. the expected duration of storage before land application; and

G. the description of precautions or practices to minimize or prevent drainage, runoff, or nuisance conditions at the storage area.

Subp. 5. Modification of management practices. If any modification of the suitable soil conditions, slopes, or separation distances in part 7041.1200, subpart 3, are requested for nonagricultural uses, the site application must indicate what the nonagricultural use is; which conditions, slopes, or separation distances should be modified; and what environmental benefits will result from bulk sewage sludge application under the proposed conditions.

Subp. 6. **Approval procedure; public notification.** Persons who prepare bulk sewage sludge shall provide notice by mail of the proposed land application site on the same date to the commissioner, the owner and occupier of the site, the city or township and county official of the area where the land application site is located, and any person known by the preparer to be interested in the approval of the site. The notice must include:

A. that the purpose is to notify local officials of the intent to apply to the commissioner for approval of the site for the beneficial use of sewage sludge;

B. site ownership and location and the name of the lessee, renter, or occupier of the site if applicable;

C. the preparer's name and how the preparer can be reached for more information;

D. a general site management and conditions information sheet prepared or approved by the commissioner;

E. that a Type IV operator or inspector certified by the commissioner in handling sewage sludge has reviewed the sites for compliance with this chapter;

F. that application is being mailed on the same date to the commissioner for a final determination on site suitability and site management for those sites;

G. that if there are comments or questions regarding approval of the sites, the agency's Water Quality Division must be contacted within 30 days of the date the notification was sent;

H. that the commissioner will approve or deny the application in writing after the 30-day comment period; and

I. that the commissioner reviews land application reports submitted annually by the preparer of sewage sludge.

Subp. 7. **Review.** Applications shall be reviewed for completeness by the commissioner. If the application is incomplete, the commissioner shall promptly advise the applicant of the incompleteness. Further processing of the application shall be suspended until the applicant has supplied the necessary information to the commissioner.

Subp. 8. **Approval or denial.** Notice of approval or denial and reasons for a denial shall be issued by the commissioner to the persons listed in subpart 6 no sooner than 30 days from the date the notification of the land application site was sent to those persons.

Subp. 9. **Final determination.** The commissioner shall attempt to resolve all comments prior to a final determination concerning the application. If the comments have been resolved, the commissioner shall issue or deny the approval. If all comments cannot be resolved, the application shall be presented to the agency board, which shall issue or deny the approval.

Subp. 10. **Enforcement.** A site approval issued to the person who prepares sewage sludge under this part shall be enforceable to the same extent and in the same manner as a permit.

Subp. 11. **Revocation of site approvals.** A site approval may be revoked in accordance with the requirements of part 7001.0170.

Statutory Authority: *MS s 116.07*

History: *21 SR 1642*

Published Electronically: *October 27, 2003*

7041.0900 STORAGE CONSTRUCTION REQUIREMENTS.

The minimum construction requirements in items A and B apply to storage facilities required to be permitted under part 7041.0600, subpart 2.

A. Any basin, tank, pit, or lagoon used to store liquid sewage sludge must not seep at a rate greater than 500 gallons per acre per day.

B. Any area used to store dewatered sewage sludge must be paved with asphalt, concrete, or other material meeting the seepage requirement in item A to a depth sufficient to bear the weight of unloading and loading trucks and equipment without cracking. The pad must be sloped and curbed to collect all runoff water. Runoff water must be routed to a wastewater treatment facility or used in a manner approved by the commissioner.

Statutory Authority: *MS s 116.07*

History: *21 SR 1642*

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7041.1000 GENERAL REQUIREMENTS.

Subpart 1. Cumulative pollutant loading rates. No person shall apply bulk sewage sludge to agricultural land, forest, a public contact site, or a reclamation site if any of the cumulative pollutant loading rates in part 7041.1100, subpart 4, item B, have been reached.

Subp. 2. Notice and necessary information for compliance. Notice and necessary information needed to comply with the requirements of this chapter must be given or obtained by preparers, appliers, and users of bulk sewage sludge according to items A to D.

A. Preparers of bulk sewage sludge must provide written notification of the concentration of total nitrogen (as N on a dry weight basis) and available nitrogen (in pounds per wet ton or pounds per 1,000 gallons, whichever is appropriate) to appliers of bulk sewage sludge.

B. Before bulk sewage sludge subject to the cumulative pollutant loading rates in part 7041.1100, subpart 4, item B, is applied to the land, the person who proposes to apply the bulk sewage sludge must contact the permitting authority for the state in which the bulk sewage sludge will be applied to determine whether cumulative pollutant loading rates have been reached. If bulk sewage sludge which has pollutant concentrations greater than those listed in part 7041.1100, subpart 4, item C, has been applied since July 20, 1993, and the cumulative amount is not known, no additional bulk sewage sludge may be applied to that land.

C. The person who prepares bulk sewage sludge, or an applier under contract to the preparer to do so, is responsible for notifying and providing the necessary information for compliance with this chapter to the users of bulk sewage sludge by specifying appropriate agronomic application rates, site restrictions, and other management practices.

D. A person who prepares sewage sludge must give notice and necessary information to comply with this chapter to other persons who prepare sewage sludge or derive a material from the sewage sludge.

Subp. 3. **Sewage sludge applied to land in another state.** Any person who prepares bulk sewage sludge in Minnesota that is applied to land in another state is responsible for providing written notice to the permitting authority for the state in which the bulk sewage sludge is proposed to be applied prior to the initial application of bulk sewage sludge. The notice must include:

A. the legal description of each land application site;

B. the approximate time period bulk sewage sludge will be applied to the site;

C. the concentration of the pollutants listed in part 7041.1100, subpart 4, item C, for the bulk sewage sludge which will be applied to the land; and

D. the name, address, telephone number, and national pollutant discharge elimination system permit number, if appropriate, for the person who prepares the bulk sewage sludge.

Statutory Authority: *MS s 116.07*

History: *21 SR 1642*

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7041.1100 POLLUTANT LIMITS.

Subpart 1. **Ceiling concentrations.** Bulk sewage sludge or sewage sludge sold or given away in a bag or other container must not be applied to the land if the concentration of any pollutant in the sewage sludge exceeds the ceiling concentration for the pollutant in subpart 4, item A.

Subp. 2. **Cumulative loading rates.** If bulk sewage sludge is applied to agricultural land, forest, a public contact site, or a reclamation site, either the cumulative loading rate for each pollutant must not exceed the cumulative pollutant loading rate for each pollutant in subpart 4, item B, or the bulk sewage sludge must be exceptional quality sewage sludge.

Subp. 3. **Pollutant concentrations.** The conditions in items A and B apply to pollutant concentrations in bulk sewage sludge and sewage sludge sold or given away in a bag or other container.

A. If bulk sewage sludge is applied to a lawn or a home garden, the concentration of each pollutant in the sewage sludge must not exceed the concentration for the pollutant in subpart 4, item C.

B. If sewage sludge is sold or given away in a bag or other container for application to the land, either:

(1) the concentration of each pollutant in the sewage sludge must not exceed the concentration for the pollutant in subpart 4, item C; or

(2) the product of the concentration of each pollutant in the sewage sludge and the annual whole sludge application rate for the sewage sludge must not cause the annual pollutant loading rate for the pollutant in subpart 4, item D, to be exceeded. The procedure used to determine the annual whole sludge application rate is outlined in part 7041.3100.

Subp. 4. **Pollutant concentrations and loading rates.** Pollutant concentrations and loading rates are given in items A to D.

A. Ceiling concentrations.

Pollutant	Ceiling

	Concentration (mg/kg)[1]
Arsenic	75
Cadmium	85
Copper	4300
Lead	840
Mercury	57
Molybdenum	75
Nickel	420
Selenium	100
Zinc	7500

[1]Dry weight basis

B. Cumulative pollutant loading rates.

Pollutant	Rate (kg/ha)	Rate (lbs/ac)
Arsenic	41	37
Cadmium	39	35
Copper	1500	1339
Lead	300	268
Mercury	17	15
Nickel	420	375
Selenium	100	89
Zinc	2800	2500

C. Pollutant concentrations.

Pollutant	Monthly Average Concentrations (mg/kg)[1]
Arsenic	41
Cadmium	39
Copper	1500
Lead	300
Mercury	17
Nickel	420
Selenium	100
Zinc	2800

[1]On a dry weight basis, the arithmetic mean of all measurements taken during the month.

D. Annual pollutant loading rates per 365-day period.

Pollutant	Rate (kg/ha)	Rate (lb/ac)

Arsenic	2.0	1.8
Cadmium	1.9	1.7
Copper	75.0	67.0
Lead	15.0	13.0
Mercury	0.85	0.76
Nickel	21.0	19.0
Selenium	5.0	4.5
Zinc	140.0	125.0

Statutory Authority: *MS s 116.07*

History: *21 SR 1642*

Published Electronically: *October 27, 2003*

7041.1200 MANAGEMENT PRACTICES AND LIMITATIONS.

Subpart 1. Endangered species. Bulk sewage sludge must not be applied to the land if it is likely to adversely affect a threatened or endangered species listed under section 4 of the Endangered Species Act of 1973, United States Code, title 16, section 1533, as amended, or its designated critical habitat.

Subp. 2. Frozen or flooded ground.

A. Bulk sewage sludge must not be applied to agricultural land, forest, a public contact site, or a reclamation site that is flooded, frozen, or snow covered so that the bulk sewage sludge enters a wetland or other surface waters.

B. In addition to the requirements in subpart 3, item B, land application of dewatered or liquid bulk sewage sludge to frozen or snow covered ground is restricted to land with zero to two percent slopes. The application of liquid bulk sewage sludge is also restricted to a 15,000 gallon per acre hydraulic loading rate for the period when the ground is frozen or snow covered and must take place no closer than 600 feet from downgradient surface waters listed in subpart 3, item B.

C. Bulk sewage sludge must be injected or incorporated within 48 hours of surface application on ground which is subject to flooding unless specified otherwise in a site approval.

Subp. 3. Suitable soil conditions, slopes, and separation distances. The suitable soil conditions in item A and the suitable slopes and separation distances in item B must be met when bulk sewage sludge is applied to agricultural land application sites. These conditions and limitations must also be met when bulk sewage sludge is applied to nonagricultural sites such as reclamation, forest, or public contact sites unless approved by the commissioner under the requirements of part 7041.0800, subpart 5. Bulk sewage sludge must not be applied to agricultural land, forest, a public contact site, or a reclamation site that is 33 feet or less from surface waters or wetlands unless specified otherwise in a permit.

A. Suitable soil conditions are as follows:

(1) the soil texture, United States Department of Agriculture classification, at the zone of sewage sludge application must be fine sand, loamy sand, sandy loam, loam, silt, silt loam, sandy clay loam, clay loam, sandy clay, silty clay loam, silty clay, or clay;

(2) the pH of the soil must be 5.5 or greater;

(3) bulk sewage sludge application to a site must be suspended when the soil extractable phosphorus content determined by the Brays P-1 test exceeds 200 parts per million (400 pounds per acre) in the surface six inches of soil unless it is demonstrated through a management plan approved by the commissioner that all resource management system level erosion control practices as determined necessary by the Natural Resources Conservation Service are in place and maintained;

(4) bulk sewage sludge application to a site must be suspended when the electrical conductivity of the saturation extract of the soil exceeds four millimhos per centimeter as determined by the soluble salt test;

(5) soil samples must be collected and analyzed for parameters in part 7041.0800, subpart 2, item C, at a minimum of once in the three-year time period prior to the land application of bulk sewage sludge unless stipulated otherwise in a site approval;

(6) liquid bulk sewage sludge must not be applied to soils with surface permeabilities of less than 0.2 inch per hour unless the sewage sludge is injected or incorporated within 48 hours of surface application; and

(7) organic soils or peat soils must not be used for bulk sewage sludge application unless subsurface drainage is provided by a system designed according to or equivalent to Natural Resources Conservation Service engineering criteria.

B. Suitable slopes and separation distances must be as described in this item. If applied through irrigation equipment, aerosol drift shall not be in contact with the feature specified.

BULK SEWAGE SLUDGE APPLIED TO THE LAND

Suitable slopes and separation distances

Criteria	Surface Applied	Incorporation within 48 hrs.	Injection
Depth to bedrock	3[1] ft.	3[1] ft.	3[1] ft.
Depth to seasonal high water table[2] or drain tile[3]	3[1] ft.	3[1] ft.	3[1] ft.
Allowable slopes	0% to 6%	0% to 12%	0% to 12%
Distance to wells			
Private supply	200 ft.	200 ft.	200 ft.
Public supply	1000 ft.	1000 ft.	1000 ft.
Irrigation	50 ft.	25 ft.	25 ft.
Distance to residences[4]	200 ft.	200 ft.	100 ft.
Distance to residential development[4]	600 ft.	600 ft.	300 ft.
Distance to public contact site[4]	600 ft.	600 ft.	300 ft.
Down gradient[5] lakes, rivers, streams, type 3, 4, and 5 wetlands, intermittent streams6, or tile inlets connected to these surface waters, and sinkholes			
Slope 0% to 6%	200 ft.	50 ft.	50 ft.
Slope >6 to 12%	N/A	100 ft.	100 ft.
Grassed Waterways[7]			
Slope 0% to 6%	100 ft.	33 ft.	33 ft.
Slope 6% to 12%	N/A	33 ft.	33 ft.

[1]The depth is calculated from the zone of sewage sludge application and the separation distance for highly permeable soils is 5 feet.

[2]For the purpose of this item, a perched water condition shall not be considered a seasonal high water table.

[3]The depth to subsurface drainage tiles shall be considered the depth to the seasonal high water table for sites with tile drainage systems that are designed according to or equivalent to Natural Resources Conservation Service engineering standards and criteria.

[4]Separation distances may be reduced with written permission from all persons responsible for residential developments and places of recreation and all persons inhabiting within the otherwise protected distance.

[5]If downgradient surface water does not receive runoff because the site is bermed, separation distances can be reduced to 33 feet.

[6]For the purpose of this item, intermittent stream means a drainage channel with definable banks that provides for runoff flow to any of the surface waters listed in this item during snow melt or rainfall events.

[7]Separation distances are from the centerline of grassed waterways. For grassed waterways which are wider than these separation distances, application is allowed to the edge of the grass strip. Grassed waterways are natural or constructed, typically broad and shallow, and seeded to grass as protection against erosion.

Subp. 4. Agronomic rates.

A. Bulk sewage sludge must be applied to agricultural land, forest, a public contact site, or a reclamation site at an application rate that is equal to or less than the agronomic rate, unless, in the case of a reclamation site, otherwise specified by the commissioner.

B. Bulk sewage sludge application rates, combined with other known sources of nitrogen such as manure, carry-over nitrogen from previous sewage sludge applications, or fertilizer, must supply no more available nitrogen than the rates as described in subitems (1) to (5).

(1) The maximum available nitrogen application rates calculated by methods provided by the commissioner which are based on realistic yield goals, soil organic matter content, and previously grown crops.

(2) For alfalfa and clovers which do not have recommended nitrogen application rates either:

(3) maximum available nitrogen application rate must not exceed 200 pounds per acre for alfalfa and 100 pounds per acre for clover, alfalfa grass, and clover grass mixtures; or

(4) the maximum available nitrogen application rates may be calculated based on realistic yield goals and measured yields in tons per acre multiplied by 50 pounds of nitrogen per ton.

(5) For soybeans, the maximum available nitrogen application rate shall be calculated by multiplying the realistic yield goal in bushels per acre times 3.5 pounds of nitrogen per bushel.

(6) The maximum available nitrogen application rate for cover crops must not exceed 50 pounds per acre per year.

(7) The available nitrogen applied after the second cutting of a hay crop must be no more than 50 percent of the maximum available nitrogen application rate for the current cropping year.

C. Bulk sewage sludge must not be applied to the land during the months of June, July, and August unless a crop is growing on the land or a crop is seeded within fourteen days following the bulk sewage sludge application.

D. Bulk sewage sludge must not be applied to fallow land, which is land that is uncropped and kept cultivated throughout a growing season and has a vegetative cover of less than 25 percent. Any land that is uncropped and cultivated during the months of September through May where a crop will be grown the following growing season is not considered fallow land.

E. The calculation of available and carry-over nitrogen in sewage sludge must be performed as described in part 7041.3000.

Subp. 5. Highly permeable soils. In addition to those specified in subparts 3 and 4, the separation distances in item A and agronomic management practices in items B and C must be met when bulk sewage sludge is applied to highly permeable soils.

A. The minimum separation distance between the zone of bulk sewage sludge application and the seasonal high water table and bedrock is five feet.

B. Bulk sewage sludge must not be applied to the land during the months of June, July, August, or September unless a crop is growing on the land or a crop is seeded within 14 days following the bulk sewage sludge application.

C. Bulk sewage sludge applied in October shall be surface applied or applied with a nitrification stabilizer which extends the time the nitrogen component remains in the soil in the ammoniacle form.

Subp. 6. Prohibited sites and other limits. The prohibited sites and other limits in items A to G apply to bulk sewage sludge applied to the land.

A. Bulk sewage sludge must not be applied on areas ponded with water or sewage sludge.

B. Bulk sewage sludge must not be applied or run onto adjoining property, roads, and the shoulders and drainage ditches alongside a road.

C. The boundary of a land application site must be identified prior to and during application with the use of conspicuous flags placed to achieve a clear and positive identification of the suitable site boundary unless apparent boundaries, such as fence rows, roads, tree lines, type of vegetation, or steep slopes, exist.

D. Bulk sewage sludge must not be applied on any land without the permission of the owner.

E. Bulk sewage sludge must be applied to land in such a manner as to provide uniform application.

F. Bulk sewage sludge must not be disposed of or placed into any cave, or sinkhole. Except as part of a reclamation project, sewage sludge must not be disposed of or placed on any mine or quarry.

G. Daily surface applications of liquid sewage sludge must not exceed the following: coarse-textured soils, 25,000 gallons per acre; medium-textured soils, 15,000 gallons per acre; or fine-textured soils, 10,000 gallons per acre.

Subp. 7. Short-term storage. Items A to C apply to the short-term storage of dewatered bulk sewage sludge.

A. The short-term storage of bulk sewage sludge shall not exceed 30 days.

B. Separation distances for short-term bulk sewage sludge storage areas shall be those provided in subpart 3, item B, except that short-term storage of bulk sewage sludge shall not occur within 100 feet of any adjoining property without the written permission of the owner or within 100 feet of any road or drainage ditch.

C. Short-term storage of bulk sewage sludge shall not take place on land with a slope greater than two percent unless measures are taken to control water runoff or the bulk sewage sludge is being spread concurrent with the unloading of bulk sewage sludge delivery trucks and will not be stockpiled overnight.

Subp. 8. Long-term storage. Items A to G apply to the long-term storage of dewatered bulk sewage sludge.

A. Long-term storage of bulk sewage sludge is only allowed at land application sites where the stored bulk sewage sludge is to be applied. Long-term storage of bulk sewage sludge that is intended for application at several land application sites is allowed provided that all sites are owned by the same person and all sites are within a one-half mile radius.

B. Long-term storage of bulk sewage sludge for land application areas of 40 acres or less shall not take place within 400 feet from any residence. This separation distance shall increase 100 feet for every additional ten acres of land application area, or portion thereof, up to a maximum of 1,000 feet. Separation distances may be reduced if written permission is obtained from all persons residing within the otherwise protected distance.

C. Long-term storage of bulk sewage sludge shall not take place within 1,000 feet of any residential development or public contact site.

D. Long-term storage of bulk sewage sludge shall not take place within 1,000 feet of any downgradient surface waters and wetlands listed in subpart 3, item B, tile inlets, or sinkholes unless measures are taken to control runoff in which case the separation distance may be reduced to 200 feet.

E. Long-term storage of bulk sewage sludge shall not be allowed on land with greater than a two percent slope.

F. Long-term bulk sewage sludge storage areas shall be located in areas where the texture of all the horizons in the soil profile to a depth of five feet is sandy loam or finer unless an impervious pad with a drainage collection system is constructed.

G. Long-term bulk sewage sludge storage shall not take place on the same area for two or more consecutive years unless an impervious pad with a drainage collection system is constructed.

Subp. 9. Labeling. A label must be affixed to the bag or other container in which sewage sludge is sold or given away for application to the land or an information sheet must be provided to the person who receives sewage sludge in another container. The label or information sheet must contain the following information:

A. the name and address of the person who prepared the sewage sludge that is sold or given away in a bag or other container;

B. a statement that application of the sewage sludge to the land is prohibited except according to the instructions on the label or information sheet; and

C. the annual whole sludge application rate for the sewage sludge that does not cause any of the annual pollutant loading rates in part 7041.1100, subpart 4, item D, to be exceeded.

Statutory Authority: *MS s 116.07*

History: *21 SR 1642; 38 SR 1001*

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7041.1300 OPERATIONAL STANDARDS; PATHOGEN REDUCTION.

Subpart 1. General. Bulk sewage sludge must meet the requirements of Class A pathogen reduction or Class B pathogen reduction and the site restrictions in subpart 3, item D, when it is applied to agricultural land, forest, a public contact site, or a reclamation site. Bulk sewage sludge applied to a lawn or home garden and sewage sludge sold or given away in a bag or other container must meet Class A pathogen reduction requirements.

Subp. 2. Pathogens in sewage sludge; Class A. To be classified Class A with respect to pathogen reduction, the requirements in items A and B must be met.

A. One of the Class A pathogen requirements in items C to H must be met either prior to or at the same time the vector attraction reduction requirements in part 7041.1400, subpart 2, are met except when the vector attraction reduction requirements in part 7041.1400, subpart 2, item F, G, or H, are met.

B. Either the density of fecal coliform in the sewage sludge must be less than 1,000 most probable number per gram of total solids (dry weight basis), or the density of Salmonella sp. bacteria in the sewage sludge must be less than three most probable number per four grams of total solids (dry weight basis) at the time the sewage sludge is applied to the land, at the time the sewage sludge is prepared for sale or giveaway in a bag or other container for application to the land, or at the time the sewage sludge or material derived from sewage sludge is prepared to meet the requirements of exceptional quality sewage sludge.

C. Class A, Alternative 1. (Not applicable for composting.) The temperature of the sewage sludge shall be maintained at a specific value for a period of time.

(1) When the percent solids of the sewage sludge is seven percent or higher, the temperature of the sewage sludge shall be 50 degrees Celsius or higher, the time period shall be 20 minutes or longer, and the temperature and time period shall be determined using the equation in this unit, except when small particles of sewage sludge are heated by either warmed gases or an immiscible liquid.

$$D = \frac{131{,}700{,}000}{10^{0.1400t}}$$

Where,

D=time in days.

t=temperature in degrees Celsius.

(2) When the percent solids of the sewage sludge is seven percent or higher and small particles of sewage sludge are heated by either warmed gases or an immiscible liquid, the temperature of the sewage sludge shall be 50 degrees Celsius or higher, the time period shall be 15 seconds or longer, and the temperature and time period shall be determined using the equation in subitem (1).

(3) When the percent solids of the sewage sludge is less than seven percent and the time period is at least 15 seconds, but less than 30 minutes, the temperature and time period shall be determined using the equation in subitem (1).

(4) When the percent solids of the sewage sludge is less than seven percent, the temperature of the sewage sludge is 50 degrees Celsius or higher, and the time period is 30 minutes or longer, the temperature and time period shall be determined using the equation in this unit.

$$D = \frac{50{,}070{,}000}{10^{0.1400t}}$$

Where,

D=time in days.

t=temperature in degrees Celsius.

D. Class A, Alternative 2. The pH of the sewage sludge shall be raised to above 12 and shall remain above 12 for 72 hours.

   (1) The temperature of the sewage sludge shall be above 52 degrees Celsius for 12 hours or longer during the period that the pH of the sewage sludge is above 12.

   (2) At the end of the 72-hour period during which the pH of the sewage sludge is above 12, the sewage sludge shall be air dried to achieve a percent solids in the sewage sludge greater than 50 percent.

E. Class A, Alternative 3. The sewage sludge shall be analyzed prior to pathogen treatment to determine whether the sewage sludge contains enteric viruses and helminth ova.

   (1) When the density of enteric viruses in the sewage sludge prior to pathogen treatment is less than one plaque-forming unit per four grams of total solids (dry weight basis), the sewage sludge is Class A with respect to enteric viruses until the next monitoring episode for the sewage sludge.

   (2) When the density of enteric viruses in the sewage sludge prior to pathogen treatment is equal to or greater than one plaque-forming unit per four grams of total solids (dry weight basis), the sewage sludge is Class A with respect to enteric viruses when the density of enteric viruses in the sewage sludge after pathogen treatment is less than one plaque-forming unit per four grams of total solids (dry weight basis) and when the values or ranges of values for the operating parameters for the pathogen treatment process that produces the sewage sludge that meets the enteric virus density requirement are documented.

   (3) After the enteric virus reduction in subitem (2) is demonstrated for the pathogen treatment process, the sewage sludge continues to be Class A with respect to enteric viruses when the values for the pathogen treatment process operating parameters are consistent with the values or ranges of values documented in subitem (2).

   (4) When the density of viable helminth ova in the sewage sludge prior to pathogen treatment is less than one per four grams of total solids (dry weight basis), the sewage sludge is Class A with respect to viable helminth ova until the next monitoring episode for the sewage sludge.

   (5) When the density of viable helminth ova in the sewage sludge prior to pathogen treatment is equal to or greater than one per four grams of total solids (dry weight basis), the sewage sludge is Class A with respect to viable helminth ova when the density of viable helminth ova in the sewage sludge after pathogen treatment is less than one per four grams of total solids (dry weight basis) and when the values or ranges of values for the operating parameters for the pathogen treatment process that produces the sewage sludge that meets the viable helminth ova density requirement are documented.

   (6) After the viable helminth ova reduction in subitem (5) is demonstrated for the pathogen treatment process, the sewage sludge continues to be Class A with respect to viable helminth ova when the values for the pathogen treatment process operating parameters are consistent with the values or ranges of values documented in subitem (5).

F. Class A, Alternative 4.

(1) The density of enteric viruses in the sewage sludge shall be less than one plaque-forming unit per four grams of total solids (dry weight basis) at the time the sewage sludge is applied to the land, at the time the sewage sludge is prepared for sale or give away in a bag or other container for application to the land, or at the time the sewage sludge or material derived from sewage sludge is prepared to meet the requirements of exceptional quality sewage sludge, unless otherwise specified by the permitting authority.

(2) The density of viable helminth ova in the sewage sludge shall be less than one per four grams of total solids (dry weight basis) at the time the sewage sludge is applied to the land; at the time the sewage sludge is prepared for sale or give away in a bag or other container for application to the land, or at the time the sewage sludge or material derived from sewage sludge is prepared to meet the requirements of exceptional quality sewage sludge, unless otherwise specified by the permitting authority.

G. Class A, Alternative 5. Sewage sludge shall be treated in one of the processes to further reduce pathogens in subitems (1) to (7).

(1) Composting. Using either the within-vessel composting method or the static aerated pile composting method, the temperature of the sewage sludge is maintained at 55 degrees Celsius or higher for three days. Using the windrow composting method, the temperature of the sewage sludge is maintained at 55 degrees or higher for 15 days or longer. During the period when the compost is maintained at 55 degrees or higher, there shall be a minimum of five turnings of the windrow.

(2) Heat drying. Sewage sludge is dried by direct or indirect contact with hot gases to reduce the moisture content of the sewage sludge to 10 percent or lower. Either the temperature of the sewage sludge particles exceeds 80 degrees Celsius or the wet bulb temperature of the gas in contact with the sewage sludge as the sewage sludge leaves the dryer exceeds 80 degrees Celsius.

(3) Heat treatment. Liquid sewage sludge is heated to a temperature of 180 degrees Celsius or higher for 30 minutes.

(4) Thermophilic aerobic digestion. Liquid sewage sludge is agitated with air or oxygen to maintain aerobic conditions and the mean cell residence time of the sewage sludge is ten days at 55 to 60 degrees Celsius.

(5) Beta ray irradiation. Sewage sludge is irradiated with beta rays from an accelerator at dosages of at least 1.0 megarad at room temperature (ca. 20 degrees Celsius).

(6) Gamma ray irradiation. Sewage sludge is irradiated with gamma rays from certain isotopes, such as Cobalt 60 and Cesium 137, at room temperature (ca. 20 degrees Celsius).

(7) Pasteurization. The temperature of the sewage sludge is maintained at 70 degrees Celsius or higher for 30 minutes or longer.

H. Class A, Alternative 6. Sewage sludge that is applied to the land shall be treated in a process that is equivalent to a process to further reduce pathogens in item G, as determined by the permitting authority.

Subp. 3. Sewage sludge; Class B. The requirements in item A, B, or C must be met for sewage sludge to be classified as Class B with respect to pathogen reduction and when Class B sewage sludge is applied to agricultural land, forest, a public contact site, or a reclamation site, the site restrictions in item D must also be met.

A. Class B, Alternative 1.

(1) Seven representative samples of the sewage sludge that is applied to the land shall be collected.

(2) The geometric mean of the density of fecal coliform in the samples collected in subitem (1) shall be less than either 2,000,000 most probable number per gram of total solids (dry weight basis) or 2,000,000 colony forming units per gram of total solids (dry weight basis).

B. Class B, Alternative 2. Sewage sludge shall be treated in one of the Processes to Significantly Reduce Pathogens in subitems (1) to (5).

(1) Aerobic digestion. Sewage sludge is agitated with air or oxygen to maintain aerobic conditions for a specific mean cell residence time at a specific temperature. Values for the mean cell residence time and temperature shall be between 40 days at 20 degrees Celsius and 60 days at 15 degrees Celsius.

(2) Air drying. Sewage sludge is dried on sand beds or on paved or unpaved basins. The sewage sludge dries for a minimum of three months. During two of the three months, the ambient average daily temperature is above zero degrees Celsius.

(3) Anaerobic digestion. Sewage sludge is treated in the absence of air for a specific mean cell residence time at a specific temperature. Values for the mean cell residence time and temperature shall be between 15 days at 35 to 55 degrees Celsius and 60 days at 20 degrees Celsius.

(4) Composting. Using either the within-vessel, static aerated pile, or windrow composting methods, the temperature of the sewage sludge is raised to 40 degrees Celsius or higher and remains at 40 degrees Celsius or higher for five days. For four hours during the five days, the temperature in the compost pile exceeds 55 degrees Celsius.

(5) Lime stabilization. Sufficient lime is added to the sewage sludge to raise the pH of the sewage sludge to 12 after two hours of contact.

C. Class B, Alternative 3. Sewage sludge shall be treated in a process that is equivalent to a process to significantly reduce pathogens, as determined by the permitting authority.

D. Site Restrictions.

MINIMUM DURATION BETWEEN APPLICATION AND HARVEST/GRAZING/PUBLIC ACCESS FOR CLASS B SEWAGE SLUDGE APPLIED TO THE LAND

Criteria	Surface Applied or Incorporated	Injected
Food crops whose harvested part may touch the soil/sludge mixture (melons, squash, tomatoes, etc.)	14 mos.	14 mos.
Food crops whose harvested parts grow in the soil (potatoes, carrots, etc.)	20/38 mos.[1]	38 mos.
Feed, other food crops (field corn, sweet corn, etc.) hay, or fiber crop	30 days	30 days
Grazing of animals	30 days	30 days
Public access to the land		
- High potential[2]	1 year	1 year
- Low potential[3]	30 days	30 days

[1]The 20-month duration between application and harvesting applies when the sewage sludge that is surface applied stays on the soil surface for four months or longer prior to incorporation into the soil. The 38-month duration is in effect when the sewage sludge remains on the soil surface for less than four months prior to incorporation.

[2]This includes, but is not limited to, a public contact site and reclamation site located in populated areas, for example, a construction site located in a city, turf farms, and plant nurseries.

[3]Land the public uses infrequently which includes, but is not limited to, agricultural land, forest, and a reclamation site located in an unpopulated area.

Statutory Authority: *MS s 116.07*

History: *21 SR 1642; 38 SR 1001*

Published Electronically: *January 22, 2014*

7041.1400 OPERATIONAL STANDARDS; VECTOR ATTRACTION REDUCTION.

Subpart 1. Agricultural and other lands. One of the vector attraction reduction requirements in subpart 2 must be met when bulk sewage sludge is applied to agricultural land, forest, a public contact site, or a reclamation site.

Subp. 2. Home use and land application. One of the vector attraction reduction requirements in items A to H must be met when bulk sewage sludge is applied to a lawn or a home garden or when sewage sludge is sold or given away in a bag or other container for application to the land.

A. The mass of volatile solids in the sewage sludge shall be reduced by a minimum of 38 percent.

B. When the 38 percent volatile solids reduction requirement in item A cannot be calculated for an anaerobically digested sewage sludge, vector attraction reduction can be demonstrated by digesting a portion of the previously digested sewage sludge anaerobically in the laboratory in a bench-scale unit for 40 additional days at a temperature between 30 and 37 degrees Celsius. When at the end of the 40 days the volatile solids in the sewage sludge at the beginning of that period is reduced by less than 17 percent, vector attraction reduction is achieved.

C. When the 38 percent volatile solids reduction requirement in item A cannot be calculated for an aerobically digested sewage sludge, vector attraction reduction can be demonstrated by digesting a portion of the previously digested sewage sludge that has a percent solids of two percent or less aerobically in the laboratory in a bench-scale unit for 30 additional days at 20 degrees Celsius. When at the end of the 30 days the volatile solids in the sewage sludge at the beginning of that period is reduced by less than 15 percent, vector attraction reduction is achieved.

D. The specific oxygen uptake rate (SOUR) for sewage sludge treated in an aerobic process shall be equal to or less than 1.5 milligrams of oxygen per hour per gram of total solids (dry weight basis) at a temperature of 20 degrees Celsius.

E. Sewage sludge shall be treated in an aerobic process for 14 days or longer. During that time, the temperature of the sewage sludge shall be higher than 40 degrees Celsius and the average temperature of the sewage sludge shall be higher than 45 degrees Celsius.

F. The pH of sewage sludge shall be raised to 12 or higher by alkali addition and, without the addition of more alkali, shall remain at 12 or higher for two hours and then at 11.5 or higher for an additional 22 hours.

G. The percent solids of sewage sludge that does not contain unstabilized solids generated in a primary wastewater treatment process shall be equal to or greater than 75 percent based on the moisture content and total solids prior to mixing with other materials at the time the sewage sludge is applied to the land, at the time the sewage sludge is prepared for sale or given away in a bag or other container for application to the land, or at the time the sewage sludge is prepared to meet the requirements of exceptional quality sewage sludge.

H. The percent solids of sewage sludge that contains unstabilized solids generated in a primary wastewater treatment process shall be equal to or greater than 90 percent based on the moisture content and total solids prior to mixing with other materials, at the time the sewage sludge is applied to the land, at the time the sewage sludge is prepared for sale or given away in a bag or other container for application to the land, or at the time the sewage sludge is prepared to meet the requirements of exceptional quality sewage sludge.

I. Sewage sludge shall be injected below the surface of the land.

   (1) No significant amount of the sewage sludge shall be present on the land surface within one hour after the sewage sludge is injected.

   (2) When the sewage sludge that is injected below the surface of the land is Class A with respect to pathogens, the sewage sludge shall be injected below the land surface within eight hours after being discharged from the pathogen treatment process.

J. Sewage sludge applied to the land surface shall be incorporated into the soil within six hours after application to the land unless specified otherwise by the permitting authority. When sewage sludge that is incorporated into the soil is Class A with respect to pathogens, the sewage sludge shall be applied to or placed on the land within eight hours after being discharged from the pathogen treatment process.

Statutory Authority: *MS s 116.07*
History: *21 SR 1642*
Published Electronically: *October 27, 2003*

7041.1500 MONITORING REQUIREMENTS.

Subpart 1. Sampling of sewage sludge. Representative samples of sewage sludge that is applied to the land must be collected and analyzed by the person who prepares the sewage sludge. The following minimum requirements apply for the sampling of parameters except pathogens and pathogen indicator organisms:

A. in the case of digesters and liquid storage tanks, a representative sample must be composed of at least four grab samples composited over a 24-hour period; and

B. in the case of lagoons, stockpiles, drying beds, and compost piles, a representative sample must be composed of at least ten grab samples composited from the sewage sludge prior to land application.

Subp. 2. Analysis. Sewage sludge must be analyzed according to the analytical procedures in part 7041.3200 or other EPA approved methods for the parameters in items A to F. All analytical values, except pH and total solids, must be recorded on a dry weight basis:

A. percentage of total solids;

B. volatile solids as percentage of total solids;

C. pH;

D. major plant nutrients, including the percentages of Kjeldahl nitrogen, ammonia nitrogen, phosphorus, and potassium;

E. concentration of metals in milligrams per kilogram of zinc, copper, lead, nickel, cadmium, mercury, arsenic, molybdenum, and selenium; and

F. polychlorinated biphenyls (PCBs) if the sewage sludge is being removed from a wastewater treatment pond described in part 7041.0300, subpart 1.

Subp. 3. Additional analysis or parameters. If the commissioner concludes that additional analysis or monitoring for additional parameters is needed to protect the public health or the environment, the commissioner shall require this analysis based on considerations about the sewage sludge in question, including the age of the sewage sludge, the size of the treatment facility, the processes used to treat the sewage sludge, the methods of land application, and the characteristics of industrial discharges to the sewer system.

Subp. 4. Frequency of monitoring. The minimum monitoring frequency for the parameters listed in subpart 2, the pathogen or indicator organism density requirements in part 7041.1300, subparts 2 and 3, and the vector attraction reduction requirements in part 7041.1400, subpart 2, items A to D and F to H, shall be the frequency in this item.

MINIMUM SAMPLING FREQUENCIES

Sewage Sludge Applied[1] (metric tons/ 365-day period)	Sewage Sludge Applied[1] (tons/365-day period)	Frequency (times/ 365-day period)
>0 but <290	>0 but <320	1
≥290 but <1,500	≥320 but <1,650	4
≥1,500 but <15,000	≥1,650 but <16,500	6
≥15,000	≥16,500	12

1Either the amount of bulk sewage sludge applied to the land or the amount of sewage sludge received by a person who prepares sewage sludge that is sold or given away in a bag or other container for application to the land (dry weight basis).

Subp. 5. Greater frequency of sewage sludge monitoring and analysis. Parameters exceeding concentrations in subpart 6, based on the average of all analyses made during the previous cropping year, must be analyzed for at least two times the minimum frequency given in subpart 4.

Subp. 6. Greater frequency of sewage sludge sampling and analysis.

GREATER FREQUENCY OF SAMPLING
Concentration Expressed in
Milligrams/Kilogram of Dry Weight

Parameter	2X Frequency
Arsenic	38
Cadmium	43
Copper	2150
Lead	420
Mercury	28
Molybdenum	38
Nickel	210
Selenium	50
Zinc	3750

Subp. 7. Reduction in monitoring frequency. After the sewage sludge has been monitored for two years at the frequency in subparts 4 and 6, the commissioner may reduce the frequency of monitoring for the parameters listed in subpart 2 and the pathogen density in part 7041.1300, subpart 2, item E, but in no case shall the frequency of monitoring be less than once per year when sewage sludge is applied to the land.

Statutory Authority: *MS s 116.07*

History: *21 SR 1642*

Published Electronically: *October 27, 2003*

7041.1600 RECORD KEEPING.

Subpart 1. General requirements. A record keeping system must be initiated and maintained by the person who prepares sewage sludge. Records required to be kept by an applier who is different than the preparer must be supplied to the preparer for record keeping purposes.

Subp. 2. Exceptional quality sewage sludge. The preparer of exceptional quality sewage sludge applied to the land either in bulk or sold or given away in a bag or other container must develop and retain the following information for five years:

A. the concentration of each parameter listed in part 7041.1500, subpart 2, items A to E;

B. the following certification statement:

> "I certify, under penalty of law, that the information that will be used to determine compliance with the Class A pathogen requirements in Minnesota Rules, part 7041.1300, subpart 2, and the vector attraction reduction requirement in [insert one of the vector attraction reduction requirements in Minnesota Rules, part 7041.1400, subpart 2, items A to H] has been prepared under my direction and supervision in accordance with the system designed to ensure that qualified personnel properly gather and evaluate the information used to determine that the pathogen requirements and vector attraction reduction requirements have been met. I am aware that there are significant penalties for false certification including the possibility of fine and imprisonment.";

C. a description of how the Class A pathogen requirements in part 7041.1300, subpart 2, are met;

D. a description of how one of the vector attraction reduction requirements in part 7041.1400, subpart 2, items A to H, is met;

E. a copy of written information required to be given as required in part 7041.0400, subpart 3; and

F. the quantity of exceptional quality sewage sludge provided to distributors or users if supplied in bulk and the quantity sold or given away in a bag or other container per 365-day period.

Subp. 3. Other Class A and Class B bulk sewage sludge. The preparer of other Class A and Class B bulk sewage sludge that is applied to the land must develop and retain the information in items A to G and subpart 5 for five years and the information in items H to N indefinitely.

A. The concentration of each parameter listed in part 7041.1500, subpart 2, items A to E.

B. The following certification statement:

> "I certify, under penalty of law, that the information that will be used to determine compliance with the pathogen requirements in Minnesota Rules, part 7041.1300, subpart 2, [insert if Class A requirements are met] or Minnesota Rules, part 7041.1300, subpart 3, [insert if Class B requirements are met] and the vector attraction reduction requirement in [insert one of the vector attraction reduction requirements in Minnesota Rules, part 7041.1400, subpart 2, items A to H, if one of those requirements is met] has been prepared under my direction and supervision according to the system designed to ensure that qualified personnel properly gather and evaluate the information used to determine that the pathogen requirements [and vector attraction reduction requirements, if applicable] have been met. I am aware that there are significant penalties for false certification including the possibility of fine and imprisonment."

C. A description of how the Class A or Class B pathogen requirement is met.

D. A description of how one of the vector attraction reduction requirements in part 7041.1400, subpart 2, items A to J, is met.

E. A record of soil test data as required by part 7041.0800, site approvals, or permits.

F. The maximum available nitrogen application rate based on the realistic yield goal and vegetation grown on the site during the cropping year.

G. The known amount of available nitrogen applied during the cropping year from all sources expressed in terms of pounds per acre.

H. The location of the land application and stockpile sites on a United States Geological Survey quadrangle or soil survey map.

I. The legal description of the land application site and the number of acres to which bulk sewage sludge was applied.

J. The amount of bulk sewage sludge applied that cropping year and cumulatively expressed in terms of tons of sewage sludge solids per acre.

K. The amount of arsenic, cadmium, copper, lead, mercury, molybdenum, nickel, selenium, and zinc applied that cropping year and cumulatively expressed in terms of pounds per acre.

L. The date bulk sewage sludge is applied to each site.

M. The following certification statement:

> "I certify, under penalty of law, that the information that will be used to determine compliance with the requirements to obtain information in Minnesota Rules, part 7041.1000, subpart 2, item B, has been prepared for each site on which bulk sewage sludge is applied under my direction and supervision according to the system designed to ensure that qualified personnel properly gather and evaluate the information used to determine that the requirements to obtain information have been met. I am aware that there are significant penalties for false certification including fine and imprisonment."

N. A description of how the requirements to obtain information in part 7041.1000, subpart 2, item B, are met.

Subp. 4. Class A sewage sludge not meeting pollutant concentrations. The person who prepares Class A sewage sludge which does not meet the pollutant concentrations in part 7041.1100, subpart 4, item C, and is sold or given away in a bag or other container for application to the land, must develop and retain the following information for five years:

A. the annual whole sludge application rate for the sewage sludge that does not cause the annual pollutant loading rates in part 7041.1100, subpart 4, item D, to be exceeded;

B. the concentration of each parameter listed in part 7041.1500, subpart 2, items A to E, in the sewage sludge;

C. the following certification statement:

> "I certify, under penalty of law, that the information used to determine compliance with the labeling requirements in Minnesota Rules, part 7041.1200, subpart 9, the Class A pathogen requirement in Minnesota Rules, part 7041.1300, subpart 2, and the vector attraction reduction requirement in [insert one of the vector attraction reduction requirements in Minnesota Rules, part 7041.1400, subpart 2, items A to H] has been prepared under my direction and supervision according to the system designed to ensure that qualified personnel properly gather and evaluate the information used to determine that the management practice, pathogen

requirement, and vector attraction reduction requirements have been met. I am aware that there are significant penalties for false certification including the possibility of fine and imprisonment.";

D. a description of how the Class A pathogen requirements in part 7041.1300, subpart 2, are met; and

E. a description of how one of the vector attraction reduction requirements in part 7041.1400, subpart 2, items A to H, is met.

Subp. 5. Appliers of bulk sewage sludge. The applier of bulk sewage sludge must provide the preparer with the information in items A and B.

A. The following certification statement:

"I certify, under penalty of law, that the information that will be used to determine compliance with the management practices in Minnesota Rules, part 7041.1200, the site restrictions in Minnesota Rules, part 7041.1300, subpart 3, item D [insert if Class B sewage sludge is applied to the land], and the vector attraction reduction requirement in [insert Minnesota Rules, part 7041.1400, subpart 2, item I or J, if met] for each site on which bulk sewage sludge is applied has been prepared under my direction and supervision according to the system designed to ensure that qualified personnel properly gather and evaluate the information used to determine that the management practices and site restrictions have been met. I am aware that there are significant penalties for false certification including the possibility of fine and imprisonment."

B. A description of how the management practices, site restrictions, and vector attraction reduction requirements, if options in part 7041.1400, subpart 2, item I or J, are met for each site on which bulk sewage sludge was applied.

Statutory Authority: *MS s 116.07*

History: *21 SR 1642*

Published Electronically: *October 27, 2003*

7041.1700 REPORTING.

Subpart 1. Annual reporting requirements.

A. The information in part 7041.1600 must be recorded, as applicable, by the person who prepares the sewage sludge on a form provided or approved by the commissioner and submitted annually to the agency no later than December 31 following the end of the cropping year unless specified otherwise in a permit or approved management plan if applicable. If bulk sewage sludge is applied, the form must be prepared by or under the supervision of a Type IV certified operator or inspector employed by the person who prepares the bulk sewage sludge.

B. If bulk sewage sludge is applied on a site in Minnesota, the legal description of the site and the information in part 7041.1600, subpart 3, items M and N, do not have to be reported.

C. For the purpose of annual reports, the month instead of the date referenced in part 7041.1600, subpart 3, item L, shall be reported on the form provided or approved by the commissioner.

Subp. 2. Special reporting requirements. The preparer of bulk sewage sludge which is not exceptional quality sewage sludge must notify the agency, in writing, when 90 percent or more of any of the cumulative pollutant loading rates in part 7041.1100, subpart 4, item B, has been reached for a site.

Statutory Authority: *MS s 116.07*

History: *21 SR 1642*

Published Electronically: *October 27, 2003*

7041.1800 PROVISIONS FOR SEWAGE SLUDGE FROM SEPTIC TANKS.

Subpart 1. General. The requirements in subparts 2 to 4 for application at agronomic rates, pathogen and vector attraction reduction, monitoring, record keeping, and reporting, unless specified otherwise in a permit, shall be met by persons who prepare the sewage sludge from septic tanks which is referred to in this part as septage.

Subp. 2. Agronomic rates. The agronomic application rate for septage applied to agricultural land, forest, or a reclamation site for a cropping year must be calculated using the equation in this subpart unless specified otherwise by the commissioner. The commissioner may specify the rate based on an actual nitrogen analysis.

$$AR = \frac{N}{0.0026}$$

Where,

AR = Application rate in gallons per acre for the cropping year.

N = The maximum available nitrogen application rate in pounds per acre per cropping year required by the crop based on realistic yield goals or nitrogen uptake by vegetation grown on the land minus the amount supplied by other sources such as manure or fertilizer.

Subp. 3. Pathogen and vector attraction reduction. To meet pathogen and vector attraction reduction requirements, the site restrictions in part 7041.1300, subpart 3, item D, must be met and either:

A. the pH of the septage must be raised to 12 or higher for 30 minutes by alkali addition and, without the addition of more alkali, shall remain at 12 or higher for 30 minutes;

B. the septage is injected and no significant amount of the septage is present on the land

C. the septage is incorporated below the surface of the land within six hours after application unless specified otherwise by the permitting authority.

Subp. 4. Monitoring, record keeping, and reporting. The permittee must obtain and keep on record for five years, the information required to be in compliance with this chapter including:

A. the following certification statement for all septage applied to the land:

"I certify, under penalty of law, that the information that will be used to determine compliance with the pathogen and vector attraction reduction requirements in subpart 3, item A, B, or C [insert either subpart 3, item A, B, or C] the management practices in part 7041.1200, and the site restrictions in part 7041.1300, subpart 3, item D, has been prepared under my direction and supervision according to the system designed to ensure that qualified personnel properly gather and evaluate the information used to determine that the pathogen and vector attraction reduction requirements have been met. I am aware that there are significant penalties for false certification including the possibility of fine and imprisonment.";

B. a description of how the pathogen and vector attraction reduction requirements are met. If alkali addition is used, records must indicate each container of septage applied is monitored for compliance with subpart 3, item A;

C. a description of how management practices and site restrictions are met;

D. a record of soil test data as required by part 7041.0800, site approvals, or permits;

E. the maximum available nitrogen application rate based on the realistic yield goal of the crop or vegetation grown on the site during the cropping year;

F. the amount of septage in gallons per acre applied that cropping year;

G. the legal description of the land application site;

H. the number of acres used;

I. the date septage is applied to the land; and

J. any other analysis or information required by the commissioner.

The information in items A to J must be recorded by the permittee on a form provided or approved by the commissioner and submitted annually to the agency no later than December 31 following the end of the cropping year.

Statutory Authority: *MS s 116.07*

History: *21 SR 1642; 38 SR 1001*

Published Electronically: *January 22, 2014*

7041.3000 CALCULATION OF AVAILABLE AND CARRY-OVER NITROGEN.

Subpart 1. Available nitrogen. The formulas in this subpart shall be used for the calculation of available nitrogen for the cropping year sewage sludge is applied to the land unless it has been demonstrated to the satisfaction of the commissioner with data from laboratory and/or field tests that another calculation based on sewage sludge or site-specific mineralization rates is more appropriate.

POUNDS OF AVAILABLE NITROGEN PER TON OF SEWAGE SLUDGE SOLIDS

Type of Stabilization	Application Method	Formula
Digested		
Anaerobic	Surface	(% organic-N x 4) + (%NH_3-N x 10)
Anaerobic	Incorporated[1] or injected	(% organic-N x 4) + (%NH_3-N x 20)
Aerobic	Surface	(% organic-N x 6) + (%NH_3-N x 10)
Aerobic	Incorporated[1] or injected	(% organic-N x 6) + (%NH_3-N x 20)
Stabilized primary and waste activated	Surface	(% organic-N x 8) + (%NH_3-N x 10)
	Incorporated[1] or injected	(% organic-N x 8) + (%NH_3-N x 20)
Composted	Surface	(% organic-N x 2) + (%NH_3-N x 10)
	Incorporated[1]	(% organic-N x 2) + (%NH_3-N x 20)

[1]Incorporated within 48 hours

Subp. 2. **First year carry-over nitrogen.** First year carry-over nitrogen from the initial application of sewage sludge shall be calculated using the formulas in this subpart.

FIRST YEAR CARRY-OVER NITROGEN FROM INITIAL SEWAGE SLUDGE APPLICATION

Type of Stabilization	Pounds per Acre
Anaerobically digested	(% organic-N) x (1.6) x (tons per acre applied)
Aerobically digested	(% organic-N) x (2.1) x (tons per acre applied)
Stabilized primary and waste activated	(% organic-N) x (2.4) x (tons per acre applied)
Composted	(% organic-N) x (0.9) x (tons per acre applied)

Subp. 3. **Second year carry-over nitrogen.** Second year carry-over nitrogen from the initial application of sewage sludge must be calculated for aerobically digested and stabilized primary and waste activated sewage sludge if the initial application provided greater than or equal to 100 pounds of available nitrogen per acre. The following formula shall be used:

Second year carry-over nitrogen = (% organic-N) x (1.0) x (tons/acre applied).

Statutory Authority: *MS s 116.07*

History: *21 SR 1642*

Published Electronically: *October 27, 2003*

7041.3100 PROCEDURE TO DETERMINE ANNUAL WHOLE SLUDGE APPLICATION RATE (AWSAR).

A. This part contains the procedure used to determine the AWSAR for a sewage sludge that does not cause the annual pollutant loading rates in part 7041.1100, subpart 4, item D, to be exceeded. The relationship between the annual pollutant loading rate (APLR) for a pollutant and the AWSAR for a sewage sludge is shown in the equation in this subpart.

$$APLR = C \times AWSAR \times 0.001$$

Where,

APLR = Annual pollutant loading rate in kilograms per hectare per 365-day period.

C = Pollutant concentration in milligrams, per kilogram of total solids (dry weight basis).

AWSAR = Annual whole sludge application rate in metric tons per hectare per 365-day period (dry weight basis).

0.001 = A conversion factor.

B. To determine the AWSAR, the equation in subpart one is rearranged as follows:

$$AWSAR = \frac{APLR}{C \times 0.001}$$

The procedure used to determine the AWSAR is described in subitems (1) to (4).

(1) Analyze a sample of the sewage sludge to determine the concentration for each of the pollutants listed in part 7041.1100, subpart 4, item D, in the sewage sludge.

(2) Using the pollutant concentrations from subpart 1 and the APLRs from part 7041.1100, subpart 4, item D, calculate an AWSAR for each pollutant using the equation in this subpart.

(3) The AWSAR for the sewage sludge is the lowest AWSAR calculated in this subpart.

(4) To convert the AWSAR to pounds per acre, multiply the AWSAR (in Kg/ha) by .892.

Statutory Authority: *MS s 116.07*

History: *21 SR 1642*

Published Electronically: *October 27, 2003*

7041.3200 ANALYTICAL PROCEDURES FOR DETERMINING CONSTITUENTS IN SEWAGE SLUDGE SAMPLES.

The documents in items A to I are incorporated by reference and are available through the Minitex interlibrary loan system. They are not subject to frequent change.

A. Analytical Procedures for Determining Organic Priority Pollutants in Municipal Sludge, issued by the United States Environmental Protection Agency as EPA 600/2-80-030 (1980), also available from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161 (PB 80-198401), 1-800-553-6847.

B. Method Development for Determination of Polychlorinated Hydrocarbons in Municipal Sludge, issued by the United States Environmental Protection Agency as EPA 600/2-80-029 (1980), also available from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161 (PB 80-200793), 1-800-553-6847.

C. Enteric Viruses, ASTM Designation: D 4994-89, "Standard Practice for Recovery of Viruses From Wastewater Sludges," 1992 Annual Book of ASTM Standards: Section 11 -- Water and Environmental Technology, ASTM, 1916 Race Street, Philadelphia, Pennsylvania 19103-1187.

D. Fecal Coliform, Part 9221E or Part 9222D, "Standard Methods for the Examination of Water and Wastewater," 18th Edition, 1992, American Public Health Association, 1015 15th Street NW, Washington, DC 20005.

E. Helminth Ova, Yanko, W.S., "Occurrence of Pathogens in Distribution and Marketing Municipal Sludges," EPA 600/1-87-014, 1987, National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161 (PB 88-154273/AS).

F. Inorganic pollutants, "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," EPA Publication SW-846, Second Edition (1982) with Updates I (April 1984) and II (April 1985) and Third Edition (November 1986) with Revision I (December 1987). Second Edition and Updates I and II are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161 (PB 87-120-291). Third Edition and Revision I are available from Superintendent of Documents, Government Printing Office, 941 North Capitol Street NE, Washington, DC 20002 (Document Number 955-001-00000-1).

G. Salmonella sp. bacteria, Part 9260D, "Standard Methods for the Examination of Water and Wastewater," 18th Edition, 1992, American Public Health Association, 1015 15th Street NW, Washington, DC 20005; Kenner, B.A. and H.P. Clark, "Detection and enumeration of Salmonella and Pseudomonas aeruginosa," Journal of the Water Pollution Control Federation, Vol. 46, No. 9, September 1974, pp. 2163-2171, Water Environment Federation, 601 Wythe Street, Alexandria, Virginia 22314.

H. Specific oxygen uptake rate, Part 2710B, "Standard Methods for the Examination of Water and Wastewater," 18th Edition, 1992, American Public Health Association, 1015 15th Street NW, Washington, DC 20005.

I. Total fixed, volatile solids, Part 2540G, "Standard Methods for the Examination of Water and Wastewater," 18th Edition, 1992, American Public Health Association, 1015 15th Street NW, Washington, DC 20005.

Statutory Authority: *MS s 116.07*

History: *21 SR 1642*

Published Electronically: *October 27, 2003*

7041.3300 COLLECTION OF SOIL SAMPLES.

At a minimum, one soil sample shall represent an area of no more than 40 acres. Additional soil samples may be required if there are areas differing greatly in previous fertilization, liming, cropping history, land management, or soil texture. The soil must be sampled to a depth of six to nine inches from at least 15 to 20 random locations in the sampling area. The samples must be composited, thoroughly mixed, and subsampled for analysis. Approximately one pint of soil is necessary for analysis.

Statutory Authority: *MS s 116.07*

History: *21 SR 1642*

Published Electronically: *October 27, 2003*

7041.3400 ANALYSIS OF SOILS.

Subpart 1. Analytical methods. Acceptable analytical methods for United States Department of Agriculture textural classification, organic matter, extractable phosphorus, exchangeable potassium, pH, and soluble salts are found in one or more of the publications in items A to C which are incorporated by reference. These documents are not subject to frequent change and are available through the Minitex interlibrary loan system or the addresses given.

A. Recommended Chemical Soil Test Procedures for the North Central Region, issued by the North Dakota Agricultural Experiment Station, North Dakota State University as North Central Regional Publication No. 221 (Revised) October 1988.

B. Methods of Soil Analysis, Chemical and Microbiological Properties edited by Alan Page et al., issued by the American Society of Agronomy as Agronomy Monograph No. 9 (Madison, Wisconsin, Part 2, second edition, 1982).

C. Procedures for Collecting Soil Samples and Methods of Analysis for Soil Survey, issued by the Natural Resources Conservation Service as Soil Survey Investigations Report 1 (revised) (Washington, D.C., United States Government Printing Office, 1984).

Subp. 2. Soil permeability. The documents in items A and B are incorporated by reference for determining soil permeability measurements for different soil types and soil horizons when the information is not available from the Natural Resources Conservation Service. These references are not subject to frequent change and are available through the Minitex interlibrary loan system or addresses given.

A. Determination by direct measurements in the field as outlined in chapter 29, Hydraulic Conductivity of Saturated Soils: Field Methods, in Methods of Soil Analysis, Physical and Mineralogical Methods, edited by Klute, issued by the American Society of Agronomy, 677 South Segoe Road, Madison, Wisconsin 53711, as Agronomy Monograph No. 9, Part 1, (Madison, Wisconsin, second edition 1986).

B. Determination in the laboratory using undisturbed soil samples as outlined in chapter 28, Hydraulic Conductivity and Diffusivity: Laboratory Methods in Methods of Soil Analysis, edited by Klute, issued by the American Society of Agronomy, 677 South Segoe Road, Madison, Wisconsin 53711, as Agronomy Monograph No. 9, Part 1, (Madison, Wisconsin, second edition 1986).

Subp. 3. Seasonal high water table. When the necessary information for determining the depth to and type of seasonal water table is not available from the Natural Resources Conservation Service, the information may be obtained from either the document in item A or the procedure identified in item B.

A. Determination of the depth of soil having mottles with a chroma of two or less as discussed in Keys to Soil Taxonomy, (2010 and as subsequently amended), issued by the United States Department of Agriculture, Natural Resources Conservation Service. The document is incorporated by reference, is subject to frequent change, and is available at http://soils.usda.gov/technical/classification/tax_keys/.

B. Measurement of water levels at monthly intervals over the course of one year in water table monitoring devices. The highest water level measurement obtained is acceptable as the seasonal high water table.

Statutory Authority: *MS s 116.07*

History: *21 SR 1642; 38 SR 1001*

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Appendix B: Biosolids Publications

EPA publications

A Plain English Guide to the EPA Part 503 Biosolids Rule

http://water.epa.gov/scitech/wastetech/biosolids/503pe_index.cfm

Table of Contents (PDF file, 905K)
Chapter 1 (PDF file, 2296K) - Use or Disposal of Sewage Sludge Biosolids
Chapter 2 (PDF file, 3306K) - Land application of Biosolids
Chapter 3 (PDF file, 2092K) - Surface Disposal of Biosolids
Chapter 4 (PDF file, 2360K) - Incineration of Biosolids
Chapter 5 (PDF file, 4274K) - Pathogen and Vector Attraction Reduction Requirements
Chapter 6 (PDF file, 2088K) - Sampling and Analysis
References (PDF file, 182K)
Appendix A (PDF file, 260K) - Permit application Requirements
Appendix B (PDF file, 616K) - Federal and State Biosolids Contacts
Appendix C (PDF file, 188K) - U.S. Department of the Interior, Fish and Wildlife Service Regional Contact

A Guide to the Biosolids Risk Assessments for the EPA Part 503 Rule

http://water.epa.gov/scitech/wastetech/biosolids/503rule_index.cfm

Table of Contents (PDF file, 361K)
Chapter 1 (PDF file, 602K) -Overview
Chapter 2 (PDF file, 2313K) - The Risk Assessment Process for the Part 503 Biosolids Rule
Chapter 3 (PDF file, 2911K) - Identification and Resolution of Risk Assessment Issues
Chapter 4 (PDF file, 3183K) - How the Risk Assessments Identified Pollutant Limits For Biosolids
Chapter 5 (PDF file, 1382K) - How the Biosolids Risk Assessment Results Were Used in the Part 503 Rule
Chapter 6 (PDF file, 1143K) - Questions and Answers on the Part 503 Risk Assessments
Chapter 7 (PDF file, 527K) - References
Appendix A (PDF file, 366K) - Parameters Used in the Land Application Risk assessment for Biosolids
Appendix B (PDF file, 492K) - Parameters, Approach, Assumptions, and Degree of Conservatism Used: Land Application Risk Assessment Appendix C (PDF file, 63K) - Team of Experts Who Assisted EPA in the Part 503 Biosolids Risk Assessment
Appendix D (PDF file, 91K) - Conversions Used to Place Pollutant Limits in the Same Units

Control of Pathogens and Vector Attraction in Sewage Sludge

http://www2.epa.gov/region8/control-pathogens-and-vector-attraction-sewage-sludge
PDF file: http://www2.epa.gov/sites/production/files/documents/625R92013ALL.pdf

Provides guidance on how to control pathogens & the attraction of vectors to sewage sludge (Including Domestic Septage) properly under the Federal regulations 40 CFR Part 503

Biosolids Recycling

http://water.epa.gov/polwaste/wastewater/treatment/biosolids/biorecyc.cfm
PDF file:
http://water.epa.gov/polwaste/wastewater/treatment/biosolids/upload/2002_06_28_mtb_biosolids_bio1-3.pdf

http://www.wef.org/biosolidsnews/

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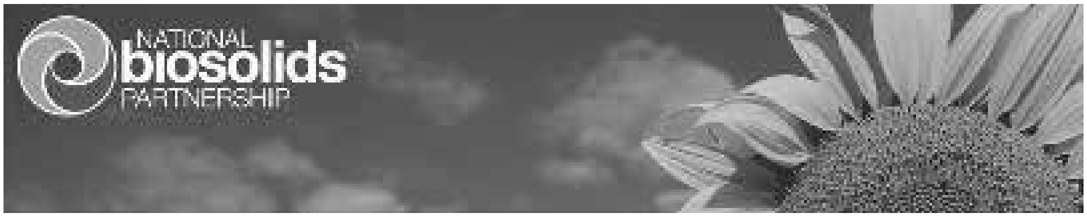

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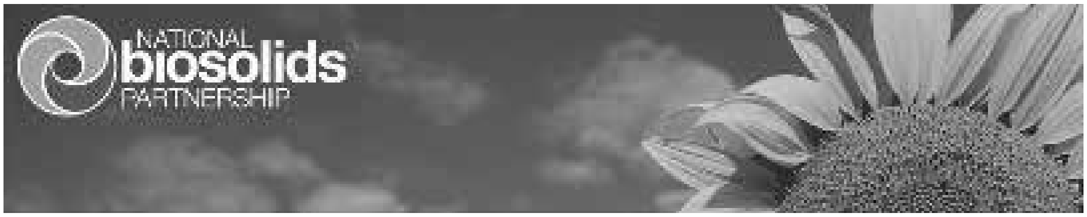
Tuesday, August 26, 2014

Northwest Biosolids Management Association Annual Biosolids Management Conference
Sunday, September 07, 2014



Technical Resources

Guidance

- Thermal Oxidation Fact Sheet (2014)
- Drying of Wastewater Solids (2014)
- Enabling the Future: Advancing Resource Recovery from Biosolids (2013)
- Advances in the State of Biosolids Management Practice Fact Sheet (2013)
- Emerging Biosolids Treatment Technologies Fact Sheet (2013)
- Potentia l Uses of Biosolids Fact Sheet (2013)
- The Potential Power of Renewable Energy Generation from Wastewater and Biosolids (2013)
- Solids Process Design and Management (2012)
- Biosolids Recycling: Beneficial Technology for a Better Environment (U.S. EPA link)
- Charting the Future of Biosolids Management – Final Report (2011)
- Charting the Future of Biosolids Management – Executive Summary (2011)
- Use and Disposal of Biosolids (Sewage Sludge) (U.S. EPA link)
- Frequently Asked Questions on Biosolids (2010)
- Design of Municipal Wastewater Treatment Plants, MOP 8, 5th Edition (2009)
- Manure Pathogens: Manure Management, Regulations, and Water Quality Protection (2009)
- Operation of Municipal Wastewater Treatment Plants, MOP 11, 6th Edition (2007)
- Microconstituents in Biosolids (2007)
- A Guide to Understanding Biosolids Issues (2006)
- Biosolids - The Various Uses of the Term July 2005 - PDF (2005)
- Biosolids Worker Health & Safety Frequently Asked Q&As (2000)

Land Application

- WEF/ABC Biosolids Land Appliers' Guide to Preparing for the Certification Examination(2012)
- WEF Land Application & Composting Fact Sheet (2010)
- VT Study - Agricultural Land Application of Biosolids in Virginia: Risks and Concerns (2009)
- Agricultural Land Application of Biosolids in Virginia: Managing Biosolids (VA Cooperative Extension link)
- Agricultural Uses of Municipal, Animal, and Industrial Byproducts (USDA link)
- Biosolids Applied to Land: Advancing Standards and Practices (7-02-02) (2002)
- Alkylphenol Ethoxylate Degradation Products in Land-Applied Sewage Sludge (Biosolids) by Hale - 2001 (2001)
- In-vessel Composting of Biosolids EPA Fact Sheet (Sept. 2000) – PDF (2000)
- USDA Report on Agricultural Uses of Biosolids (USDA link)

Policy

Case Law

- WEF letter of request for publication of California Court of Appeals Opinion re: City of Los Angeles v. County of Kern- 2013
- Amicus Brief filed by WEF and Other Associations - 2010 - PDF (2010)
- Amicus Brief filed by the Metropolitan Water Reclamation District of Greater Chicago, et al.- 2010 - PDF (2010)
- WEF Amicus Brief - 2008 - PDF (2008)
- Amicus Brief Filed by NACWA in Support of Appellees (June 2, 2008) - PDF (2008)
- Kern County U.S District Court in Southern CA Order Denying Kern County Measure E Petition to Ban Land Application (8-10-07) (2007)

Regulations

- Links to State Regulations

- **U.S. EPA Part 503 Rule**

  - A Guide to the Biosolids Risk Assessments for the EPA Part 503 Rule (U.S. EPA link)
  - A Plain English Guide to the EPA Part 503 Biosolids Rule (U.S. EPA link)
  - Domestic Septage Regulatory Guidance: A Guide to The EPA 503 Rule (1993)

Research

- See also, http://www.werf.org

- Alkylphenols in Biosolids Fact Sheet (3/02) - PDF (2002)
- Global Atlas of Excreta, Wastewater Sludge and Biosolids 2nd Edition (2008) - PDF (2008)
- Radioactive Materials in Sewage Sludge& Ash Guidance at POTWs (June 2000) (2000)
- Reducing Children's Risk from Lead in Soil (1-1-2004) (2004)

Surveys

- Clean Watersheds Needs Survey
  - EPA Clean Watersheds Needs Survey 2012 Data Entry (U.S. EPA link)
  - EPA 2008 Clean Watersheds Needs Survey (U.S. EPA link)
  - EPA 2004 Clean Watersheds Needs Survey (U.S. EPA link)

Appendix C: Pathogen Reduction – Survival Times of Pathogens

Survival Times of Pathogens in Soil

Pathogen	Absolute Maximum	Common Maximum
Bacteria	1 year	2 months
Viruses	1 year	3 months
Protozoan cysts	10 days	2 days
Helminth ova	7 years	2 years

Survival Times of Pathogens on Plant Surfaces

Pathogen	Absolute Maximum	Common Maximum
Bacteria	6 months	1 month
Viruses	2 months	1 month
Protozoan cysts	5 days	2 days
Helminth ova	5 months	1 month

Appendix C: Pathogen Reduction

The following information in Appendix C, *Class A Pathogen Requirements,* is an excerpt from EPA's publication *Environmental Regulations and Technology – Control of Pathogens and Vector Attraction in Sewage Sludge* available at http://www.epa.gov/nrmrl/pubs/625r92013/625R92013.pdf

Chapter 4
Class A Pathogen Requirements

4.1 Introduction

This chapter principally discusses the Class A pathogen requirements in Subpart D of the 40 CFR Part 503 regulation. Biosolids that are sold or given away in a bag or other container for application to land **must** meet these requirements (see Section 3.4). Bulk biosolids applied to a lawn or home garden also **must** meet these requirements. Bulk biosolids applied to other types of land **must** meet these requirements if site restrictions are not met (see Chapter 5 for guidance on Class B biosolids). Some discussion is, however, presented of vector attraction reduction.

There are six alternative methods for demonstrating Class A pathogen reduction. Two of these alternatives provide continuity with 40 CFR Part 257 by allowing use of Processes to Further Reduce Pathogens (PFRPs) and equivalent technologies (see Sections 4.8 and 4.9). Any one of these six alternatives may be met for the sewage sludge to be Class A with respect to pathogens. The implicit objective of all these requirements is to reduce pathogen densities to below detectable limits which are:

Salmonella sp.	less than 3 MPN per 4 grams total solids biosolids (dry weight basis)
Enteric viruses[1]	less than 1 PFU per 4 grams total solids biosolids (dry weight basis)
Viable helminth ova	less than 1 viable helminth ova/ 4 gram total solids biosolids (dry weight basis)

One of the vector attraction reduction requirements (see Chapter 8) also must be met when biosolids are applied to the land or placed on a surface disposal site. To meet the Part 503 regulatory requirements, pathogen reduction must be met before vector attraction reduction or at the same time vector attraction reduction is achieved.

For the following sections, the title of each section provides the number of the Subpart D requirement discussed in the section. The exact regulatory language can be found in Appendix B, which is a reproduction of Subpart D. Chapters 9 and 10 provide guidance on the sampling and analysis needed to meet the Class A microbiological monitoring requirements.

[1] Enteric viruses are monitored using a method that detects several enterovirus species--a subset of enteric viruses. This method is presumed to be a good indicator of enteric viruses. Since the objective of the Part 503 regulation is to reduce all enteric viruses to less than 1 PFU per 4 grams total solids sewage sludge, this document refers to "enteric viruses" when discussing this requirement, although, in reality, the detection method enumerates only enteroviruses.

4.2 Vector Attraction Reduction to Occur With or After Class A Pathogen Reduction [503.32(a)(2)]

Although vector attraction reduction and pathogen reduction are separate requirements, they are often related steps of a process. Chapter 8 discusses the vector attraction reduction options in greater detail.

The order of Class A pathogen reduction in relation to the reduction of vector attraction is important when certain vector attraction reduction options are used. Part 503.32(a)(2) requires that Class A pathogen reduction be accomplished before or at the same time as vector attraction reduction, except for vector attraction reduction by alkali addition [503.33(b)(6)] or drying [503.33(b)(7) and (8)] (see Chapter 8).

This requirement is necessary to prevent the growth of bacterial pathogens after sewage sludge is treated. Contamination of biosolids with a bacterial pathogen after one of the Class A pathogen reduction alternatives has been conducted may allow extensive bacterial growth unless: a) an inhibitory chemical is present, b) the biosolids are too dry to allow bacterial growth, c) little food remains for the microorganisms to consume, or d) an abundant population of non-pathogenic bacteria is present. Vegetative cells of non-pathogenic bacteria repress the growth of pathogenic bacteria by "competitive inhibition" which is in substantial part due to competition for nutrients. It should be noted that vector attraction reduction by alkali addition [503.3(b)(6)] or drying [503.3(b)(7)] and (8) is based on the characteristic of the biosolids (pH or total solids) remaining elevated. Should the pH drop or the biosolids absorb moisture, the biosolids may be more hospitable to microorganisms, and pathogenic bacteria, if introduced, may grow. Therefore it is recommended that biosolids treated with these methods be stored appropriately.

Biological treatment processes like anaerobic digestion, aerobic digestion, and composting produce changes in the sewage sludge so that it satisfies one of the vector attraction reduction requirements [503.3(b)(1) through (5)]. They repress bacterial growth by minimizing the food supply and providing competition for the remaining food from non-pathogenic organisms. The pathogen reduction alternative must precede the vector attraction reduction process; otherwise, the large number of non-pathogenic bacterial cells would be killed and growth of pathogenic bacteria could occur. Certain pathogen reduction processes such as composting accomplish vector attraction reduction by a biological process simultaneously with thermal reduction of pathogens. A non-pathogenic bacterial community survives which adequately suppresses growth of pathogenic bacteria.

In the case of Class B biosolids, a population of non-pathogenic bacteria is retained and inhibits the growth of pathogenic bacteria through competition, and site restrictions are imposed with their land application to reduce the risk of exposure to pathogens. Therefore, bacterial growth is not a concern for Class B biosolids, and vector attraction reduction and pathogen reduction for compliance with the Part 503 Rule requirements may be met in any order.

4.3 Monitoring of Fecal Coliform or *Salmonella* sp. to Detect Growth of Bacterial Pathogens [503.32(a)(3)-(8)]

The goal of Class A processes is to reduce the level of pathogens to below detectable levels and below the level at which they are infectious. The Class A processes have been shown to sufficiently reduce pathogen levels in biosolids, and studies to date have not found that the growth of pathogenic bacteria may occur in materials after processes take place or during storage. Favorable conditions for the growth of pathogenic bacteria would be: adequate moisture, absence of an inhibitory chemical, and inadequate reduction of nutritive value of the sewage sludges.

Because Class A biosolids may be used without site restrictions, all Class A material must be tested to show that the microbiological requirements are met at the time when *it is ready to be used or disposed.* In addition to meeting process requirements, Class A biosolids must meet one of the following requirements:

- Either the density of fecal coliforms in the sewage sludge be less than 1,000 MPN[2] per gram total solids (dry weight basis).
- Or the density of *Salmonella* sp. bacteria in the sewage be less than 3 MPN per 4 grams of total solids (dry weight basis).

Although the Part 503 regulation does not specify the number of samples that should be taken to show compliance with Class A density requirements, sampling programs should provide adequate representation of the biosolids generated. Chapter 9 provides guidance for calculating the number of samples that should be taken per sampling event. Unlike Class B biosolids, compliance with Class A requirements is not based on an average value. **Each sample analyzed must comply with the numerical requirements.**

The microbiological requirement must be met either:

- At the time of use or disposal[3], or
- At the time the biosolids are prepared for sale or give away in a bag or other container for land application, or
- At the time the biosolids or material derived from the biosolids is prepared to meet the requirements in 503.10(b), 503. 10(c), 503. 10(e), or 503. 10(f)[4].

If a facility stores material before it is distributed for use or disposal, microbiological testing should take place after storage.

In each case, the timing represents the last practical monitoring point before the biosolids are applied to the land or placed on a surface disposal site. Biosolids that are sold or given away cannot be monitored just prior to actual use or disposal; instead monitoring is required as it is prepared for sale or give away. Biosolids that meet the 503.10(b, c, d, or e) requirements are considered "Exceptional Quality" and are therefore not subject to further control (see Section 1.4). For this reason, the microbiological requirements must be met at the time the biosolids are prepared to meet the 503.10 requirements, which in most cases is the last time the biosolids are under the control of a biosolids preparer.

As discussed in Chapter 9, the timing of pathogen sampling is also a function of laboratory turnaround time. Obtaining results for fecal coliform and *Salmonella* sp. analysis may take several days if tests are performed in-house, but commercial labs may require more time to process and report results. It is not unusual for laboratories to have a turnaround time of 2 weeks, even for simple tests such as fecal coliform. If this is the case, this time should be factored into the sampling program so that results can be obtained before biosolids are distributed for use or disposal.

Monitoring Fecal Coliforms or Salmonella sp.

Fecal coliforms are used in the Part 503 as an indicator organism, meaning that they were selected to be monitored because reduction in fecal coliforms correlates to reduction in *Salmonella* sp. and other organisms. The re-

[2]The membrane filter method is not allowed for Class A because, at the low fecal coliform densities expected, the filter would have too high a loading of sewage sludge solids to permit a reliable count of the number of fecal coliform colonies.

[3]Minus the time needed to test the biosolids and obtain the test results prior to use or disposal (see Chapter 10).

[4]The 503.10(b)(c)(e) and (f) requirements are not discussed in this document.

quirements were based on experimental work by Yanko (1987) and correlations developed from Yanko's data by Farrell (1993) which show that this level of fecal coliforms correlate with a very low level of *Salmonella* sp. detection in composted sewage sludge (EPA, 1992).

Anecdotal reports suggest that some composting facilities may have difficulty meeting this requirement even when *Salmonella* sp. are not detected. This might be expected under several circumstances. For example, very severe thermal treatment of sewage sludge during composting can totally eliminate *Salmonella* sp. yet leave residual fecal coliforms. If the sewage sludge has been poorly composted and thus is a good food source, fecal coliforms may grow after the compost cools down from thermophilic temperatures. Because the *Salmonella* sp. are absent, they cannot grow. An even more probable circumstance could occur if the sewage sludge is treated with lime before composting. Lime effectively destroys *Salmonella* sp. in sewage sludge and leaves surviving fecal coliforms (Farrell et al., 1974). Under conditions favorable for growth, the fecal coliforms can regrow to levels higher than 1,000 MPN per gram. Research has shown that detection of *Salmonella* sp. is much rarer in composted sewage sludge that has been lime treated and composted than detection of fecal coliforms. *Fecal coliform densities maybe high therefore compared to pathogen densities in such cases and maybe overly conservative.* For this reason, all of the Part 503 Class A alternatives allow the direct measurement of *Salmonella* sp. or fecal coliform analysis, but do not require both.

4.4 Alternative 1: Thermally Treated Sewage Sludge [503.32(a)(3)]

This alternative may be used when the pathogen reduction process uses specific time-temperature regimes to reduce pathogens. Under these circumstances, time-consuming and expensive tests for the presence of specific pathogens can be avoided. It is only necessary to demonstrate that:

- Either fecal coliform densities are below 1,000 MPN per gram of total solids (dry weight basis), or *Salmonella* sp. bacteria are below detection limits (3 MPN per 4 grams total solids [dry weight basis]) at the time the sewage sludge is used or disposed, at the time the sewage sludge is prepared for sale or given away in a bag or other container for land application, **or** at the time the sewage sludge or material derived from the sewage sludge is prepared to meet the requirements in 503.10(b), 503.10(c), 503.10(e), or 503.10(f).

- And the required time-temperature regimes are met.

Time-Temperature Requirement

Four different time-temperature regimes are given in Alternative 1. Each regime is based on the percent solids of the sewage sludge and on operating parameters of the treatment process. Experimental evidence (EPA, 1992) demonstrates that these four time-temperature regimes reduce the pathogenic organisms to below detectable levels.

The four time-temperature regimes are summarized in Table 4-1. They involve two different time-temperature equations. The equation used in Regimes A through C results in requirements that are more stringent than the requirement obtained using the equation in Regime D. For any given time, the temperature calculated for the Regime D equation will be 3 Celsius degrees (5.4 Fahrenheit degrees) lower than the temperature calculated for the Regimes A through C equation.

The time-temperature relationships described for Alternative 1 are based on extensive research conducted to correlate the reduction of various pathogens in sewage sludge to varying degrees of thermal treatment. The resulting time-temperature relationship which is the basis for Alternative 1 is shown in Figure 4-1. These requirements are similar to the FDA requirements for treatment of eggnog, a food product with flow characteristics similar to those of liquid sewage sludge. The Regimes A through D differ depending on the characteristics of sewage sludge treated and the type of process used because of the varying efficiency of heat transfer under different conditions.

It is important to note that **it is mandatory for all sewage sludge particles to meet the time-temperature regime.** Therefore, testing of temperatures throughout the sewage sludge mass and agitating the material to ensure uniformity would be appropriate. For processes such as thermophilic digestion, it is important that the digester design not allow for short circuiting of untreated sewage sludge. One approach that has been used to overcome this problem has been to draw off treated sewage sludge and charge feed intermittently with a sufficient time period between draw-down and feeding to meet the time-temperature requirement of Alternative 1. Another option would be to carry out the process in two or more vessels in series so as to prevent bypassing.

These time-temperature regimes are not intended to be used for composting (the time-temperature regime for composting is covered in Alternative 5: Processes to Further Reduce Pathogens).

A more conservative equation is required for sewage sludges with 7% or more solids (i.e., those covered by Regimes A and B) because these sewage sludges form an internal structure that inhibits the mixing that contributes to uniform distribution of temperature. The more stringent equation is also used in Regime C (even though this regime applies to sewage sludges with less than 7% solids) because insufficient information is available to apply the less stringent equation for times less than 30 minutes.

The time-temperature requirements apply to every particle of sewage sludge processed. Time at the desired temperature is readily determined for batch or plug flow operations, or even laminar flow in pipes. Time of contact also can be calculated for a number of completely mixed

Table 4-1. The Four Time-Temperature Regimes for Alternative 1 (Thermally Treated Sewage Sludge) [503.32(a)(3)]

Regime	Part 503 Section	Applies to	Required Time-Temperature[1]
A	503.32(a)(3)(ii)(A)	Sewage sludge with at least 7% solids (except those covered by Regime B)	$D = 131{,}700{,}000/10^{0.1400t}$ $t \geq 50°C$ (122°F)[2] $D \geq 0.0139$ (i.e., 20 minutes)[3]
B	503.32(a)(3)(ii)(B)	Sewage sludge with at least 7% solids that are small particles heated by contact with either warmed gases or an immiscible liquid[4]	$D = 131{,}700{,}000/10^{0.1400t}$ $t \geq 50°C$ (122°F)[2] $D \geq 1.74 \times 10^{-4}$ (i.e., 15 seconds)[5]
C	503.32(a)(3)(ii)(C)	Sewage sludge with less than 7% solids treated in processes with less than 30 minutes contact time	$D = 131{,}700{,}000/10^{0.1400t}$ 1.74×10^{-4} (i.e., 15 seconds) $\leq D \leq 0.021$ (i.e. 30 minutes)[6]
D	503.32(a)(3)(ii)(D)	Sewage sludge with less than 7% solids treated in processes with at least 30 minutes contact time	$D = 50{,}070{,}000/10^{0.1400t}$ $t \geq 50°C$ (122°F)[2] $D \geq 0.021$ (i.e. 30 minutes)[7]

[1] D = time in days; t = temperature (°C).
[2] The restriction to temperatures of at least 50°C (122°F) is imposed because information on the time-temperature relationship at lower temperatures is uncertain.
[3] A minimum time at 20 minutes is required to ensure that the sewage sludge has been uniformly heated.
[4] Two examples of sewage sludge to which this requirement applies are:
- Sewage sludge cake that is mixed with previously dried solids to make the entire mass a mixture of separate particles, and is then dried by contact with a hot gas stream in a rotary drier.
- Sewage sludge dried in a multiple-effect evaporator system in which the system sludge particles are suspended in a hot oil that is heated by indirect heat transfer with condensing steam.

[5] Time-at-temperature of as little as 15 seconds is allowed because, for this type of sewage sludge, heat transfer between particles and the healing fluid is excellent. Note that the temperature is the temperature achieved by the sewage sludge particles, not the temperature of the carrier medium.
[6] Time-at-temperature of as little as 15 seconds is allowed because heat transfer and uniformity of temperature is excellent in thiswage sludge. The maximum time of 30 minutes is specified because a less stringent regime (D) applies when time-at-temperature is 30 minutes or more.
[7] Time-at-temperature of at least 30 minutes is required because information on the effectiveness of this time-temperature regime for reducing pathogens at temperatures of less than 30 minutes is uncertain.

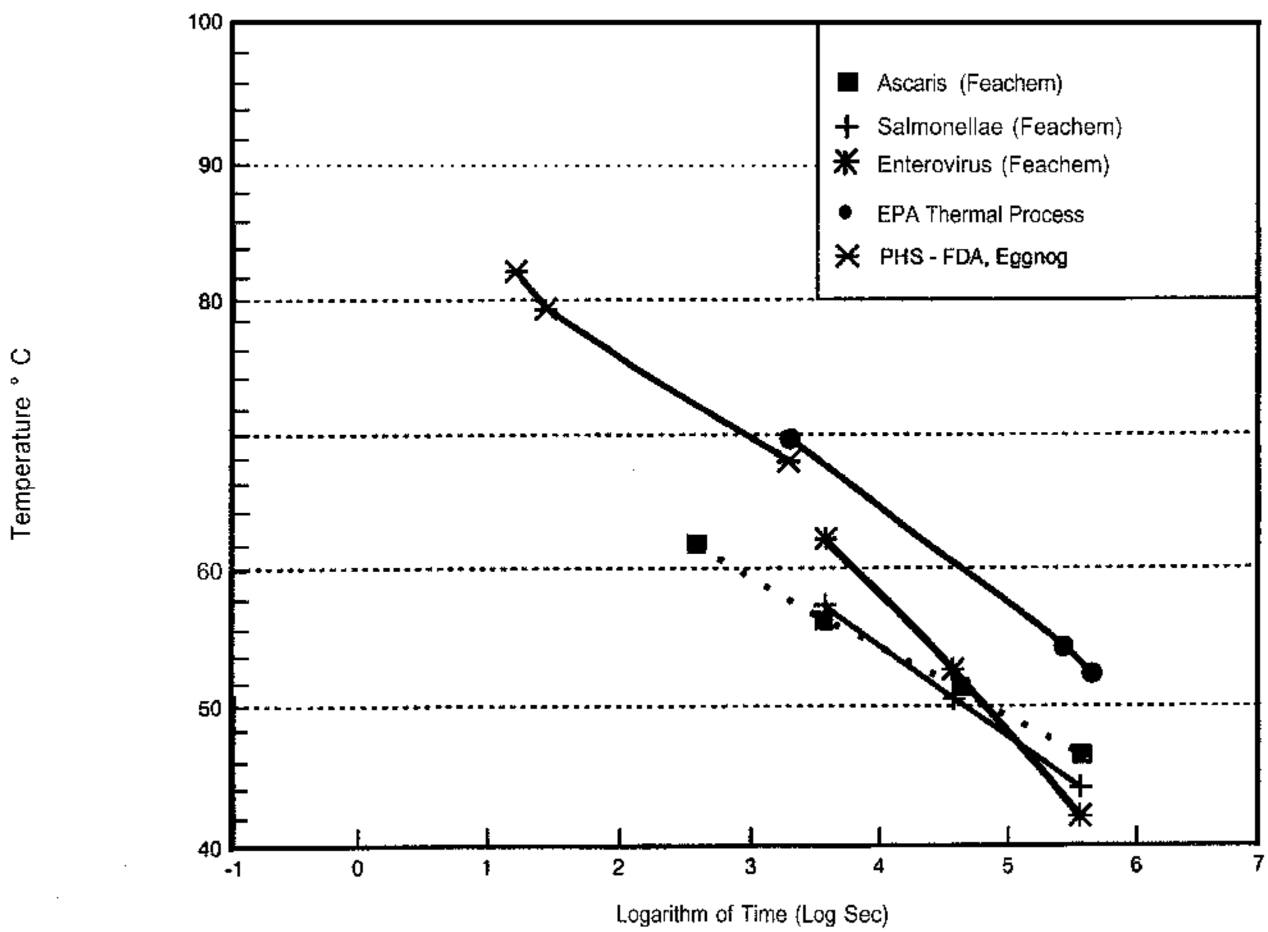


Figure 4-1. EPA's time-temperature relationship for thermal disinfection compared with other time-temperature relationships.

reactors in series (Schafer, et al, 1994). However, there are concerns that flow-through systems may permit some sludge to pass through without adequate treatment. It is recommended that facilities wishing to use this alternative for a flow-through system conduct tracer studies to demonstrate that sewage sludge is treated at the required temperature for sufficient time.

Vector Attraction Reduction

Thermally treated sewage sludge must be treated by an additional vector attraction reduction process since thermal treatment does not necessarily break down the volatile solids in sewage sludge. Vector attraction reduction can be met by further processing the sewage sludge with pH adjustment or heat drying (Options 6 and 7), or by meeting one of the other options (Options 8 - 11). Options 1 through 5 would not be applicable to thermally treated sludge unless the sludge was subject to biological digestion after or during thermal treatment.

Example of Meeting Class A Pathogen and Vector Attraction Reduction Requirements

Type of Facility	Thermophilic Anaerobic Digester Class A Digested sewage sludge is retained for at least 5 days at 50°C (Regime D). Sewage sludge is agitated regularly to ensure thorough mixing, and temperatures are monitored continually in a batch mode of operation.
Testing	Sewage sludge is sampled 6 times each year for pollutants and fecal coliforms. Compliance with vector attraction reduction is also monitored.
Vector Attraction Reduction	VAR is met by reducing volatile solids by over 38 percent. Five samples of input and output sewage sludge from each batch are analyzed for volatile solids content over a period of two weeks.
Use or Disposal	The Class A biosolids are land applied.

Microbiological Requirement

Microbiological monitoring for either fecal coliforms or *Salmonella* sp. is required to ensure that growth of bacterial pathogens has not occurred.

4.5 Alternative 2: Sewage Sludge Treated in a High pH-High Temperature Process (Alkaline Treatment) [503.32(a)(4)]

This alternative describes conditions of a high temperature-high pH process that has proven effective in reducing pathogens to below detectable levels. The process conditions required by the Part 503 regulation are:

- Elevating pH to greater than 12 and maintaining the pH for more than 72 hours.
- Maintaining the temperature above 52°C (126°F) throughout the sewage sludge for at least 12 hours during the period that the pH is greater than 12.
- Air drying to over 50% solids after the 72-hour period of elevated pH.

The hostile conditions of high pH, high temperature, and reduced moisture for prolonged time periods allow a variance to a less stringent time-temperature regime than for the thermal requirements under Alternative 1. The pH of the sewage sludge is measured at 25°C (77°F) or an appropriate correction is applied (see Section 10.7).

Example of Meeting Class A Pathogen and Vector Attraction Reduction

Type of Process Class	Alkaline Treatment
Pathogen Reduction	Alkaline material is used to bring sewage sludge pH to 12 for 72 hours during which time temperatures are above 52°C for 72 hours. Sewage sludge is agitated during the heat pulse phase to maintain even distribution, and temperature and pH are measured at multiple points within the sewage sludge. The sewage sludge is then moved to piles and maintained until moisture is reduced to 50 percent.
Testing	Piles are tested quarterly for polutants and *Salmonella* sp. Samples are taken from stockpiled material, and material is not distributed for use or disposal until test results are received
Vector Attraction Reduction	VAR Option 6,pH adjustment; pH is to remain elevated until use/disposal.
Use or Disposal	During winter months (Nov-March), biosolids remain on site. In the spring, biosolids are retested for pathogens before being distributed.

Operational Issues

Because the elevated pH and temperature regimes must be met by the entire sewage sludge mass, operational protocols which include monitoring pH and temperature at various points in a batch and agitating the sewage sludge during operations to ensure consistent temperature and pH are appropriate.

Vector Attraction Reduction

The pH requirement of vector attraction reduction Option 6 is met when Alternative 2 is met. Compliance with Alternative 2 exceeds the pH requirements of Option 6.

Microbiological Requirements

As with all the Class A alternatives, microbiological monitoring for fecal coliforms or *Salmonella* sp. is required (see Section 4.3) to ensure that pathogens have been reduced and growth of pathogenic bacteria has not occurred.

4.6 Alternative 3: Sewage Sludge Treated in Other Processes [503.32(a)(5)]

This alternative applies to sewage sludge treated by processes that do not meet the process conditions required by Alternatives 1 and 2. This requirement relies on comprehensive monitoring of bacteria, enteric viruses and viable helminth ova to demonstrate adequate reduction of pathogens:

- Either the density of fecal coliforms in the sewage sludge must be less than 1000 MPN per gram of total solids (dry weight basis), or the *Salmonella* sp. bacteria in sewage sludge must be less than 3 MPN per 4 grams of total solids (dry weight basis) at the time the sewage is used or disposed, at the time the sewage sludge is prepared for sale or given away in a bag or other container for land application, or at the time the sewage sludge or material derived from the sewage sludge is prepared to meet the requirements in 503.10(b), 503.10(c), 503.10(e), or 503.10(f).

- The density of enteric viruses in the sewage sludge after pathogen treatment must be less than 1 PFU per 4 grams of total solids (dry weight basis).

- The density of viable helminth ova in the sewage sludge after pathogen treatment must be less than 1 per 4 grams of total solids (dry weight basis).

Testing for enteric viruses and viable helminth ova can be complicated by the fact that they are sometimes not present in the untreated sewage sludge. In this case, an absence of the organisms in the treated sewage sludge does not demonstrate that the process can reduce them to below detectable limits. For this reason, Alternative 3 requires that the feed sewage sludge be analyzed for enteric viruses and viable helminth ova. If these organisms are not detected in the feed sewage sludge, the sewage sludge is presumed to be acceptable as a Class A material until the next monitoring episode. Monitoring is continued until enteric viruses and/or viable helminth ova are detected in the feed sewage sludge (i.e., the density of enteric viruses is greater than or equal to 1 PFU per 4 grams total solids (dry weight basis) and/or the density of viable helminth ova is greater than or equal to 1 per 4 grams total solids (dry weight basis). At this point, the treated sewage sludge is analyzed to see if these organisms survived treatment. If enteric viruses densities are below detection limits, the sewage sludge meets Class A requirements for enteric viruses, and will continue to do so as long as the treatment process is operated under the same conditions that successfully reduced the enteric virus densities. If the viable helminth ova densities are below detection limits, the process meets the Class A requirements for enteric viruses and will continue to do so as long as the treatment process is operated under the same conditions that successfully reduced the viable helminth ova densities. Thus, it is essential to monitor and document operating conditions until adequate enteric virus and helminth ova reduction has been successfully demonstrated. Samples of untreated and treated sewage sludge must correspond (see Section 7.4).

Enteric Virus and Viable Helminth Ova Testing

Tests for enteric viruses and viable helminth ova take substantial time: 4 weeks to determine whether helminth ova are viable, and 2 weeks or longer for enteric viruses. The treatment works operator does not know whether the feed sewage sludge has enteric viruses or helminth ova until at least 2 to 4 weeks after the first samples for testing feed densities are taken. This works with rapid processes but long-term process systems need to have temporally related samples. In such cases, it may be feasible to obtain results within the processing time constraints. For enteric viruses, the sewage sludge should be stored frozen, unless the sample can be processed within 24 hours, in which case the samples may be stored at 4°C (39°F). For viable helminth ova, the sewage sludge should be stored at 4°C (39°F) (see Section 9.6).

Finding a laboratory that performs viable helminth ova and virus testing has been difficult for some sewage sludge preparers. Chapter 9 has more information on how to select a laboratory. State and Regional EPA sludge coordinators should also be contacted for information on qualified labs in the region.

Since this option relies on testing, rather than process and testing, to protect public health additional testings should be completed. At a minimum, a detailed sampling plan should be submitted to the permitting authority for review.

Vector Attraction Reduction

For both Alternatives 3 and 4, meeting vector attraction reduction depends on the process by which pathogen reduction is met. For example, sewage sludge subject to long-term storage may meet vector attraction reduction through volatile solids reduction (Options 1 - 3). Sewage sludges may also undergo additional processing or be applied following the requirements in Options 8 - 11.

Microbiological Requirements

As with all the Class A alternatives, microbiological monitoring for fecal coliforms or *Salmonella* sp. is required (see Section 4.3) to ensure that pathogens have been reduced and growth of pathogenic bacteria has not occurred.

4.7 Alternative 4: Sewage Sludge Treated in Unknown Processes [503.32(a)(6)]

The sewage sludge must meet the following limits at the time the biosolids (or material derived from sludge) are used or disposed, at the time the sewage sludge is prepared for sale or given away in a bag or other container for land application, or at the time the sewage sludge or material derived from the sewage sludge is prepared to meet the requirements in 503.10(b), 503.10(c), 503.10(e), or 503.10(f):

- The density of enteric viruses in the sewage sludge must be less than 1 PFU per 4 grams of total solids (dry weight basis).
- The density of viable helminth ova in the sewage sludge must be less than 1 per 4 grams of total solids (dry weight basis).

In addition, as for all Class A biosolids, the sewage sludge must meet fecal coliform or *Salmonella* sp. limits. As with Alternative 3, Alternative 4 depends on a successful sampling program that provides accurate representation of the sewage sludge's microbial quality (see Chapter 9).

Example Of Meeting Class A Pathogen Vector Attraction Reduction

Type of Facility	Unknown Process
Class	A
Pathogen Reduction	Sewage sludge is digested and retained in a lagoon up to 2 years. Sewage sludge is then moved to a stockpiling area where it may stay for up to 2 years.
Testing	Before sewage sludge is distributed, each pile, representing approximately 1 year of sewage sludge production, is tested for *Salmonella* sp., viable helminth ova, and enteric viruses. Since quarterly testing is mandated, based on the amount of sewage sludge which is used or disposed, four samples per pile are submitted
Vector Attraction Reduction	VAR is demonstrated by showing a 38 percent reduction in volatile solids. Records of incoming material and volume, bulk density, and percent volatile solids of outgoing material are used to calculate the reduction.
Distribution	Biosolids are distributed for land application and agricultural land.

Examples of situations where Alternative 4 may be used:

- Sewage sludge treatment process is unknown.
- The sewage sludge was produced with the process operating at conditions less stringent than the operating conditions at which the sewage sludge could qualify as Class A under other alternatives.

Enteric Virus and Viable Helminth Ova Testing

Tests for enteric viruses and viable helminth ova take substantial time: 4 weeks to determine whether helminth ova are viable, and 2 weeks or longer for enteric viruses. The treatment works operator does not know whether the feed sewage sludge has enteric viruses or helminth ova until at least 2 to 4 weeks after the first samples for testing feed densities are taken. This option works with rapid processes but long-term process systems need to have temporally related samples. In such cases, it may be feasible to obtain results within the processing time constraints. For enteric viruses, the sewage sludge should be stored frozen, unless the sample can be processed within 24 hours, in which case the samples may be stored at 4°C (39°F). For viable helminth ova, the sewage sludge should be stored at 4°C (39°F) (see Section 9.6).

Finding a laboratory that performs viable helminth ova and virus testing has been difficult for some sewage sludge preparers. Chapter 9 has more information on how to select a laboratory. State and Regional EPA sludge coordinators should also be contacted for information on qualified labs in the region.

Since this option relies on testing, rather than process and testing, to protect public health additional testings should be completed. At a minimum, a detailed sampling plan should be submitted to the permitting authority for review.

Vector Attraction Reduction

For both Alternatives 3 and 4, meeting vector attraction reduction depends on the process by which pathogen reduction is met. For example, sewage sludge subject to long-term storage may meet vector attraction reduction through volatile solids reduction (Options 1-3). Sewage sludges may also undergo additional processing or be applied following the requirement in Options 8-11.

4.8 Alternative 5: Use of PFRP [503.32(a)(7)]

Alternative 5 provides continuity with the 40 CFR Part 257 regulation. This alternative states that sewage sludge is considered to be Class A if:

- It has been treated in one of the Processes to Further Reduce Pathogens (PFRPs) listed in Appendix B of the regulation, and
- Either the density of fecal coliforms in the sewage sludge is less than 1,000 MPN per gram total solids (dry weight basis), or the density of *Salmonella* sp. bacteria in the sewage sludge is less than 3 MPN per 4 grams total solids (dry weight basis) at the time the sewage sludge is used or disposed, at the time the sewage sludge is prepared for sale or give away in a bag or other container for land application, or at the

time the sewage sludge or material derived from the sewage sludge is prepared to meet the requirements in 503.10(b), 503.10(c), 503.10(e), or503.10(f).

To meet this requirement, the sewage sludge treatment processes must be operated according to the conditions listed in Appendix B of the regulation.

The Appendix B list of PFRPs is reproduced in Table 4-2. This list is very similar to the PFRP technologies listed in 40 CFR Part 257, with two major differences:

- All requirements related to vector attraction reduction have been removed.
- All the "add-on" processes listed in Part 257 are now full-fledged PFRPs.

Under this Alternative, treatment processes classified as PFRP under 40 CFR Part 257 can continue to be operated; however, microbiological monitoring must now be performed to ensure that the pathogen density levels are below detection limits and to ensure that growth of *Salmonella* sp. bacteria does not occur between treatment and use or disposal.

For all PFRP processes, the goal of temperature monitoring should be to represent all areas of a batch or pile and to ensure that temperature profiles from multiple points in the process all meet mandated temperatures. In some instances it may be possible to monitor representative areas of a batch or pile or a reasonable worst case area to ensure compliance. Chapter 7 contains more guidelines about the operation of PFRP processes.

4.9 Alternative 6: Use of a Process Equivalent to PFRP [503.32(a)(8)]

The 40 CFR Part 257 regulation allowed any treatment process to be determined *equivalent* to a PFRP. Under Alternative 6, sewage sludge is considered to be a Class A sewage sludge if:

- It is treated by any process equivalent to a PFRP, **and**
- Either the density of fecal coliforms in the sewage sludge is less than 1,000 MPN per gram total solids (dry weight basis), or the density of *Salmonella* sp. bacteria in the sewage sludge is less than 3 MPN per 4 grams total solids (dry weight basis) at the time the sewage sludge is used or disposed, at the time the sewage sludge is prepared for sale or give away in a bag or other container for land application, or at the time the sewage sludge or material derived from the sewage sludge is prepared to meet the requirements in 503.10(b), 503.10(c), 503.10(e), or 503.10(f).

Facilities that meet Alternative 6 for pathogen reduction must still meet vector attraction reduction requirements.

Processes Already Recommended as Equivalent

Processes recommended to be equivalent to PFRP are shown in Table 11.2. Products of all equivalent processes must still meet the Class A fecal coliform or *Salmonella* sp. requirements.

Who Determines Equivalency?

Part 503 gives the permitting authority responsibility for determining equivalency under Alternative 6. The EPA's Pathogen Equivalency Committee (PEC) is available as a resource to provide guidance and recommendations on equivalency determinations to both the permitting authority and the regulated community (see Chapter 11).

4.10 Frequency of Testing

The Part 503 regulation sets forth minimum sampling and monitoring requirements. Table 3-4 in Chapter 3 de-

Table 4-2. Processes to Further Reduce Pathogens (PFRPs) Listed in Appendix B of 40 CFR Part 503[1]

Composting	Using either the within-vessel composting method or the static aerated pile composting method, the temperature of sewage sludge is maintained at 55°C (131°F) or higher for 3 consecutive days. Using the windrow composting method, the temperature of the sewage sludge is maintained at 55°C (131°F) or higher for 15 consecutive days or longer. During the period when the compost is maintained at 55°C (131°F) or higher, there shall be a minimum of five turnings of the windrow.
Heat Drying	Sewage sludge is dried by direct or indirect contact with hot gases to reduce the moisture content of the sewage sludge to 10% or lower. Either the temperature of the sewage sludge particles exceeds 80°C (176°F) or the wet bulb temperature of the gas in contact with the sewage sludge as the sewage sludge leaves the dryer exceeds 80°C (176°F).
Heat Treatment	Liquid sewage sludge is heated to a temperature of 180°C (356°F) or higher for 30 minutes.
Thermophilic Aerobic Digestion	Liquid sewage sludge is agitated with air or oxygen to maintain aerobic conditions and the mean cell residence time (i.e., the solids retention time) of the sewage sludge is 10 days at 55°C (131°F) to 60°C (140°F).
Beta Ray Irradiation	Sewage sludge is irradiated with beta rays from an electron accelerator at dosages of at least 1.0 megarad at room temperature (ca. 20°C [68°F]).
Gamma Ray Irradiation	Sewage sludge is irradiated with gamma rays from certain isotopes, such as Cobalt 60 and Cesium 137, at dosages of at least 1.0 megarad at room temperature (ca. 20°C [68°F]).
Pasteurization	The temperature of the sewage sludge is maintained at 70°C (158°F) or higher for 30 minutes or longer.

[1]Chapter 7 provides a detailed description of these technologies.

scribes the minimum frequency at which the sewage sludge must be sampled and analyzed for pathogens or vector attraction reduction in order to meet regulatory requirements. In addition to meeting these minimal requirements, the EPA recommends that sewage sludge generators and preparers also consider the potential public health impact pathways and possible liability issues when designing a sampling program. In some cases, it may be appropriate to sample more frequently than the required minimum.

Classification of biosolids as Class A or Class B is based on the most recent test results available. For example, if a facility produces a Class A compost, and sampling is performed once each quarter, the compost produced after each test result verifying Class A is returned is also assumed to be Class A, assuming that the same process continues to be followed. If a test result indicates that compost is not achieving Class A, all compost subsequently generated would be classified as Class B (assuming it meets Class B requirements). The Class B classification would remain until a test result confirming Class A quality is returned.

This raises several issues. Land application of Class B biosolids without site restrictions is a violation of the 503 regulation. In addition, if material is mistakenly classified as EQ biosolids and land applied without restriction to the public, the biosolids preparer may be inadvertently creating a public health risk as well as opening the facility to liability. The key issues to consider are:

At what point between the two sampling events does the material change from Class A to Class B? This depends on the particular situation. The Class B test result may be an exception – the result of cross contamination or faulty sampling or monitoring for one pile. On the other hand, the test result could be indicative of an operation which is not adequately reducing pathogens. The piles which were actually sampled may have been used or distributed under the classification of the previous lab results while lab results were pending (it generally takes 2 weeks to get lab results back). Because distribution of this material as Class A would constitute a violation of the Part 503 regulation, it is recommended that material generated during and subsequent to a sampling event remain on site until lab results are available.

What can you do if you suspect Class B biosolids have been distributed as Class A biosolids? The first question to answer is: has this material created a public health risk. The material should be resampled to determine if it is indeed Class B and not Class A. The Part 503 requires that Class A biosolids meet either the fecal coliform or the *Salmonella* sp. requirements (except for Alternatives 3 and 4). If the material is out of compliance for fecal coliforms, it should immediately be tested for *Salmonella* sp. (and vice versa). In addition, the validity of the test results should be checked by contacting the lab and reviewing the data.

Material distribution should then be tracked to determine where material has been used. Businesses and individuals to whom material has been distributed should be notified and informed of the potential quality issue. If material is stockpiled at distribution points such as at a soil blender or landscaper, the material should be retested for pathogen levels, and distribution be curtailed until the process is reviewed and acceptable results are achieved. The facility may even consider recalling the biosolids from the users.

If material has already been distributed to public access areas, including homes, gardens, parks, or other public areas, the biosolids preparer may consider testing the soil. If the testing indicates problems, corrective actions may be necessary.

How can a situation like this be avoided? There are several sampling practices that a facility should follow in order to avoid a situation like this.

First, sampling should take place close enough to the time of distribution so that results accurately reflect material quality.

If possible, material sampled and subsequently produced material should not be distributed until the results are available; there is usually a 2-week waiting period for lab results for fecal coliform or *Salmonella* sp. analysis.

More frequent sampling can help pinpoint when operational conditions change. This may allow more rapid correction of operations.

Stockpile biosolids in discrete batches and take multiple samples per sampling event. This will allow better identification of which piles may be out of compliance and will allow for the distribution of material that is identified as Class A.

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Appendix D: Vector Attraction Reduction

The four fact sheets in Appendix D are taken from EPA Publication 625/10-89/006, *Environmental Regulations and Technology – Control of Pathogens in Municipal Wastewater Sludge*, September 1989.

The information, *Guidance on Three Vector Attraction Reduction Tests*, is an excerpt from EPA's publication *Environmental Regulations and Technology – Control of Pathogens and Vector Attraction in Sewage Sludge* available at http://www.epa.gov/nrmrl/pubs/625r92013/625R92013.pdf

Composting Sludge, Static Pile **Fact Sheet**

Description -Wastewater sludge is converted to compost in approximately eight weeks in a four-step process:

Preparation - Sludge is mixed with a bulking material such as wood chips or leaves, in order to facilitate handling, to provide the necessary structure and porosity for aeration, and to lower the moisture content of the biomass to 60 percent or less. Following mixing, the aerated pile is constructed and positioned over porous pipe through which air is drawn. The pile is covered for insulation.

Digestion -The aerated pile undergoes decomposition by thermophilic organisms, whose activity generates a concomitant elevation in temperature to 60°C (140°F) or more. Aerobic composting conditions are maintained by drawing air through the pile at a predetermined rate. The effluent air stream is conducted into a small pile of screened, cured compost where odorous gases are effectively absorbed. After about 21 days the composting rates and temperatures decline, and the pile is taken down, the plastic pipe is discarded, and the compost is either dried or cured, depending upon weather conditions.

Drying and Screening - Drying to 40 to 45 percent moisture facilitates clean separation of compost from wood chips. The unscreened compost is spread out with a front end loader to a depth of 12 inches. Periodically a tractor drawn harrow is employed to facilitate drying. Screening is performed with a rotary screen. The chips are recycled.

Curing - The compost is stored in piles for about 30 days to assure no offensive odors remain and to complete stabilization. The compost is then ready for utilization as a low grade fertilizer, a soil amendment, or for land reclamation.

Modifications - 1. Extended High Pile - pile height is extended to 18 ft using a crane (still experimental). Can result in savings of space and materials. 2. Aerated Extended Pile -each day's pile is constructed against the shoulder of the previous day's pile, forming a continuous or extended pile. Can result in savings of space and materials.

Technology Status- Successfully demonstrated at four locations and projected to be capable of serving large cities. Experiments are ongoing on various operating parameters.

Applications - Suitable for converting digested and undigested sludge cake to an end product of some economic value. Insulation of the pile and a controlled aeration rate enable better odor and quality control than the windrow process from which it evolved.

Limitations - The drying process is weather-dependent and requires at least two rainless days. The use of compost on land is limited by the extent to which sludge is contaminated by heavy metals and industrial chemicals. Industrial pretreatment of wastewater treatment plant influent should increase the availability of good quality sludges for composting.

Performance - Sludge is generally stabilized after 21 days at elevated temperatures. Maximum temperatures of between 60° to 80°C are produced during the first three to five days, during which time odors, pathogens and weed seeds are destroyed. Temperatures above 55°C (131°F) for sufficient periods can effectively destroy most human pathogens. The finished compost is humus-like material, free of malodors, and useful as a soil conditioner containing low levels of essential plant macronutrients such as nitrogen and phosphorus and often adequate levels of micronutrients such as copper and zinc.

Chemicals Required - None

Residuals Generated - Final product is compost.

Design Criteria (79) - Construction of the pile for a 10 dry ton/d (43 wet tons) operation: 1. A 6-in. layer of unscreened compost for base. 2. A 94-ft loop of 4-in. dia. perforated plastic pipe is placed on top (hole dia. 0.25 in.). 3. Pipe is covered with 6-in. layer of unscreened compost or wood chips. 4. Loop is connected to a 1/3 hp blower by 14ft of solid pipe fitted with water trap to collect condensate. 5. Timer is set for cycle of 4 minutes on and 16 minutes off. 6. Blower is connected to conical scrubber pile (2 yd3 wood chips covered with 10 yd3 screened compost) by 16 ft of solid pipe. 7. Sludge (wet) -wood chip mixture in a volumetric ratio of 1:2.5 is placed on prepared base. 8. A 12-in. layer of screened compost is placed on top for insulation. Air Flow: 100 ft3/h/ton of sludge; land area requirement for 10 dry tons processed daily: 3.5 acres, including runoff collection pond, bituminous surface for roads, mixing, composting, drying, storage, and administration area. Pile dimension: 53 ft x 12 ft x 8ft high. Population equivalent, 100,000.

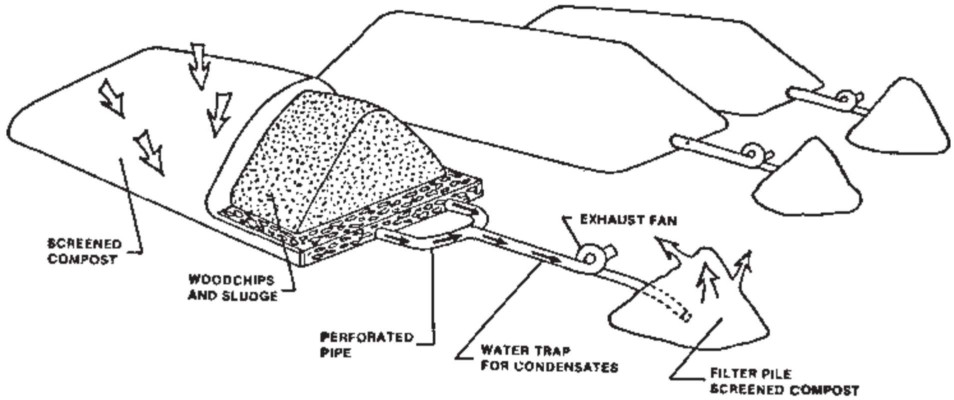
Process Reliability- High degree of process reliability through simplicity of operation. Thoroughness (percent stabilization) is a function of recycle scheme, porosity distribution in pile, and manifold design.

Taxies Management- Heavy metals entering the process remain in the final product. The degree of removal of organic toxic substances is not defined.

From EPA Publication 625/10-89/006, *Environmental Regulations and Technology – Control of Pathogens in Municipal Wastewater Sludge*, September 1989

Composting Sludge, Static Pile | Fact Sheet

FLOW DIAGRAM



Composting Sludge, Windrow **Fact Sheet**

Description - Composting is the microbial degradation of sludge and other putrescible organic solid material by aerobic metabolism in piles or windrows on a surfaced outdoor area. The piles are turned periodically to provide oxygen tor the microorganisms to carry out the stabilization and to carry ott the excess heat that is generated by the process. When masses of solids are assembled, and conditions of moisture, aeration and nutrition are favorable tor microbial activity and growth, the temperature rises spontaneously. As a result of biological self-heating, composting masses easily reach 60°C (140°F) and commonly exceed 70°C (150°F). Peak composting temperatures approaching gooc (194°F) have been recorded. Temperatures of 140° to 160°F serve to kill pathogens, insect larvae and weed seeds. Nuisances such as odors, insect breeding and vermin harborage are controlled through rapid destruction of putrescible materials. Sequential steps involved in composting are preparation, composting, curing and finishing.

Preparation- To be compostable, a waste must have at least a minimally porous structure and a moisture content of 45 to 65 percent. Therefore, sludge cake, which is usually about 20 percent solids, cannot be composted by itself but must be combined with a bulking agent, such as soil, sawdust, wood chips, refuse, or previously manufactured compost. Sludge and refuse make an ideal process combination. Refuse brings porosity to the mix, while sludge provides needed moisture and nitrogen, and both are converted synergistically to an end product amenable to resource recovery. The sludge is suitably prepared and placed in piles or windrows.

Composting - The composting period is characterized by rapid decomposition. Air is supplied by periodic turnings. The reaction is exothermic, and wastes reach temperatures of 140°F to 160°F or higher. Pathogen kill and the inactivation of insect larvae and weed seeds are possible at these temperatures. The period of digestion is normally about six weeks.

Curing- This is characterized by a slowing of the decomposition rate. The temperature drops back to ambient, and the process is brought to completion. The period takes about two more windrow weeks.

Finishing - It municipal solid waste fractions containing non-digestible debris have been included, or if the bulking agent such as wood chips is to be separated and recycled, some sort of screening or other removal procedure is necessary. The compost may be pulverized with a shredder, it desired.

Common Modifications- Composting by the static pile method is discussed in Fact Sheet 6.2.3. Composting within a vessel is an emerging technology.

Technology Status- Successfully demonstrated.

Applications - A sludge treatment method that successfully kills pathogens, larvae and weed seeds. Is suitable for converting undigested primary and/or secondary sludge to an end product amenable to resource recovery with a minimum capital investment and relatively small operating commitment.

Limitations - A small porous windrow may permit such rapid air movement that temperatures remain too low for effective composting. The outside of the pile may not reach temperatures sufficiently high for pathogen destruction. Pathogens may survive and regrow. Sale of product may be difficult.

Performance - Sludge is converted to a relatively stable organic residue, reduced in volume by 20 to 50 percent. The residue loses its original identity with respect to appearance, odor and structure. The end product is humitied, has earthy characteristics; pathogens, weed seeds and insect larvae are destroyed.

Chemical Requirements - None

Residuals Generated - None

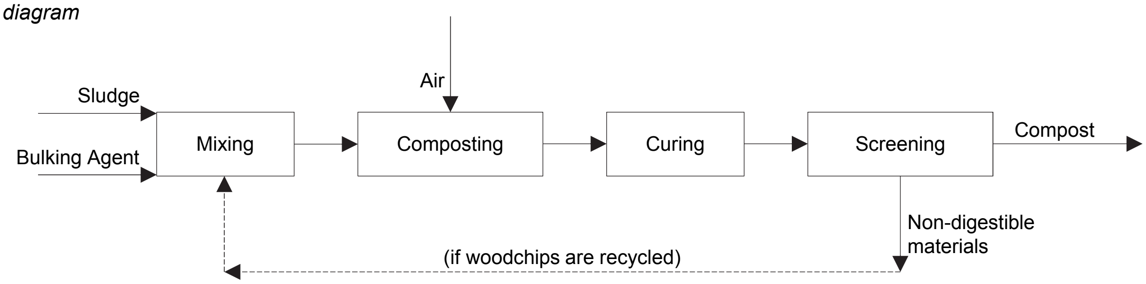
Design Criteria -Approximate land requirement: 1/3 acre/dry ton sludge daily production, which is roughly equivalent to a population of 10,000 with primary and secondary treatment. Windrows can be 4 to 8 tt high, 12 to 25 ft wide at the base, and variable length. Sludge cannot be composted by itself but must be combined with a bulking agent to provide the biomass with the necessary porosity and moisture content. Biomass criteria: moisture content, 45 to 65 percent; C/N ratio between 30 to 35:1; C/P, 75 to 150:1; air flow 10 to 30 ft3 air/d/lb VS. Detention time, six weeks to 1 year.

Process Reliability- Highly reliable. Ambient temperatures and moderate rainfall do not affect the process.

From EPA Publication 625/10-89/006, *Environmental Regulations and Technology – Control of Pathogens in Municipal Wastewater Sludge*, September 1989

Composting Sludge, Windrow **Fact Sheet**

Flow diagram



Digestion, Aerobic **Fact Sheet**

Description - Aerobic digestion is a method of sludge stabilization in an open tank that can be regarded as a modification of the activated sludge process. Microbiological activity beyond cell synthesis is stimulated by aeration, oxidizing both the biodegradable organic matter and some cellular material into CO_2, H_2O and NO_3. The oxidation of cellular matter is called endogenous respiration and is normally the predominant reaction occurring in aerobic digestion. Stabilization is not complete until there has been an extended period of primarily endogenous respiration (typically 15 to 20 days). Major objectives of aerobic digestion include odor reduction, reduction of biodegradable solids and improved sludge dewaterability. Aerobic bacteria stabilize the sludge more rapidly than anaerobic bacteria, although a less complete breakdown of cells is usually achieved. Oxygen can be supplied by surface aerators or by diffusers. Other equipment may include sludge recirculation pumps and piping, mixers and scum collection baffles. Aerobic digesters are designed similarly to rectangular aeration tanks and use conventional aeration systems, or employ circular tanks and use an eductor tube for deep tank aeration.

Common Modifications- Both one- and two-tank systems are used. Small plants often use a one-tank batch system with a complete mix cycle followed by settling and decanting (to help thicken the sludge). Larger plants may consider a separate sedimentation tank to allow continuous flow and facilitate decanting and thickening. Air may be replaced with oxygen (see Fact Sheet 6.4.3).

Technology Status- Primarily used in small plants and rural plants, especially where extended aeration or contact stabilization are practiced.

Applications -Suitable for waste primary sludge, waste biological sludges (activated sludge or trickling filter sludge) or a combination of any of these. Advantages of aerobic digestion over anaerobic digestion include simplicity of operation, lower capital cost, lower BOD concentrations in supernatant liquid, recovery of more of the fertilizer value of sludge, fewer effects from interfering substances (such as heavy metals), and no danger of methane explosions. The process also reduces grease content and reduces the level of pathogenic organisms, reduces the volume of the sludge and sometimes produces a more easily dewatered sludge (although it may have poor characteristics for vacuum filters). Volatile solids reduction is generally not as good as anaerobic digestion.

Limitations- High operating costs (primarily to supply oxygen) make the process less competitive at large plants. The required stabilization time is highly temperature sensitive, and aerobic stabilization may require excessive periods in cold areas or will require sludge heating, further increasing its cost. No useful by-products, such as methane, are produced. The process efficiency also varies according to sludge age, and sludge characteristics, and pilot work should be conducted prior to design. Improvement in dewaterability frequently does not occur.

Performance -

	Influent	*Effluent*	*Reduction*
Total solids	2-7%	3-12%	
Volatile solids	50 - 80% of above		30-70% (typical 35- 45%)
Pathogens			Up to 85%

Physical, Chemical, and Biological Aids- pH adjustment may be necessary. Depending on the buffering capacity of the system, the pH may drop below 6 at long detention times, and although this may not inhibit the process over long periods, alkaline additions may be made to raise the pH to neutral.

Residuals Generated- Supernatant Typical Quality: SS 100 to 12,000 mg/1, BODs 50 to 1,700 mg/1, soluble BODs 4 to 200 mg/1, COD 200 to 8,000 mg/1, Kjeldahl N 10 to 400 mg/1, Total P 20 to 250 mg/1, Soluble P 2 to 60 mg/1, pH 5.5 to 7.7. Digested sludge.

Design Criteria- Solids retention time (SRT) reqwired for 40% VSS reduction: 18 to 20 days at 20°C for mixed sludges from AS or TF plant, 10 to 16 days for waste activated sludge only, 16 to 18 days average for activated sludge from plants without primary settling; volume allowance: 3 to 4 ft3/capita: VSS loading: 0.02 to 0.4 lb/ft3/d; air requirements, 20 to 60 ft3/min/1000 ft3; minimum DO: 1 to 2 mg/1; energy for mechanical mixing: 0.75 to 1.25 hp/1,000 ft3; oxygen requirements: 2 lb/lb of cell tissue destroyed (includes nitrification demand), 1.6 to 1.9 lb/lb of BOD removed in primary sludge.

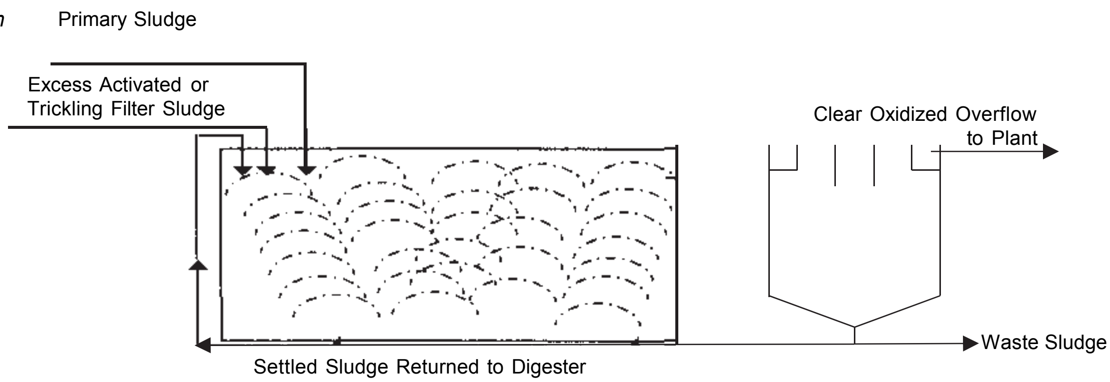
Reliability- Less sensitive to environmental factors than anaerobic digestion. Requires less laboratory control and daily maintenance. Relatively resistant to variations in loading, pH and metals interference. Lower temperatures require much longer detention times to achieve a fixed level of VSS reduction. However, performance loss does not necessarily cause an odorous product. Maintenance of the DO at 1 to 2 mg/1 with adequate detention results in a sludge that is often easier to dewater (except on vacuum filters).

From EPA Publication 625/10-89/006, *Environmental Regulations and Technology – Control of Pathogens in Municipal Wastewater Sludge*, September 1989

Digestion, Aerobic

Fact Sheet

Flow diagram



Digestion, Two-Stage Anaerobic **Fact Sheet**

Description- A two vessel system of sludge stabilization, where the first tank is used for digestion and is equipped with one or more of the following: heater, sludge recirculation pumps, methane gas recirculation, mixers and scum breaking mechanisms. The second tank is used for storage and concentration of digested sludge and for formation of a supernatant. Anaerobic digestion results in the breakdown of the sludge into methane, carbon dioxide, unusable intermediate organics and a relatively small amount of cellular protoplasm, This process consists of two distinct simultaneous stages of conversion of organic material by acid forming bacteria and gasification of the organic acids by methane forming bacteria. The methane producing bacteria are very sensitive to conditions of their environment and require careful control of tamperature, pH, excess concentrations of soluble salts, metal cations, oxidizing compounds and volatile acids. They also show an extreme substrate specificity. Can operate at various loading rates and is therefore not always clearly defined as either standard or high rate. Digester requires periodic cleanout (from 1 to 2 years) due to buildup of sand and gravel on digester bottom.

Technology Status- Widespread use (60 to 70 percent) for primary or primary and secondary sludge in plants having a capacity of 1 Mgal/d or more.

Applications- Suitable for primary sludge or combinations of primary ludge and limited amounts of secondary sludges. Digested sludge is reduced in volume and pathogenic organism content, is less odorous and easily dewatered, and is suitable for ultimate disposal. Advantages over single stage digestion include increased gas production, a clearer supernatant liquor, necessity for heating a smaller primary tank thus economizing in heat, and more complete digestion. Process also lends itself to modification changes, such as to high-rate digestion.

Limitations - Is relatively expensive, about twice the capital cost of single-stage digestion. It is the most sensitive operation in the POTW and is subject to upsets by interfering substances, e.g., excessive quantities of heavy metals, sulfides, chlorinated hydrocarbons. The addition of activated and advanced waste treatment sludges can cause high operating costs and poor plant efficiencies. The additional solids do not readily settle after digestion. Digester requires periodic cleanout due to buildup of sand and gravel on digester bottom.

Performance -

	Influent	*Effluent*	*Reduction*
Total solids	2-7%	2.5-12%	33-58%
Volatile solids			35-50%
Pathogens			85- <
Odor Reduction			100%

Sidestream - Gas Production

Quantity - 8 to 12 ft3/lb volatile solids added, or 12 to 18 ft3/lb volatile solids destroyed or 0.6 to 1.25 ft3/cap, or 11 to 12 ft3/lb total solids digested.

Quality- 65 to 70% methane N_2, H_2, H_2S, NH_3, e.t al.,- trace 25 to 30% CO_2 550 to 600 Btu/ft3

Physical, Chemical, and Biological Aids -Heat; maintain pH with lime, also ammonia, soda ash, bicarbonate of soda, and lye are used; addition of powder activated carbon may improve stability of overstressed digesters; precipitate heavy metals with ferrous or ferric sulfate; control odors with hydrogen peroxide.

Residuals Generated- Supernatant- Quality: SS 200 to 15,000 mg/1, BOD_5 500 to 10,000 mg/1, COD 1,000 to 30,000 mg/1, TKN 300 to 1,000 mg/1, Total P 50 to 1,000 mg/1, scum, sludge, gas.

Design Criteria - Solids retention time (SRT) required at various temperatures (22).

	Mesophilic Range				
Temperature, °F	50	67	75	85	95
SRT, days	55	40	30	25	20

Volume Criteria, (ft3/capita): Primary sludge 1.3-3, Primary and Trickling Filter Sludges 2.6-5, Primary and Waste Activated Sludges 2.6-6. Tank Size (ft): diameter, 20-115; depth 25-45; bottom slope 1 vertical/4 horizontal. Solids Loading (lb vss/ft3/d): 0.04-0.40. Volumetric Loading (ft3/cap/d): 0.038-0.1. Wet Sludge Loading (lb/cap/d): 0.12-0.19. pH 6.7-7.6.

Overall Reliability- Successful operation subject to a variety of physical, chemical and biological phenomena, e.g., pH, alkalinity, temperature, concentrations of toxic substances of digester contents. Sludge digester biomass is relatively intolerant to changing environmental conditions. Under one set of conditions particular concentrations of a substance can cause upsets, while under another set of conditions higher concentrations of the same substance are harmless. Requires careful monitoring of pH, gas production, and volatile acids.

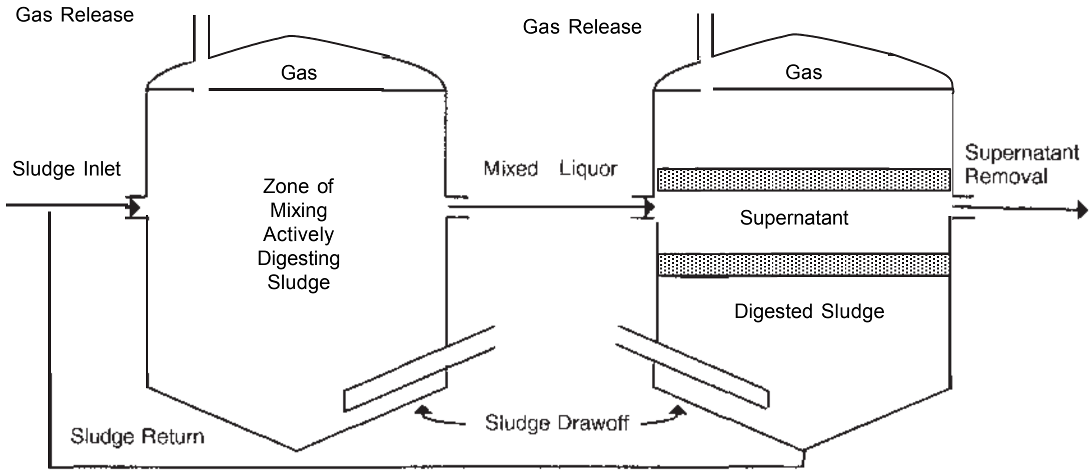
Miscellaneous Information - Digester gas can be used for on-site generation of electricity and/or for any in-plant purpose requiring fuel. Can also be used off-site in a natural gas supply system. Off-site use usually requires treatment to remove impurities such as hydrogen sulfide and moisture. Removal of CO_2 further increases the heat value of the gas. Utilization is more successful when a gas holder is provided.

From EPA Publication 625/10-89/006, *Environmental Regulations and Technology – Control of Pathogens in Municipal Wastewater Sludge*, September 1989

Digestion, Two Stage Anaerobic

Fact Sheet

Flow diagram



Appendix D
Guidance on Three Vector Attraction Reduction Tests

This appendix provides guidance for the vector attraction reduction Options 2,3, and 4 to demonstrate reduced vector attraction (see Chapter 8 for a description of these requirements).

1. Additional Digestion Test for Anaerobically Digested Sewage Sludge

Background

The additional digestion test for anaerobically digested sewage sludge is based on research by Jeris et al. (1985). Farrell and Bhide (1993) explain in more detail the origin of the time and volatile solids reduction requirements of the test.

Jeris et al. (1985) measured changes in many parameters including volatile solids content while carrying out additional digestion of anaerobically digested sludge from several treatment works for long periods. Samples were removed from the digesters weekly for analysis. Because substantial amount of sample was needed for all of these tests, they used continuously mixed digesters of 18 liters capacity. The equipment and procedures of Jeris et al., although not complex, appear to be more elaborate than needed for a control test. EPA staff (Farrell and Bhide, 1993) have experimented with simplified tests and the procedure recommended is based on their work.

Recommended Procedure

The essentials of the test are as follows:

- Remove, from the plant-scale digester, a representative sample of the sewage sludge to be evaluated to determine additional volatile solids destruction. Keep the sample protected from oxygen and maintain it at the temperature of the digester. Commence the test within 6 hours after taking the sample.

- Flush fifteen 100-mL volumetric flasks with nitrogen, and add approximately 50 mL of the sludge to be tested into each flask. Frequently mix the test sludge during this operation to assure that its composition remains uniform. Select five flasks at random, and determine total solids content and volatile solids content, using the entire 50 mL for the determination. Seal each of the remaining flasks with a stopper with a single glass tube through it to allow generated gases to escape.

- Connect the glass tubing from each flask through a flexible connection to a manifold. To allow generated gases to escape and prevent entry of air, connect the manifold to a watersealed bubbler by means of a vertical glass tube. The tube should be at least 30-cm long with enough water in the bubbler so that an increase in atmospheric pressure will not cause backflow of air or water into the manifold. Maintain the flasks containing the sludge at constant temperature either by inserting them in a water bath (the sludge level in the flasks must be below the water level in the bath) or by placing the entire apparatus in a constant temperature room or box. The temperature of the additional digestion test should be the average temperature of the plant digester, which should be in the range of 30°C to 40°C (86°F to 104°F). Temperature should be controlled within + 0.15°C (0.27°F).

- Each flask should be swirled every day to assure adequate mixing, using care not to displace sludge up into the neck of the flask. Observe the water seal for the first few days of operation. There should be evidence that gas is being produced and passing through the bubbler.

- After 20 days, withdraw five flasks at random. Determine total and volatile solids content using the entire sample for the determination. Swirl the flask vigorously before pouring out its contents to minimize the hold up of thickened sludge on the walls and to assure that any material left adhering to the flask walls will have the same average composition as the material withdrawn. Use a consistent procedure. If holdup on walls appears excessive, a minimal amount of distilled water may be used to wash solids off the walls. Total removal is not necessary, but any solids left on the walls should be approximately of the same composition as the material removed.

- After 40 days, remove the remaining five flasks. Determine total and volatile solids content using the entire sample from each flask for the determination. Use the same precautions as in the preceding step to remove virtually all of the sludge, leaving only material with the same approximate composition as the material removed.

Total and volatile solids contents are determined using the procedures of Method 2540 G of Standard Methods (APHA, 1992).

Mean values and standard deviations of the total solids content, the volatile solids content, and the percent volatile solids are calculated. Volatile solids reductions that result from the additional digestion periods of 20 and 40 days are calculated from the mean values by the Van Kleeck equation and by a material balance (refer to Appendix C for a general description of these calculations). The results obtained at 20 days give an early indication that the test is proceeding satisfactorily and will help substantiate the 40-day result.

Alternative approaches are possible. The treatment works may already have versatile bench-scale digesters available. This equipment could be used for the test, provided accuracy and reproducibility can be demonstrated. The approach described above was developed because Farrell and Bhide (1993) in their preliminary work experienced much difficulty in withdrawing representative samples from large digesters even when care was taken to stir the digesters thoroughly before sampling. If an alternative experimental setup is used, it is still advisable to carry out multiple tests for the volatile solids content in order to reduce the standard error of this measurement, because error in the volatile solids content measurement is inflated by the nature of the equation used to calculate the volatile solids reduction.

Variability in flow rates and nature of the sludge will result in variability in performance of the plant-scale digesters. It is advisable to run the additional digestion test routinely so that sufficient data are available to indicate average performance. The arithmetic mean of successive tests (a minimum of three is suggested) should show an additional volatile solids reduction of $\leq$ 17%.

Calculation Details

Appendix C, Determination of Volatile Solids Reduction by Digestion, describes calculation methods to use for digesters that are continuously fed or are fed at least once a day. Although the additional anaerobic digestion test is a batch digestion, the material balance calculations approach is the same. Masses of starting streams (input streams) are set equal to masses of ending streams (output streams).

The test requires that the fixed volatile solids reduction (FVSR) be calculated both by the Van Kleeck equation and the material balance method. The Van Kleeck equation calculations can be made in the manner described in Appendix C.

The calculation of the volatile solids reduction (and the fixed fractional solids reduction [FFSR]) by the mass balance method shown below has been refined by subtracting out the mass of gas lost from the mass of sludge at the end of the digestion step. For continuous digestion, this loss of mass usually is ignored, because the amount is small in relation to the total digesting mass, and mass before and after digestion are assumed to be the same. Considering the inherent difficulty in matching mass and composition entering to mass and composition leaving for a continuous process, this is a reasonable procedure. For batch digestion, the excellent correspondence between starting material and final digested sludge provides much greater accuracy in the mass balance calculation, so inclusion of this lost mass is worthwhile.

In the equations presented below, concentrations of fixed and volatile solids are mass fractions--mass of solids per unit mass of sludge (mass of sludge includes both the solids and the water in the sludge)-- and are indicated by, the symbols lowercase y and x. This is different from the usage in Appendix C where concentrations are given in mass per unit volume, and are indicated by the symbols uppercase y and x. This change has been made because masses can be determined more accurately than volumes in small-scale tests.

In the material balance calculation, it is assumed that as the sludge digests, volatile solids and fixed solids are converted to gases that escape or to volatile compounds that distill off when the sludge is dried. Any production or consumption of water by the biochemical reactions in digestion is assumed to be negligible. The data collected (volatile solids and fixed solids concentrations of feed and digested sludge) allow mass balances to be drawn on volatile solids, fixed solids, and water. As noted, it is assumed that there is no change in water mass -- all water in the feed is present in the digested sludge. Fractional reductions in volatile solids and fixed solids can be calculated from these mass balances for the period of digestion. Details of the calculation of these relationships are given by Farrell and Bhide (1993). The final form of the equations for fractional volatile solids reduction (mass balance [m.b.] method) and fractional fixed solids reduction (m.b. method) are given below:

$$\text{FVSR(m.b.)} = \frac{y_f(1-x_b)-y_b(1-x_f)}{y_f(1-x_b-y_b)} \quad (1a)$$

$$\text{FFSR(m.b.)} = \frac{x_f(1-y_b)-x_b(1-y_f)}{x_f(1-x_b-y_b)} \quad (1b)$$

where:

y = mass fraction of volatile solids in the liquid sludge
x = mass fraction of fixed solids in the liquid sludge
f = indicates feed sludge at start of the test
b = indicates "bottoms" sludge at end of the test

If the fixed solids loss is zero, these two equations are reduced to Equation 2 below:

$$\text{FVSR(m.b.)} = (y_f - y_b)/y_f\,(1-y_b) \quad (2)$$

If the fixed solids loss is not zero but is substantially smaller than the volatile solids reduction, Equation 2 gives surprisingly accurate results. For five sludges batch-digested by Farrell and Bhide (1993), the fixed solids reductions were about one-third of the volatile solids reductions. When the FVSR(m.b.) calculated by Equation 1a averaged 15%, the FVSR(m.b.) calculated by Equation 2 averaged 14.93%, which is a trivial difference.

The disappearance of fixed solids unfortunately has a relatively large effect on the calculation of FVSR by the Van Kleeck equation. The result is lower than it should be. For five sludges that were batch-digested by Farrell and Bhide (1993), the FVSR calculated by the Van Kleeck method averaged 15%, whereas the FVSR (m.b.) calculated by Equation 1a or 2 averaged about 20%. When the desired endpoint is an FVSR below 17%, this is a substantial discrepancy.

The additional digestion test was developed for use with the Van Kleeck equation, and the 17% requirement is based on results calculated with this equation. In the future, use of the more accurate mass balance equation may be required, with the requirement adjusted upward by an appropriate amount. This cannot be done until more data with different sludge become available.

2. Specific Oxygen Uptake Rate

Background

The specific oxygen uptake rate of a sewage sludge is an accepted method for indicating the biological activity of an activated sewage sludge mixed liquor or an aerobically digesting sludge. The procedure required by the Part 503 regulation for this test is presented in Standard Methods (APHA, 1992) as Method 2710 B, Oxygen-Consumption Rate.

The use of the specific oxygen uptake rate (SOUR) has been recommended by Eikum and Paulsrud (1977) as a reliable method for indicating sludge stability provided temperature effects are taken into consideration. For primary sewage sludges aerobically digested at 18°C (64°F), sludge was adequately stabilized (i.e., it did not putrefy and cause offensive odors) when the SOUR was less than 1.2 mg O_2/hr/g VSS (volatile suspended solids). The authors investigated several alternative methods for indicating stability of aerobically digested sludges and recommended the SOUR test as the one with the most advantages and the least disadvantages.

Ahlberg and Boyko (1972) also recommend the SOUR as an index of stability. They found that, for aerobic digesters operated at temperatures above 10°C (50°F), SOUR fell to about 2.0 mg O_2/hr/gVSS after a total sludge age of 60 days and to 1.0 mg O_2/hr/g VSS after about 120 days sludge age. These authors state that a SOUR of less than 1.0 mg O_2/hr/g VSS at temperatures above 10°C (50°F) indicates a stable sludge.

The results obtained by these authors indicate that long digestion times--more than double the residence time for most aerobic digesters in use today--are needed to eliminate odor generation from aerobically digested sludges. Since the industry is not being deluged with complaints about odor from aerobic digesters, it appears that a higher SOUR standard can be chosen than they suggest without causing problems from odor (and vector attraction).

The results of long-term batch aerobic digestion tests by Jeris et al. (1985) provide information that is helpful in setting a SOUR requirement that is reasonably attainable and still protective. Farrell and Bhide (1993) reviewed the data these authors obtained with four sewage sludges from aerobic treatment processes and concluded that a standard of 1.5 mg O_2/hr/g TS at 20°C (68°F) would discriminate between adequately stabilized and poorly stabilized sludges. The "adequately digested" sludges were not totally trouble-free, i.e., it was possible under adverse conditions to develop odorous conditions. In all cases where the sludge was deemed to be adequate, minor adjustment in plant operating conditions created an acceptable sludge.

The SOUR requirement is based on total solids rather than volatile suspended solids. This usage is preferred for consistency with the rest of the Part 503 regulation where all loadings are expressed on a total solids basis. The use of total solids concentration in the SOUR calculation is rational since the entire sludge solids and not just the volatile solids degrade and may exert some oxygen demand. Making an adjustment for the difference caused by basing the requirement on TS instead of VSS, the standard is about 1.8 times higher than Eikum and Paulsrud's recommended value and 2.1 times higher than Ahlberg and Boykos' recommendation.

Unlike anaerobic digestion, which is typically conducted at 35°C (95°F), aerobic digestion is carried out without any deliberate temperature control. The temperature of the digesting sludge will be close to ambient temperature, which can range from 5°C to 30°C (41°F to 86°F). In this temperature range, SOUR increases with increasing temperature. Consequently, if a requirement for SOUR is selected, there must be some way to convert SOUR test results to a standard temperature. Conceivably, the problem could be avoided if the sludge were simply heated or cooled to the standard temperature before running the SOUR test. Unfortunately, this is not possible, because temperature changes in digested sludge cause short-term instabilities in oxygen uptake rate (Benedict and Carlson [1973], Farrell and Bhide [1993]).

Eikum and Paulsrud (1977) recommend that the following equation be used to adjust the SOUR determined at one temperature to the SOUR for another temperature:

$$(SOUR)_{T1} / (SOUR)_{T2} = \theta^{(T1-T2)} \quad (3)$$

where:

$(SOUR)_{T1}$ = specific oxygen uptake rate at T_1
$(SOUR)_{T2}$ = specific oxygen uptake rate at T_2
θ = the Streeter-Phelps temperature sensitivity coefficient

These authors calculated the temperature sensitivity coefficient using their data on the effect of temperature on the rate of reduction in volatile suspended solids with time during aerobic digestion. This is an approximate approach, because there is no certainty that there is a one-to-one relationship between oxygen uptake rate and rate of volatile solids disappearance. Another problem is that the coeffficient depends on the makeup of each individual sludge. For example, Koers and Mavinic (1977) found the value of θ to be less than 1.072 at temperatures above 15°C (59°F) for aerobic digestion of waste activated sludges, whereas Eikum and Paulsrud (1977) determined θ to equal 1.112 for primary sludges. Grady and Lim (1980) reviewed the data of several investigators and recommended that θ = 1.05 be used for digestion of waste-activated sludges when more specific information is not available. Based on a review of the available information and their own work, Farrell and Bhide (1993) recommend that Eikum and Paulsruds' temperature correction procedure be utilized, using a temperature sensitivity coefficient in the range of 1.05 to 1.07.

Recommended Procedure for Temperature Correction

A SOUR of 1.5 mg O_2/hr/g total solids at 20°C (68°F) was selected to indicate that an aerobically digested sludge has been adequately reduced in vector attraction.

The SOUR of the sludge is to be measured at the temperature at which the aerobic digestion is occurring in the treatment works and corrected to 20°C (68°F) by the following equation:

$$SOUR_{20} = SOUR_T \times \theta^{(20-T)} \quad (4)$$

where
θ = 1.05 above 20°C (68°F)
1.07 below 20°C (68°F)

This correction may be applied only if the temperature of the sludge is between 10°C and 30°C (50°F and 86°F). The restriction to the indicated temperature range is required to limit the possible error in the SOUR caused by selecting an improper temperature coefficient. Farrell and Bhide's (1993) results indicate that the suggested values for θ will give a conservative value for SOUR when translated from the actual temperature to 20°C (68°F).

The experimental equipment and procedures for the SOUR test are those described in Part 2710 B, Oxygen Consumption Rate, of Standard Methods (APHA, 1992). The method allows the use of a probe with an oxygen-sensitive electrode or a respirometer. The method advises that manufacturer's directions be followed if a respirometer is used. No further reference to respirometric methods will be made here. A timing device is needed as well as a 300-mL biological oxygen demand (BOD) bottle. A magnetic mixer with stirring bar is also required.

The procedure of Standard Method 2710 B should be followed with one exception. The total solids concentration instead of the volatile suspended solids concentration is used in the calculation of the SOUR. Total solids concentration is determined by Standard Method 2540 G. Method 2710 B cautions that if the suspended solids content of the sludge is greater than 0.5%, additional stirring besides that provided by the stirring bar be considered. Experiments by Farrell and Bhide (1993) were carried out with sludges up to 2% in solids content without difficulty if the SOUR was lower than about 3.0 mg O_2/g/h. It is possible to verify that mixing is adequate by running repeat measurements at several stirrer bar speeds. If stirring is adequate, oxygen uptake will be independent of stirrer speed.

The inert mineral solids in the wastewater in which the sludge particles are suspended do not exert an oxygen demand and probably should not be part of the total solids in the SOUR determination. Ordinarily, they are such a small part of the total solids that they can be ignored. If the ratio of inert dissolved mineral solids in the treated wastewater to the total solids in the sludge being tested is greater than 0.15, a correction should be made to the total solids concentration. Inert dissolved mineral solids in the treated wastewater effluent is determined by the method of Part 2540 B of Standard Methods (APHA, 1992). This quantity is subtracted from the total solids of the sludge to determine the total solids to be used in the SOUR calculation.

The collection of the sample and the time between sample collection and measurement of the SOUR are important. The sample should be a composite of grab samples taken within a period of a few minutes duration. The sample should be transported to the laboratory expeditiously and kept under aeration if the SOUR test cannot be run immediately. The sludge should be kept at the temperature of the digester from which it was drawn and aerated thoroughly before it is poured into the BOD bottle for the test. If the temperature differs from 20°C (68°F) by more than ±10°C (±18°F), the temperature correction may be inappropriate and the result should not be used to prove that the sewage sludge meets the SOUR requirement.

Variability in flow rates and nature of the sludge will result in variability in performance of the plant-scale digesters. It is advisable to run the SOUR test routinely so that sufficient data are available to indicate average performance. The arithmetic mean of successive tests-a minimum of seven over 2 or 3 weeks is suggested-should give a SOUR of ≤ 1.5 mg O_2/hr/g total solids.

3. Additional Digestion Test for Aerobically Digested Sewage Sludge

Background

Part 503 lists several options that can be used to demonstrate reduction of vector attraction in sewage sludge. These options include reduction of volatile solids by 38% and demonstration of the SOUR value discussed above (see also Chapter 8). These options are feasible for many, but not all, digested sludges. For example, sludges from extended aeration treatment works that are aerobically digested usually cannot meet this requirement because they already are partially reduced in volatile solids content by their exposure to long aeration times in the wastewater treatment process.

The specific oxygen uptake test can be utilized to evaluate aerobic sludges that do not meet the 38% volatile solids reduction requirement. Unfortunately, this test has a number of limitations. It cannot be applied if the sludges have been digested at temperatures lower than 10°C (50°F) or higher than 30°C (86°F). It has not been evaluated under all possible conditions of use, such as for sludges of more than 2% solids.

A straightforward approach for aerobically treated sludges that cannot meet either of the above criteria is to determine to what extent they can be digested further. If they show very little capacity for further digestion, they will have a low potential for additional biodegradation and odor generation that attracts vectors. Such a test necessarily takes many days to complete, because time must be provided to get measurable biodegradation. Under most circumstances, this is not a serious drawback. If a digester must be evaluated every 4 months to see if the sewage sludge meets vector attraction reduction requirements, it will be necessary to start a regular assessment program. A record can be produced showing compliance. The sludge currently being produced cannot be evaluated quickly but it will be possible to show compliance over a period of time.

The additional digestion test for aerobically digested sludges in Part 503 is based on research by Jeris et al. (1985), and has been discussed by Farrell et al. (EPA, 1992). Farrell and Bhide (1993) explain in more detail the origin of the time and volatile solids reduction requirements of the test.

Jeris et al. (1985) demonstrated that several parameters--volatile solids reduction, COD, BOD, and SOUR--declined smoothly and approached asymptotic values with time as sludge was aerobically digested. Any one of these parameters potentially could be used as an index of vector attraction reduction for aerobic sludges. SOUR has been adopted (see above) for this purpose. Farrell and Bhide (1993) have shown that the additional volatile solids reduction that occurs when sludge is batch digested aerobically for 30 days correlates equally as well as SOUR with the degree of vector attraction reduction of the sludge. They recommend that a sewage sludge be accepted as suitably reduced in vector attraction when it shows less than 15% additional volatile solids reduction after 30 days additional batch digestion at 20°C (68°F). For three out of four sludges investigated by Jeris et al. (1985), the relationship between SOUR and additional volatile solids reduction showed that the SOUR was approximately equal to 1.5 mg O_2/hr/g (the Part 503 requirement for SOUR) when additional volatile solids reduction was 15%. The two requirements thus agree well with one another.

Recommended Procedure

There is considerable flexibility in selecting the size of the digesters used for the additional aerobic digestion test. Farrell and Bhide (1993) used a 20-liter fish tank. A tank of rectangular cross-section is suggested because sidewalls are easily accessible and are easily scraped clean of adhering solids. The tank should have a loose-fitting cover that allows air to escape. It is preferable to vent exhaust gas to a hood to avoid exposure to aerosols. Oil and particle-free air is supplied to the bottom of the digester through porous stones at a rate sufficient to thoroughly mix the sewage sludge. This will supply adequate oxygen to the sludge, but the oxygen level in the digesting sludge should be checked with a dissolved oxygen meter to be sure that the supply of oxygen is adequate. Oxygen level should be at least 2 mg/L. Mechanical mixers also were used to keep down foam and improve mixing.

If the total solids content of the sewage sludge is greater than 2%, the sludge must be diluted to 2% solids with secondary effluent at the start of the test. The requirement stems from the results of Reynolds (1973) and Malina (1966) which demonstrate that rate of volatile solids reduction decreases as the feed solitis concentration increases. Thus, for example, a sludge with a 2% solids content that showed more than 15% volatile solids reduction when digested for 30 days might show a lower volatile solids reduction and would pass the test if it were at 4%. This dilution may cause a temporary change in rate of volatile solids reduction. However, the long duration of the test should provide adequate time for recovery and demonstration of the appropriate reduction in volatile solids content.

When sampling the sludge, care should be taken to keep the sludge aerobic and avoid unnecessary temperature shocks. The sludge is digested at 20°C (68°F) even if the digester was at some other temperature. It is expected that the bacterial population will suffer a temporary shock if there is a substantial temperature change, but the test is of sufficient duration to overcome this effect and show a normal volatile solids reduction. Even if the bacteria are shocked and do not recover completely, the test simulates what would happen to the sludge in the environment. If it passes the test, it is highly unlikely that the sludge will attract vectors when used or disposed to the environment. For example, if a sludge digested at 35°C (95°F) has not been adequately reduced in volatile solids and is shocked into biological inactivity for 30 days when its temperature is lowered to 20°C (68°F), it will be shocked in the same way if it is applied to the soil at ambient temperature. Consequently, it is unlikely to attract vectors.

The digester is charged with about 12 liters of the sewage sludge to be additionally digested, and aeration is commenced. The constant flow of air to the aerobic digestion test unit will cause a substantial loss of water from the digester. Water loss should be made up every day with distilled water.

Solids that adhere to the walls above and below the water line should be scraped off and dispersed back into the sludge daily. The temperature of the digesting sludge should be approximately 20°C (68°F). If the temperature of the laboratory is maintained at about 22°C (72°F), evaporation of water from the digester will cool the sludge to about 20°C (68°F).

Sewage sludge is sampled every week for five successive weeks. Before sampling, makeup water is added (this will generally require that air is temporarily shut off to allow the water level to be established), and sludge is scraped off the walls and redistributed into the digester. The sludge in the digester is thoroughly mixed with a paddle before sampling, making sure to mix the bottom sludge with the top. The sample is comprised of several grab samples collected with a ladle while the digester is being mixed. The entire sampling procedure is duplicated to collect a second sample.

Total and volatile solids contents of both samples are determined preferably by Standard Method 2540 G (APHA, 1992). Percent volatile solids is calculated from total and volatile solids content. Standard Methods (APHA, 1992) states that duplicates should agree within 5% of their average. If agreement is substantially poorer than this, the sampling and analysis should be repeated.

Calculation Details

Fraction volatile solids reduction is calculated by the Van Kleeck formula (see Appendix C) and by a mass balance method. The mass balance (m.b.) equations become very simple, because final mass of sludge is made very nearly equal to initial mass of sludge by adjusting the volume by adding water. These equations for fractional volatile solids reduction (FVSR) and fractional fixed solids reduction (FFSR) are:

$$FVSR(m.b.) = (y_f - y_b) / y_f \quad (5a)$$

$$FFSR(m.b.) = (x_f - x_b) / x_f \quad (5b)$$

where:

y and x = mass fraction of volatile and fixed solids, respectively (see previous section on "Calculation details" for explanation of "mass fraction")

f and b = subscripts indicating initial and final sludges

This calculation assumes that initial and final sludge densities are the same. Very little error is introduced by this assumption.

The calculation of the fractional fixed solids reduction is not a requirement of the test, but it will provide useful information.

The test was developed from information based on the reduction in volatile solids content calculated by the Van Kleeck equation. As noted in the section on the additional anaerobic digestion test, for batch processes the material balance procedure for calculating volatile solids reduction is superior to the Van Kleeck approach. It is expected that the volatile solids reduction by the mass balance method will show a higher volatile solids reduction than the calculation made by using the Van Kleeck equation.

4. References

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Calculation Worksheet for
Determining Annual Whole Sludge Application Rate (AWSAR)

Applicability:

For sewage sludge sold or given away in a bag or other container where the pollutant concentrations exceed those in Table 3 of §503.13 but do not exceed those in Table 1 of §503.13.

Procedure:

Step 1: Measure the concentration of the pollutants listed in column 1 for the sewage sludge. Record the concentration in column 3 according to milligrams of pollutant per kilogram of solids in the sludge.

Step 2: Perform the calculation as shown for each pollutant and record the annual whole sludge application rate in column 4.

Column 1	Column 2		Column 3		Column 4
Pollutant	**Annual pollutant loading rate, kg/ha/365 days**		**Pollutant concentration, mg/kg**		**Annual whole sludge application rate, tonnes/ha/365 days**
Arsenic	2.0	÷	______	X 1000 =	______
Cadmium	1.9	÷	______	X 1000 =	______
Chromium	150	÷	______	X 1000 =	______
Copper	75	÷	______	X 1000 =	______
Lead	15	÷	______	X 1000 =	______
Mercury	0.85	÷	______	X 1000 =	______
Molybdenum	0.90	÷	______	X 1000 =	______
Nickel	21	÷	______	X 1000 =	______
Selenium	5.0	÷	______	X 1000 =	______
Zinc	140	÷	______	X 1000 =	______

Step 3: Compare each of the annual whole sludge application rates in column 4 and choose the lowest recorded rate. Record the number in the space provided below.

The allowable AWSAR* is ____________________ metric tons per hectare per 365 days.

*Please note that any time the sludge quality changes, the annual whole sludge application rate must be reevaluated. To reduce the frequency that the label must be changed, the preparer may opt to base the AWSAR on the highest concentration recorded for each pollutant from historical data. However the preparer must continue to compare sludge concentrations data to the pollutant concentrations sed to develop the AWSAR.

Worksheet re-created from EPA publication 831B-93-002a, August 1993, Appendix A available at http://water.epa.gov/scitech/wastetech/biosolids/upload/guide.pdf

(k) The dispersion factor for the site where the sewage sludge incinerator is located.

(l) The control efficiency for lead, arsenic, cadmium, chromium, and nickel for each sewage sludge incinerator.

(m) The risk specific concentration for chromium calculated using equation (6), if applicable.

(n) A calibration and maintenance log for the instruments used to measure the total hydrocarbons concentration and oxygen concentration in the exit gas from the sewage sludge incinerator stack, the information needed to determine moisture content in the exit gas, and the combustion temperatures.

(Approved by the Office of Management and Budget under control number 2040–0157)

[58 FR 9387, Feb. 19, 1993, as amended at 64 FR 42573, Aug. 4, 1999]

§ 503.48 Reporting.

Class I sludge management facilities, POTWs (as defined in 40 CFR 501.2) with a design flow rate equal to or greater than one million gallons per day, and POTWs that serve a population of 10,000 people or greater shall submit the information in § 503.47(b) through § 503.47(h) to the permitting authority on February 19 of each year.

(Approved by the Office of Management and Budget under control number 2040–0157)

Appendix A to Part 503—Procedure To Determine the Annual Whole Sludge Application Rate for a Sewage Sludge

Section 503.13(a)(4)(ii) requires that the product of the concentration for each pollutant listed in Table 4 of § 503.13 in sewage sludge sold or given away in a bag or other container for application to the land and the annual whole sludge application rate (AWSAR) for the sewage sludge not cause the annual pollutant loading rate for the pollutant in Table 4 of § 503.13 to be exceeded. This appendix contains the procedure used to determine the AWSAR for a sewage sludge that does not cause the annual pollutant loading rates in Table 4 of § 503.13 to be exceeded.

The relationship between the annual pollutant loading rate (APLR) for a pollutant and the annual whole sludge application rate (AWSAR) for 1a sewage sludge is shown in equation (1).

$$APLR = C \times AWSAR \times 0.001 \qquad (1)$$

Where:

APLR=Annual pollutant loading rate in kilograms per hectare per 365 day period.

C=Pollutant concentration in milligrams, per kilogram of total solids (dry weight basis).

AWSAR=Annual whole sludge application rate in metric tons per hectare per 365 day period (dry weight basis).

0.001=A conversion factor.

To determine the AWSAR, equation (1) is rearranged into equation (2):

$$AWSAR = \frac{APLR}{C \times 0.001} \qquad (2)$$

The procedure used to determine the AWSAR for a sewage sludge is presented below.

PROCEDURE:

1. Analyze a sample of the sewage sludge to determine the concentration for each of the pollutants listed in Table 4 of § 503.13 in the sewage sludge.
2. Using the pollutant concentrations from Step 1 and the APLRs from Table 4 of § 503.13, calculate an AWSAR for each pollutant using equation (2) above.
3. The AWSAR for the sewage sludge is the lowest AWSAR calculated in Step 2.

Appendix B to Part 503—Pathogen Treatment Processes

A. Processes To Significantly Reduce Pathogens (PSRP)

1. Aerobic digestion—Sewage sludge is agitated with air or oxygen to maintain aerobic conditions for a specific mean cell residence time at a specific temperature. Values for the mean cell residence time and temperature shall be between 40 days at 20 degrees Celsius and 60 days at 15 degrees Celsius.

2. Air drying—Sewage sludge is dried on sand beds or on paved or unpaved basins. The sewage sludge dries for a minimum of three months. During two of the three months, the ambient average daily temperature is above zero degrees Celsius.

3. Anaerobic digestion—Sewage sludge is treated in the absence of air for a specific mean cell residence time at a specific temperature. Values for the mean cell residence time and temperature shall be between 15 days at 35 to 55 degrees Celsius and 60 days at 20 degrees Celsius.

4. Composting—Using either the within-vessel, static aerated pile, or windrow composting methods, the temperature of the sewage sludge is raised to 40 degrees Celsius or higher and remains at 40 degrees Celsius or higher for five days. For four hours during the five days, the temperature in the compost pile exceeds 55 degrees Celsius.

5. Lime stabilization—Sufficient lime is added to the sewage sludge to raise the pH of

Soil types and soil texture

There are two major types of soils: mineral (inorganic) and organic. Mineral soils are a mixture of weathered minerals and decayed plants and animals. There are four main components to consider when studying a mineral soil: mineral matter, organic matter, water, and air (figure 1). A loam soil in an ideal condition for plant growth consists of 45 percent soil mineral particles, 5 percent organic matter, 25 percent air, and and 25 percent water by volume. The amount of air and water in the soil can be extremely variable depending on the frequency and amount of precipitation. The combination of these four components helps determine a soil's potential as a building site.

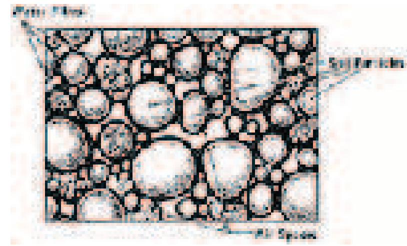


Fig. 1: Representation of the physical relationship between soil particles, water films, and air space in a soil. A silt loam soil in a condition ideal for plant growth consists of 45% soil mineral particles, 5% organic matter, 25% air, and 25% water volume.

The size range of individual mineral particles (sand, silt, clay) is expressed by soil texture. This size range or texture influences the amount of the other three components present at any one time in a specific volume of soil.

Organic soils consist mostly of decayed plant material (figure 2) and occur in swamps, bogs, and marshes. Such soils feel very light when dry. Well-decayed muck and peat are powdery when dry but partially decayed peat contains easily identified plant stems and leaves.

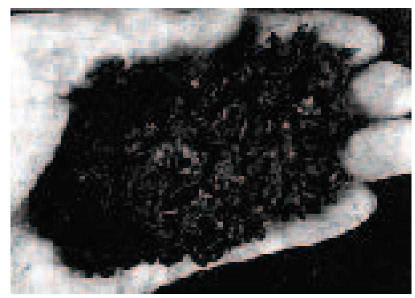


Fig. 2: Organic soil (peat).

Soil textural classes

Soil texture is determined by the quantities of various inorganic particle sizes present (sand, silt, clay). These particles are grouped according to size, called separates. There are several schemes for the classification of soil separates. The U.S. Department of Agriculture (USDA) system is used in the classification of soils for soil surveys. The textural classes discussed here are from this system.

Sands are coarse soil particles. Most sand particles can be seen without magnification. Sand particles feel rough when rubbed between the thumb and fingers.

Clay is the smallest of soil particles. It takes a strong microscope to show individual clay particles. When separate and dry, clay particles feel smooth and powdery. Dried chunks of clay are very hard and difficult to break. Wet clay is slick and sticky; it holds the molded form easily.

Silt particles are larger than clay but smaller than sand. A microscope is required to see individual silt particles. Dry silt particles feel smooth and floury. Wet silt feels smooth but not slick and sticky; it, too, holds the molded form.

Twelve soil textural classes are generally identified using the USDA system. However, an adequate evaluation of the soil texture can be made by being able-to distinguish in the field between six general textural classes.

Table 1. Soil textural classes

General texture classes	USDA texture classes
1. Sand	1. Sand, loamy sand
2. Sandy loam	2. Sandy loam
3. Loam	3. Loam
4. Silt loam	4. Silt loam, silt
5. Clay loam	5. Clay loam, sandy clay loam, silty clay loam
6. Clay	6. Sandy clay, silty clay, clay

Estimation of soil texture by the feel method

Knowledge of the soil texture at the surface is not a basis for conclusions about the soil texture for the entire soil depth. Usually the texture changes with the depth of the soil. Soil texture should be estimated for an intended use at the depth of the intended use. For example, if the basement foundations will be installed at an 8-foot depth that is where the texture should be estimated.

An experienced soil scientist or engineer can determine the texture of soil material quite accurately using both feel and sight. A good estimate of the textural class can be made using the following procedures.

First, moisten a marble-sized portion of the soil and hand knead it until it is the consistency of putty. Then, squeeze the ball of soil between thumb and forefinger, pressing the thumb forward over the forefinger to push the soil into a ribbon (figure 4). Whether or not a ribbon forms the type of ribbon indicates the textural class.

Clay-Fine-textured soil that usually forms very hard lumps or clods when dry and is quite plastic when wet. It can be very sticky when wet. When the moist soil is squeezed, it will form a long flexible ribbon. A clay soil leaves a "slick" surface when rubbed with a long

Fig. 4: Fine-textured soil forms a long, shiny pliable ribbon. The moist ribbon feels smooth and sticky. Dry clods are very hard.

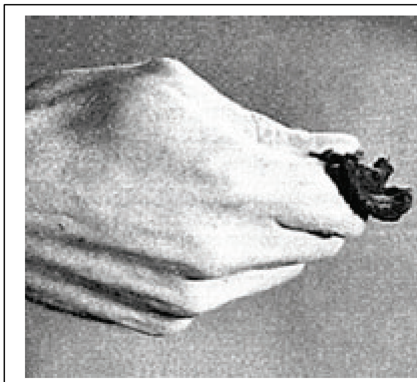


Fig. 5 Medium-textured soil does not form ribbons. Medium textured soil feels fairly smooth and floury. Dry clods are readily

stroke and firm pressure. Clay tends to hold the thumb and forefingers together, due to its stickiness (figure 4).

Clay Loam-Fine-textured soil which usually breaks into clods or lumps that are hard when dry. When moist soil is squeezed, it will form a thin ribbon which will break readily, barely sustaining its own weight. The moist soil is plastic and will form a cast which will bear more handling. When hand kneaded it does not crumble readily, but tends to become a heavy, compact mass.

Silt Loam-When dry, may appear quite freely cloddy, but lumps are readily broken; when pulverized, it feels soft and floury. When wet, the soil readily runs together. Either dry or moist, it will form casts which can be handled freely without breaking, but when moistened and squeezed, it will not ribbon but will have a broken effect (figure 5).

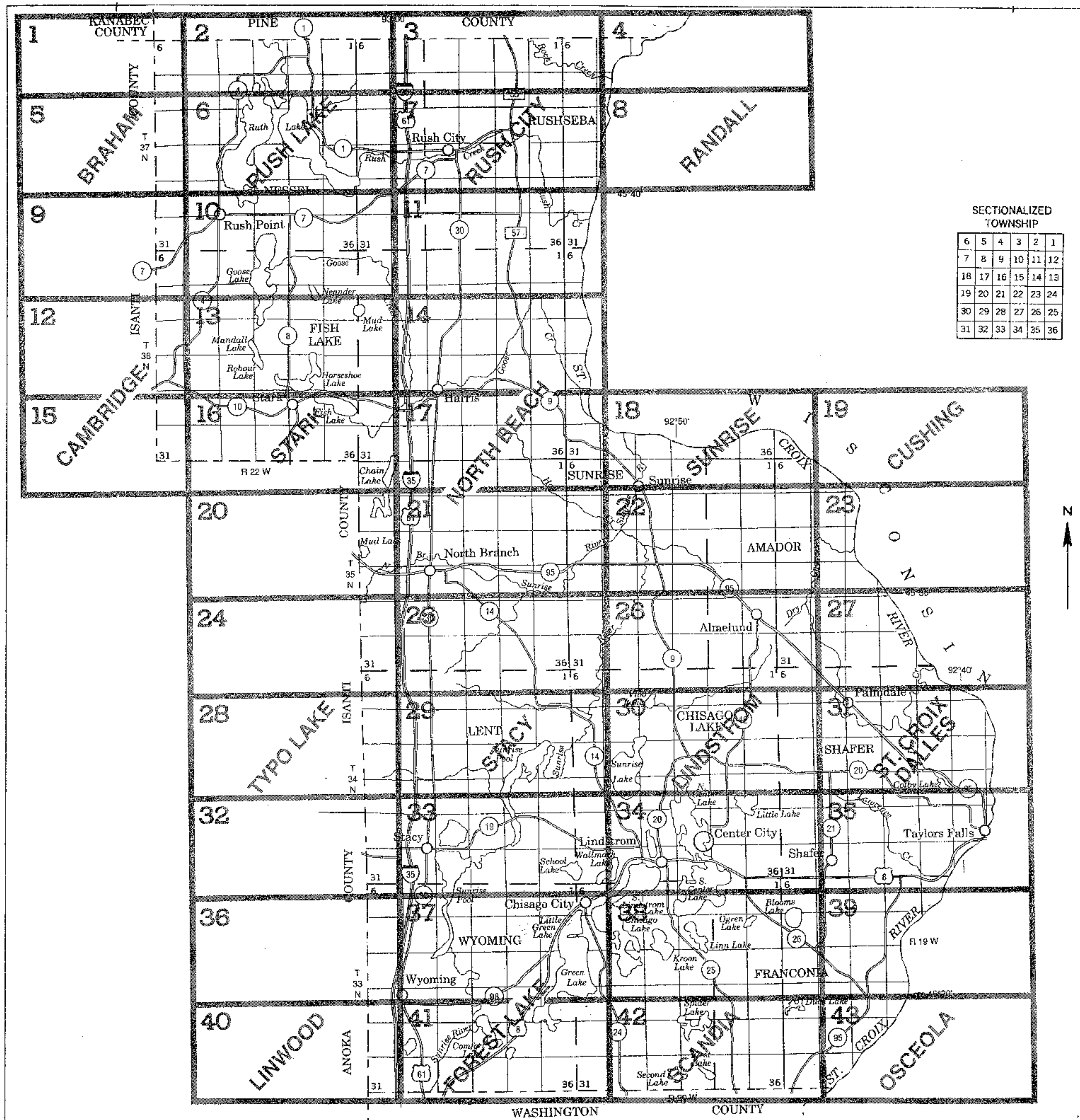
Loam-Has a relatively even mixture of sands, silt, and clay. A loam feels somewhat gritty, yet fairly smooth and highly plastic. Squeezed when moist, it will form a cast which can be handled quite freely without breaking and it will not form a ribbon (figure 6).

Sandy Loam-Contains much sand, but has enough silt and clay to make it somewhat sticky. Individual sand grains can be seen readily and felt. Squeezed when dry, it will form a cast which will fall apart and not form a ribbon, but if squeezed when moist, a cast can be formed which will bear careful handling without falling apart (figure 7).

Fig. 6: Cast formed when moist soil is squeezed in the palm of the hand.

Fig.7: Coarse-textured soil feels very gritty. It is not slick or smooth, formed casts of such soils fall apart when touched.

Information excerpted from University of Minnesota Extension website at http://www.extension.umn.edu/environment/housing-technology/moisture-management/evaluating-soil-texture-for-a-house-site/



SECTIONALIZED TOWNSHIP

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

INDEX TO MAP SHEETS

CHISAGO COUNTY, MINNESOTA

Scale 1:190,080

1 0 1 2 3 Mi

1 0 3 6 Km

SOIL LEGEND

Map symbols consist of numbers or a combination of numbers and a letter. The initial numbers represent the kind of soil. A capital letter following these numbers indicates the class of slope. Symbols without a slope letter are for nearly level soils or miscellaneous areas.

SYMBOL	NAME
40B	Nebish loam, 2 to 6 percent slopes
40C	Nebish loam, 6 to 12 percent slopes
40D	Nebish loam, 12 to 25 percent slopes
40F	Nebish loam, 25 to 40 percent slopes
75	Bluffton loam
119B	Pomroy loamy fine sand, 1 to 6 percent slopes
119C	Pomroy loamy fine sand, 6 to 12 percent slopes
155B	Chetek sandy loam, 1 to 6 percent slopes
155C	Chetek loam, 6 to 12 percent slopes
158B	Zimmerman loamy fine sand, 1 to 6 percent slopes
158C	Zimmerman loamy fine sand, 6 to 12 percent slopes
159B	Anoka loamy very fine sand, 1 to 6 percent slopes
159C	Anoka loamy fine sand, 6 to 12 percent slopes
161	Isanti loamy fine sand
162	Lino loamy fine sand
169B	Braham loamy fine sand, 2 to 6 percent slopes
169C	Braham loamy fine sand, 6 to 12 percent slopes
182	Halder sandy loam
204B	Cushing loam, 2 to 6 percent slopes
204C	Cushing loam, 6 to 12 percent slopes
204D	Cushing loam, 12 to 20 percent slopes
204F	Cushing loam, 20 to 35 percent slopes
207B	Nymore loamy sand, 1 to 6 percent slopes
207C	Nymore loamy sand, 6 to 12 percent slopes
207D	Nymore loamy sand, 12 to 18 percent slopes
207E	Nymore loamy sand, 18 to 25 percent slopes
265	Soderville loamy fine sand
274	Newson mucky loamy sand
292	Alstad loam
325	Prebish sandy loam
328B	Sartell fine sand, 1 to 6 percent slopes
328C	Sartell fine sand, 6 to 12 percent slopes
328D	Sartell fine sand, 12 to 25 percent slopes
337	Warman loam
346	Talmoon loam
454B	Mahtomedi loamy sand, 1 to 6 percent slopes
454C	Mahtomedi loamy sand, 6 to 12 percent slopes
454D	Mahtomedi loamy sand, 12 to 20 percent slopes
454F	Mahtomedi loamy sand, 20 to 35 percent slopes
540	Seelyeville muck
543	Markey muck
544	Cathro muck
545	Rondeau muck
565	Eckvoll loamy sand
676B	Kost loamy fine sand, 1 to 6 percent slopes
677	Siren silt loam
678	Beltrami loam, thick solum
682B	Milaca sandy loam, 2 to 6 percent slopes, very stony
682C	Milaca sandy loam, 6 to 12 percent slopes, very stony
682D	Milaca sandy loam, 12 to 18 percent slopes, very stony
682E	Milaca sandy loam, 18 to 25 percent slopes, very stony
717B	Novak silt loam, 0 to 6 percent slopes
722	Blomford loamy sand, lacustrine substratum
726	Kratka loamy fine sand, thick solum
792	Fordum sandy loam, frequently flooded
928B	Mahtomedi-Cushing complex, 2 to 6 percent slopes
928C	Mahtomedi-Cushing complex, 6 to 12 percent slopes
928D	Mahtomedi-Cushing complex, 12 to 20 percent slopes
1030	Udorthents-Pits, gravel, complex
1068	Caryville sandy loam, occasionally flooded
1069C	Fairport-Rock outcrop complex, 2 to 12 percent slopes
1070D	Plainbo-Rock outcrop complex, 12 to 40 percent slopes
1977	Mora loam, very stony
1980	Ronneby loam, extremely stony

CONVENTIONAL AND SPECIAL SYMBOLS LEGEND

CULTURAL FEATURES

BOUNDARIES

- National, state or province
- County or parish
- Reservation (national forest or park, state forest or park, and large airport)
- Field sheet matchline & neatline

AD HOC BOUNDARY (label)

- Small airport, airfield, park, oilfield, cemetery, or flood pool — Davis Airstrip; FLOOD POOL LINE

STATE COORDINATE TICK — 2 350 000 FEET

LAND DIVISION CORNERS (sections and land grants)

ROAD EMBLEMS & DESIGNATIONS

- Interstate — 35
- Federal — 8
- State — 95

DAMS

- Medium or small — water; w

PITS

- Gravel pit

WATER FEATURES

DRAINAGE

- Perennial, double line
- Perennial, single line
- Intermittent
- Drainage end
- Canals or ditches
- Drainage and/or irrigation

LAKES, PONDS AND RESERVOIRS

- Perennial — water; w

MISCELLANEOUS WATER FEATURES

- Marsh or swamp
- Spring
- Wet spot

SPECIAL SYMBOLS FOR SOIL SURVEY

SOIL DELINEATIONS AND SYMBOLS — 292; 204B

ESCARPMENTS

- Other than bedrock (points down slope)

SHORT STEEP SLOPE

MISCELLANEOUS

- Gravelly spot
- Rock outcrop (includes sandstone and shale)
- Sandy spot
- Stony spot
- Better drained rise in wet area

How to Sample: Farm/Commercial Horticultural Field

Soil tests can be no better than the sample. Therefore, proper collection of the soil sample is extremely important.

Divide the field into uniform areas

Each area should have the same soil color and texture, cropping history, and fertilizer, lime and manure treatments. One sample should not represent more than **20 acres** on level, uniform landscapes, or **5 acres** on hilly or rolling land.

Sample each area

Within each area collect 15-30 subsamples (cores, borings, or spade slices) in a zig-zag pattern throughout the designated field area. The more variable the soil, the more subsamples should be combined per area sampled. Scrape off all surface residue from the subsample site. Sample to a depth of 6-8 inches (plow layer) for cultivated crops, or 3 inches for pasture or sod fields. Sample row crop fields between rows, except for ridgetill plantings. Where RIDGETILL is used, take the sample to a depth of 6-8 inches on the **shoulder** of the ridge, avoiding the starter fertilizer band. Also avoid sampling dead or back furrows, terraces, old fence rows, lime or fertilizer spill areas, headlands, eroded knolls, low spots, or small saline areas. Sample at least 300 feet away from gravel or crushed limestone roads because their dust changes soil pH.

Mix the subsamples

Mix the subsamples thoroughly in a clean plastic pail, and fill the sample box or bag to the fill line (1 pint). If the samples must be taken wet, they should be dried before being mixed and submitted to the Laboratory. Do not exceed a drying temperature of 97F, and do not use a microwave unless only the nitrate test is requested.

Soil Sample Information Sheet Instructions

Crop History (1): This information is essential for us to provide the most accurate nitrogen recommendations. Indicate crops grown the past **two** most recent growing seasons. BE SURE TO USE THE CROP CODE NUMBER FROM THE LISTING ON THE SHEET. If alfalfa was the crop grown during either or both of the two previous growing seasons, it is important to indicate the number of plants (crowns) per square foot.

Proposed Crops and Yield Goals (2): You can select recommendations for up to **three crops** by entering the corresponding crop code number, **or three yield goals** for one crop. At least one option must be completed to receive a fertilizer recommendation, but there is no requirement to complete all options. If alfalfa is planned for the second crop year, list the crop code 01 under Option 2 or Option 3 with the desired yield in order to get a lime recommendation to pH 6.5. For CRP acres, list the crop most similar to that being seeded (e.g. 04 for legume/grass hay, or 22 for native grasses).

Test Requested (3): Indicate the tests requested for each sample. Before selecting nitrate, read the information given below (under ‘Nitrate Test’) to see if it applies to your area or crop. The cost for each test is shown on the Sheet.

- *Regular Series:* Includes phosphorus, potassium, pH and lime requirement, percent organic matter and texture. Sample the plow layer for cultivated land, or to three inches for permanent pastures or sod fields.
- *Special Test:* Includes sulfur, zinc, copper, iron, manganese, boron, calcium, magnesium, % organic matter, soluble salts (electrical conductivity). Copper recommendations apply only for peat or muck soils. Research has shown that for Minnesota soils, tests for iron and manganese are not practical; they are included to accommodate special requests. These tests are to be determined only on the plow layer sample.
- *Nitrate Test:* **This test requires soil be collected to a depth of 24 inches. There are two options. One is to submit two samples, 0-6 inch and 6-24 inch depths. The second is to collect the soil from 0-24 inches.** The test applies to non-sandy soils in western Minnesota with an exception noted below. This test is preferred for making nitrogen recommendations for the counties west of and including Lake of the Woods, Beltrami, Becker, Otter Tail, Douglas, Pope, Kandiyohi, Renville, Redwood, Cottonwood, and Jackson counties. In these counties, the test is used in making nitrogen recommendations for corn, small grains, potatoes and sugar beets.

If you're in western Minnesota and you want the *regular series test or any of the other special tests* in addition to the nitrate test, take samples from 0-6 and 0-24 inches and enter on separate lines on the sheet.

For the counties east of those cited above*,* the soil nitrate test is used *only* if the sample is collected in the spring before or near planting (April 1 – June 15). Nitrogen fertilizer recommendations *will not* be based on the analysis of only plow layer samples for nitrate-nitrogen. If only a plow layer sample is submitted, nitrogen recommendations will be based on cropping history, intended crop, yield goal, and soil organic matter level.

Samples collected for the nitrate test **must be air-dried immediately to slow down microbial activity** and sent to the Lab within 24 hours. Drying can be accomplished by spreading the soil in the sun, or placing near a heat source. If *only* nitrate is to be determined, the samples can be dried in a microwave oven using several 2 minute power cycles, stirring between each cycle. Alternatively, samples can be frozen and sent to the Lab in a well insulated package.

University of Minnesota Soil Testing Laboratory – http://soiltest.cfans.umn.edu/

Soil Testing Laboratory
Room 135 Crops Research Building
1902 Dudley Ave
St Paul, MN 55108-6089

Phone: 612 625-3101
FAX: 612 624-3420

email: soiltest@umn.edu

UNIVERSITY OF MINNESOTA
Soil Testing Laboratory

FARM/FIELD AND COMMERCIAL HORTICULTURE CROPS

SOIL ANALYSIS REQUEST SHEET

Report No.

Instructions for filling out this form are given on the back side

LOCATION REFERENCE (if different then "mail reports to" address)

Name ______

Address ______

City, State, Zip ______

Phone ______

Soil Location: County ______

Township ______

Check for $ ______ enclosed

MAIL REPORTS TO:

Name ______

Address ______

City, State, Zip ______

Phone ______

Sample Identification			1 Crop History				2 Proposed Crops						3 Check Test Requested (plow layer sample)								
			Crop Grown Before Last		Last Grown Crop		Option 1		Option 2		Option 3										
Laboratory Number (Lab Use Only)	Field or Sample No. or Letter	Check if Irrigated	Crop Code No.	If Alfalfa check plants per sq ft	Crop Code No.	If Alfalfa check plants per sq ft	Crop Code No.	Expected Yield	Crop Code No.	Expected Yield	Crop Code No.	Expected Yield	* Regular Series P K, pH, %OM $15	Sulfur** $7	Zinc, Iron, Copper, Manganese $12	Boron $7	Calcium and Magnesium $7	Lead $16	Nutrient Mgmt P $7	Soluble Salts $7	Nitrate Before selecting this test please read the section on nitrate on the BACK SIDE Sampling to 24" is required for this test.
				☐ 4+ ☐ 2-3 ☐ 0-1		☐ 4+ ☐ 2-3 ☐ 0-1															$8 ☐ 0-6"/6-24" sample ☐ 0-24" sample
				☐ 4+ ☐ 2-3 ☐ 0-1		☐ 4+ ☐ 2-3 ☐ 0-1															$8 ☐ 0-6"/6-24" sample ☐ 0-24" sample
				☐ 4+ ☐ 2-3 ☐ 0-1		☐ 4+ ☐ 2-3 ☐ 0-1															$8 ☐ 0-6"/6-24" sample ☐ 0-24" sample
				☐ 4+ ☐ 2-3 ☐ 0-1		☐ 4+ ☐ 2-3 ☐ 0-1															$8 ☐ 0-6"/6-24" sample ☐ 0-24" sample
				☐ 4+ ☐ 2-3 ☐ 0-1		☐ 4+ ☐ 2-3 ☐ 0-1															$8 ☐ 0-6"/6-24" sample ☐ 0-24" sample
				☐ 4+ ☐ 2-3 ☐ 0-1		☐ 4+ ☐ 2-3 ☐ 0-1															$8 ☐ 0-6"/6-24" sample ☐ 0-24" sample

Recommendations available for these crops:

**See comments on back side

*THE REGULAR SERIES **INCLUDES** PERCENT ORGANIC MATTER

Crop Code	Name	Yield Unit
	LEGUMES	
01.	Alfalfa, New Seed	ton/acre
02.	Alfalfa, Established	ton/acre
03.	Birdsfoot Trefoil	ton/acre
04.	Legume/Grass Hay	ton/acre
05.	Legume/Grass Pasture	–
06.	Red Clover	ton/acre
	CORN	
07.	Corn, Grain	bu/acre
08.	Corn, Silage	ton/acre
09.	Sweet Corn	ton/acre
	SMALL GRAINS	
10.	Barley	bu/acre
11.	Oats	bu/acre
12.	Rye/Triticale	bu/acre
13.	Wheat	bu/acre
	MISCELLANEOUS	
14.	Buckwheat	lb/arce
15.	Edible Beans	lb/arce
16.	Fallow	–
17.	Flax	bu/acre
18.	Grass Hay	tons/acre
19.	Grass Seed Prod.	lb/arce
20.	Grass Pasture	–
21.	Millet	lb/arce
22.	Native Grasses	tons/acre
23.	Potatoes	cwt/acre
	MISCELLANEOUS (continued)	
24.	Rape/Mustard/Canola	cwt/acre
25.	Sorghum Sudan	–
26.	Soybeans	bu/acre
27.	Sugarbeets	tons/acre
28.	Sunflowers	lb/arce
29.	Wild Rice	–
	VEGETABLES	
30.	Asparagus, New Planting	
31.	Asparagus, Establ. Planting	
32.	Beans, Snap	
33.	Beets, Table	
34.	Broccoli	
35.	Brussels Sprouts	
36.	Cabbage	
37.	Cauliflower	
38.	Carrots	
	VEGETABLES (continued)	
39.	Celery	
40.	Cucumbers	
41.	Lettuce	
42.	Melons	
43.	Onions, Dry	
44.	Onions, Green	
45.	Parsnips	
46.	Peas	
47.	Peppers	
48.	Pumpkins/Squash	
49.	Radishes	
50.	Turnips	
51.	Rhubarb	
52.	Rutabagas	
53.	Spinach	
54.	Tomatoes	
	FRUITS	
55.	Apples	
56.	Blueberries	
57.	Grapes	
58.	Raspberries/Brambles	
59.	Strawberries	
	TURF	
60.	Cultured Sod	
61.	**NURSEY - FIELD STOCK TREES/SCRUBS** Suggested tests: Regular, Soluble Salts,Nitrate. For sampling instructions, please see Nursery Form	
62.	Other ______	

INSTRUCTIONS FOR COMPLETING SOIL SAMPLE SUBMISSION FORM

Field History (1): This information is essential for us to provide the most accurate nitrogen recommendations possible. Indicate crops grown the past **two** growing seasons. BE SURE TO USE THE CROP CODE NUMBER FROM THE LISTING ON THE FRONT SIDE. If alfalfa was the crop grown during either or both of the two previous growing seasons, it is important to indicate the number of plants (crowns) per sq. ft.

Proposed Crops and Yield Goals (2): You can select recommendations for up to **three crops** by entering the corresponding crop code number, **or three yield goals** for one crop. At least one option must be completed to receive a fertilizer recommendation. If alfalfa is planned for the following year, list the crop code 01 under Option 2 or Option 3 with the desired yield in order to get a lime recommendation to reach pH 6.5. For CRP acres, list the crop most similar to that being seeded (e.g., 04 for legume/grass hay, or 22 for native grasses.)

Tests Requested (3): Indicate test choices for each sample. Cost for each test is shown. **Before selecting nitrate, read the information below for Nitrate Test** to see if it applies to your area or crop.

- **Regular Series:** Sample the plow layer (6-8 inches) for cultivated land, or to 3 inches for pastures or sod fields. Includes phosphorus, potassium, pH - lime requirement, percent organic matter, estimated texture.

- **Special Tests:** These tests are conducted only on the plowlayer depth. Includes zinc, copper, iron, manganese, boron, calcium, magnesium, soluble salts (electrical conductivity). (Copper recommendations apply only for peat or muck soils.) Research has shown that for Minnesota soils, tests for iron and manganese are not practical; they are included to accommodate special requests.

- **Sulfur Test:** The sulfur test is not a reliable predictor of sulfur needs. Sulfur recommendations are based on crop and soil texture. See your county extension educator for details.

- **Nutrient Management P Test:** This test is an Olsen extractable P test, but is designed for situations where the soil test level for phosphorus is expected to be in the high range (>50 ppm Olsen) and is required for nutrient management decisions. Range is 20 – 250 ppm extractable Olsen P.

- **Nitrate Test**: For the N recommendation to be based on the nitrate value, **the soil MUST be collected to a depth of 24 inches**. There are two options: 1) submit two separate samples, a 0-6" depth and a 6"-24" depth sample; 2) collect the soil from 0-24" for the nitrate test only. The nitrate test applies to non-sandy soils in western Minnesota with an exception noted below. This test is preferred for making N recommendations for the counties west of and including Lake of the Woods, Beltrami, Becker, Otter Tail, Douglas, Pope, Kandiyohi, Renville, Redwood, Cottonwood, and Jackson. In these counties, the nitrate test is used in making N recommendations for corn, small grains, potatoes, and sugar beets.

  For the counties EAST of those cited, the nitrate test is used to recommend N only if the sample is collected in the spring before or near planting (April 1 – June 15).

  N fertilizer recommendations will not be based on the analysis of only plow layer samples for nitrate-nitrogen. If only a plow layer sample is submitted, N recommendations will be based on cropping history, intended crop, yield goal, and soil organic matter level.

  Samples collected for the nitrate test should be **frozen or air-dried immediately**. Drying can be accomplished by spreading the soil in the sun, or placing near a heat source. If only nitrate is to be determined, the samples can be dried in a microwave oven using several 2-minute power cycles, stirring between each cycle. Please use an insulated container for shipping frozen samples, as premature thawing can affect nitrate test results.

SAMPLING INSTRUCTIONS

Submit one sample for each area of the field. Each area should have fairly uniform soil color and texture, cropping history, fertilizer, lime, and manure treatments. One sample should not represent more than **20 acres** on level, uniform landscapes, or **5 acres** on hilly or rolling land. Within each area collect 15-30 sub-samples (cores, borings, or spade slices) in a grid pattern. The more variable the soil, the more sub-samples should be combined per area sampled. Mix the sub-samples thoroughly in a clean plastic pail, and fill the sample box or bag to the fill line (1 pint). If samples must be taken wet, they should be dried before being mixed and submitted to the laboratory. Do not exceed a drying temperature of 97°F, and do not use a microwave oven unless only the nitrate test is requested.

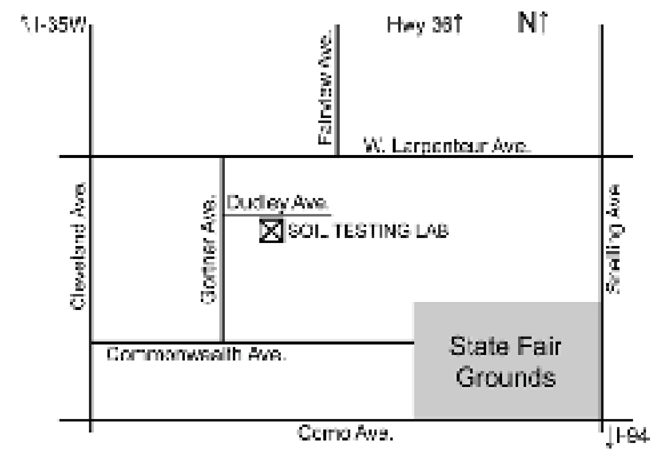
Sample each area as follows: Scrape off all surface residue. Sample to the plow layer for cultivated crops or 3 inches for pasture or sod fields. Sample row crop fields between rows, except for ridge-till plantings. Where ridge-till is used, take the sample to a depth of 6-8 inches on the shoulder of the ridge, avoiding the starter fertilizer band. Avoid sampling dead or back furrows, terraces, old fence rows, lime or fertilizer spill areas, headlands, eroded knolls, low spots, or small saline areas. Sample at least 300 feet away from gravel or crushed limestone roads because their dust changes soil pH.

SHIPPING INSTRUCTIONS

Fill out the information sheet as completely as possible so that accurate recommendations can be given. Keep a copy for your records. Place samples in a shipping carton and **enclose the information sheet with a check made payable to The University of Minnesota**. Please do not send cash. The lab is not responsible for cash payment by mail. If the shipping carton is a re-used box, wrap in heavy brown paper.

Ship samples to:

Soil Testing Laboratory
University of Minnesota
135 Crops Research Building
1902 Dudley Avenue
St. Paul, MN 55108



For additional information on soil analyses, please see our website: http://soiltest.cfans.umn.edu, or call or visit your local county extension office. You may also call the Landscape Arboretum Yard and Garden line at (952) 443-1426, or the Soil Testing Laboratory at (612) 625-3101.

Soil Sample Information Sheet Instructions

Crop History (1): This information is essential for us to provide the most accurate nitrogen recommendations. Indicate crops grown the past **two** most recent growing seasons. BE SURE TO USE THE CROP CODE NUMBER FROM THE LISTING ON THE SHEET. If alfalfa was the crop grown during either or both of the two previous growing seasons, it is important to indicate the number of plants (crowns) per square foot.

Proposed Crops and Yield Goals (2): You can select recommendations for up to **three crops** by entering the corresponding crop code number, **or three yield goals** for one crop. At least one option must be completed to receive a fertilizer recommendation, but there is no requirement to complete all options. If alfalfa is planned for the second crop year, list the crop code 01 under Option 2 or Option 3 with the desired yield in order to get a lime recommendation to pH 6.5. For CRP acres, list the crop most similar to that being seeded (e.g. 04 for legume/grass hay, or 22 for native grasses).

Test Requested (3): Indicate the tests requested for each sample. Before selecting nitrate, read the information given below (under 'Nitrate Test') to see if it applies to your area or crop. The cost for each test is shown on the Sheet.

- *Regular Series:* Includes phosphorus, potassium, pH and lime requirement, percent organic matter and texture. Sample the plow layer for cultivated land, or to three inches for permanent pastures or sod fields.
- *Special Test:* Includes sulfur, zinc, copper, iron, manganese, boron, calcium, magnesium, % organic matter, soluble salts (electrical conductivity). Copper recommendations apply only for peat or muck soils. Research has shown that for Minnesota soils, tests for iron and manganese are not practical; they are included to accommodate special requests. These tests are to be determined only on the plow layer sample.
- *Nitrate Test:* **This test requires soil be collected to a depth of 24 inches. There are two options. One is to submit two samples, 0-6 inch and 6-24 inch depths. The second is to collect the soil from 0-24 inches.** The test applies to non-sandy soils in western Minnesota with an exception noted below. This test is preferred for making nitrogen recommendations for the counties west of and including Lake of the Woods, Beltrami, Becker, Otter Tail, Douglas, Pope, Kandiyohi, Renville, Redwood, Cottonwood, and Jackson counties. In these counties, the test is used in making nitrogen recommendations for corn, small grains, potatoes and sugar beets.

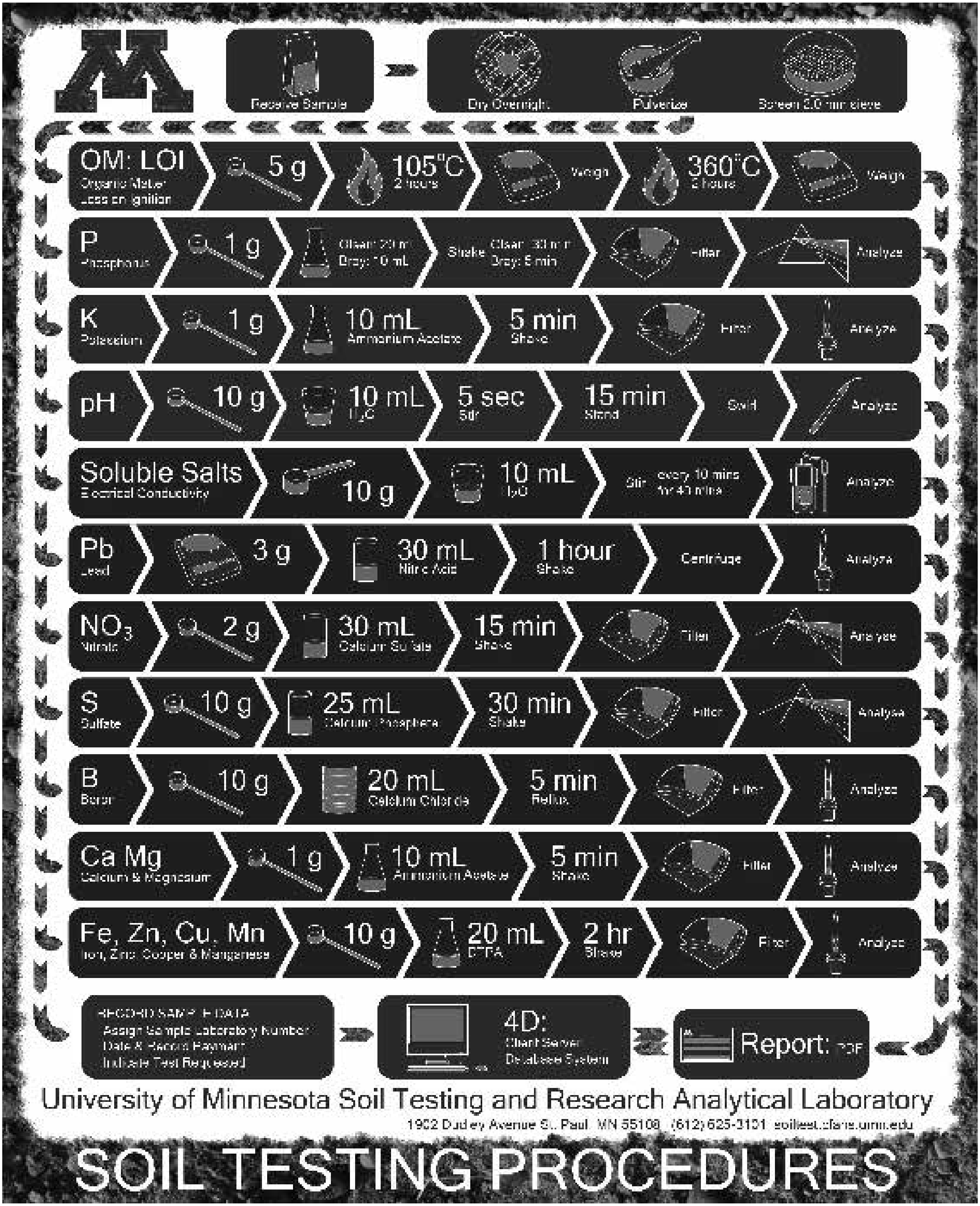
If you're in western Minnesota and you want the *regular series test or any of the other special tests* in addition to the nitrate test, take samples from 0-6 and 0-24 inches and enter on separate lines on the sheet.

For the counties east of those cited above*,* the soil nitrate test is used *only* if the sample is collected in the spring before or near planting (April 1 – June 15). Nitrogen fertilizer recommendations *will not* be based on the analysis of only plow layer samples for nitrate-nitrogen. If only a plow layer sample is submitted, nitrogen recommendations will be based on cropping history, intended crop, yield goal, and soil organic matter level.

Samples collected for the nitrate test **must be air-dried immediately to slow down microbial activity** and sent to the Lab within 24 hours. Drying can be accomplished by spreading the soil in the sun, or placing near a heat source. If *only* nitrate is to be determined, the samples can be dried in a microwave oven using several 2 minute power cycles, stirring between each cycle. Alternatively, samples can be frozen and sent to the Lab in a well insulated package.

From U of M Soil Testing Laboratory at **http://soiltest.cfans.umn.edu/how-to-submit-samples/farm-commercial/soil-sample-information-sheet-instructions/**

http://soiltest.cfans.umn.edu/files/2012/08/how-to-soil-test-v2.png

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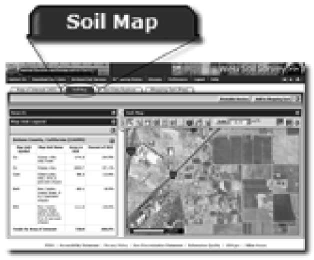
Archived Soil Surveys
Status Maps
Official Soil Series Descriptions (OSD)
Soil Series Extent Mapping Tool
Geospatial Data Gateway
eFOTG
National Soil Characterization Data
Soil Geochemistry Spatial Database
Soil Quality
Soil Geography
The simple yet powerful way to access and use soil data.
START WSS
Welcome to Web Soil Survey (WSS)
Web Soil Survey (WSS) provides soil data and information produced by the National Cooperative Soil Survey. It is operated by the USDA Natural Resources Conservation Service (NRCS) and provides access to the largest natural resource information system in the world. NRCS has soil maps and data available online for more than 95 percent of the nation's counties and anticipates having 100 percent in the near future. The site is updated and maintained online as the single authoritative source of soil survey information.
Soil surveys can be used for general farm, local, and wider area planning. Onsite investigation is needed in some cases, such as soil quality assessments and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center or your NRCS State Soil Scientist.
Four Basic Steps
Define.
Area of Interest (AOI)
Use the Area of Interest tab to define your area of interest.
Click to view larger image.
I Want To...
Start Web Soil Survey (WSS)
Know the requirements for running Web Soil Survey — will Web Soil Survey work in my web browser?
Know the Web Soil Survey hours of operation
Find what areas of the U.S. have soil data
Find information by topic
Know how to hyperlink from other documents to Web Soil Survey
Announcements/Events
Web Soil Survey 3.1 has been released! View description of new features and fixes.
Web Soil Survey Release History
Sign up for e-mail updates via GovDelivery
I Want Help With...
Getting Started With Web Soil Survey
How to use Web Soil Survey
How to use Web Soil Survey Online Help

- Known Problems and Workarounds
- Frequently Asked Questions
- Citing Web Soil Survey as a source of soils data

2 View.



Click the Soil Map tab to view or print a soil map, and detailed descriptions of the soils in your Area of Interest.

Click to view larger image.

3 Explore.

Click the Soil Data Explorer tab to access soil data for your area and determine the suitability of the soils for a particular use. The items you want saved in a report can be added to your shopping cart.

Click to view larger image.

4 Check Out.

Use the Shopping Cart tab to get your custom printable report immediately, or download it later.

Click to view larger image.

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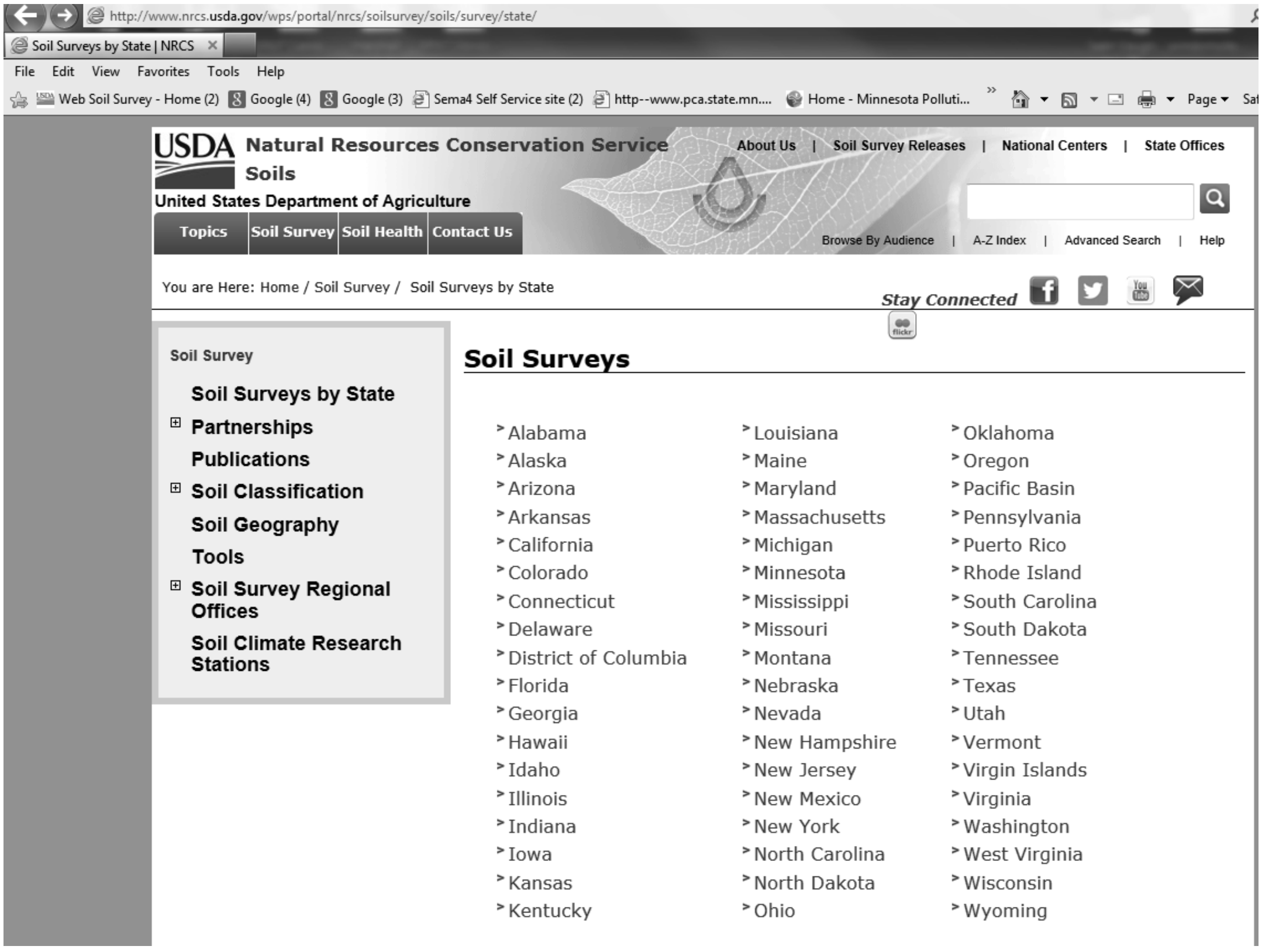
http://www.nrcs.usda.gov/wps/portal/nrcs/soilsurvey/soils/survey/state/
Soil Surveys by State | NRCS
File Edit View Favorites Tools Help
Web Soil Survey - Home (2) Google (4) Google (3) Sema4 Self Service site (2) http--www.pca.state.mn.... Home - Minnesota Polluti...
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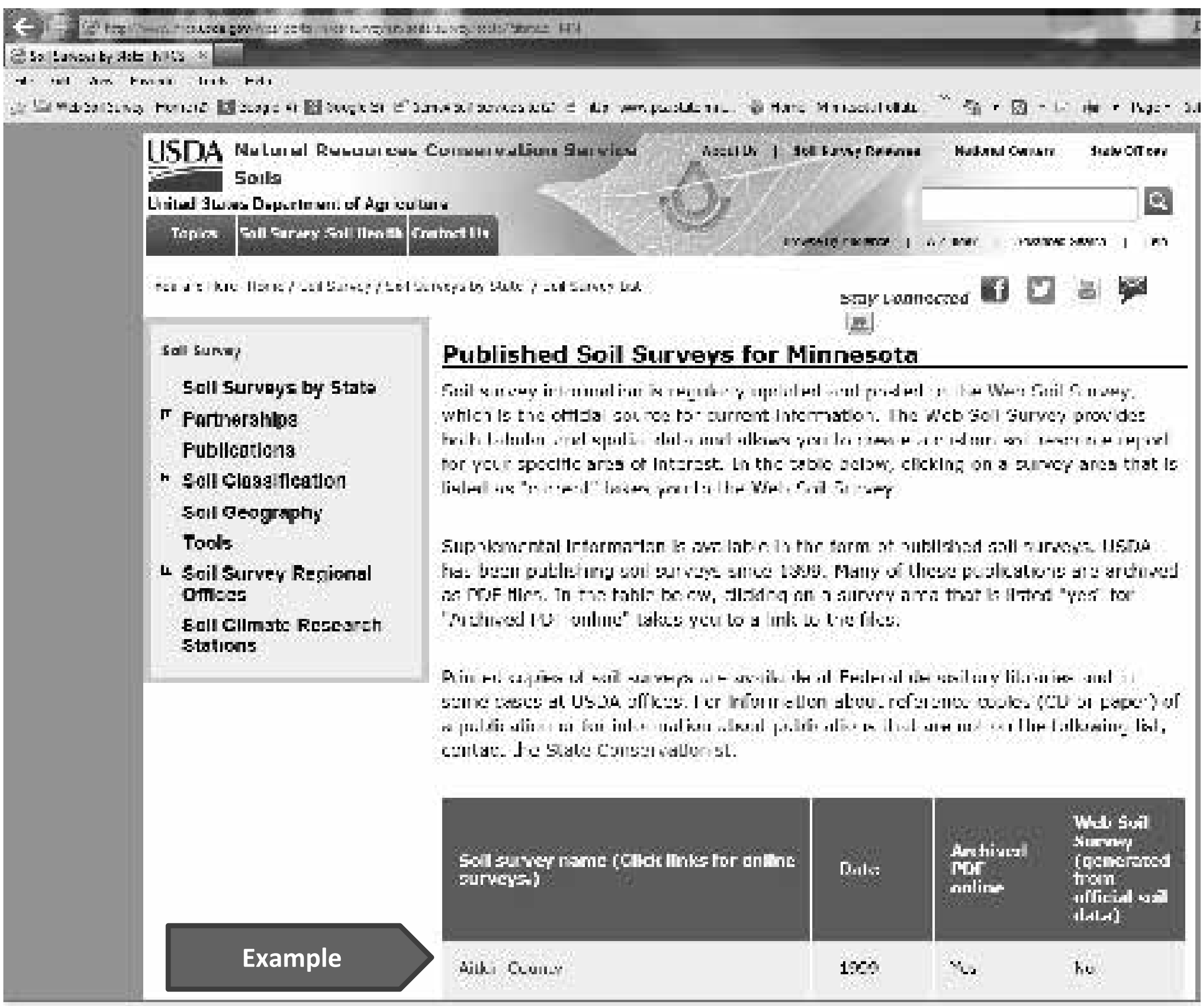
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Soil Classification
Soil Geography
Tools
Soil Survey Regional Offices
Soil Climate Research Stations
Published Soil Surveys for Minnesota
Soil survey name (Click links for online surveys.)
Date
Archived PDF online
Web Soil Survey (generated from official soil data)
Example

Useful Nutrient Management Data

Crop Nutrient Removal

CROP	NUTRIENT (lbs. per unit of indicated yield) N	P_2O_5	P	K_2O	K
Corn[1]					
Grain, 100 bu.	90	36	16	26	22
Stover, 1 ton (dry)	22	8	4	32	26
Corn silage[2], 10 tons	83	36	16	83	69
Sorghum silage, 1 ton	40	15	7	58	48
Soybeans[1], Grain, 50 bu.	188	44	19	69	58
Beans[1], **dry,** Grain, 50 bu.	125	42	18	42	35
Wheat[1]					
Grain, 50 bu.	63	31	14	19	16
Straw, 1 ton	13	3	1	40	19
Barley[1]					
Grain, 50 bu.	44	19	9	13	11
Straw, 1 ton	15	5	2	30	25
Oats[1]					
Grain, 100 bu.	62	25	11	19	16
Straw, 1 ton	12	8	3	40	33
Sunflower[2], Grain, 10 cwt.	36	17	7.5	11	9.1
Sugarbeets[2], Beet, 10 tons	42	5	2.2	83	69
Alfalfa hay[3], 1 ton	45	10	4	45	37
Timothy hay[3], 1 ton	24	10	4	38	32
Potatoes, Tubers, 500 cwt.	175	75	33	280	232

[1] Grain crops cannot be compared on a bushel basis because the weight per bushel varies among crops.

[2] Numbers taken from Potash and Phosphate Institute publications.

[3] Composition, espececially nitrogen, varies with maturity of the crop.

All other numbers taken from the "Modern Corn Publication", S. R. Alsdrich et al., 1986.

Common Fertilizer Analyses

FERTILIZER	ANALYSIS	CHEMICAL FORMULA
N		
Anhydrous ammonia	82-0-0	NH_3
Ammonium nitrate	34-0-0	NH_4NO_3
Urea	46-0-0	$(NH_2)_2CO$
UAN solution (Urea ammonium nitrate)	28 to 32-0-0	NH_4NO_3 plus $(NH_2)_2CO$ in water
Aqua ammonia	20-0-0	NH_3 in water
Ammonium sulfate	21-0-0-24(S)	$(NH_4)_2SO_4$
P		
Triple superphosphate (TSP)	0-44 to 46-0	$Ca(H_2PO_4)_2$
Diammonium phospahate (DAP)	18-46-0	$(NH_4)_2HPO_4$
Monoammonium phosphate MAP)	11-48-0	$NH_4H_2PO_4$
Ammonium polyphosphate liquid (APP)	10-34-0	$NH_4H_2PO_4$ plus $(NH_4)_3HP_2O_7$
Ammonium polyphosphate dry (APP)	15-62-0	*Same as liquid*
K		
Potassium chloride (Muriate of potash)	0-0-60	KCI
Potassium sulfate	0-0-50-18(S)	K_2SO_4
Potassium-magnesium sulfate (Sul-fo-mag)	0-0-22-22(S)-11(Mg)	$K_2SO_4 \bullet 2MgSO_4$
Potassium nitrate	13-0-44	KNO_3

Per Animal Daily Manure Production And Pounds of Nutrients[1]

	LBS.	GALS.	N	P_2O_5	K_2O
	Lbs.				
Beef (1,000 lbs.)	60	7.5	0.34	0.25	0.29
Dairy (1,400 lbs.)	115	13.9	0.57	0.24	0.46
Swine (200 lbs.)	13.1	1.5	0.09	0.07	0.07
Turkey	0.7		0.009	0.008	0.00
Chicken (layer)	0.2		0.003	0.003	0.00

[1] Adjust proportionately for different animal weights. Does not account for storage or application losses.

Numbers taken from Minnesota Extension Service publications.

Nutrient Analysis of Beef, Dairy, Swine and Poultry Manure

	Total N	P_2O_5	K_2O
DAIRY			
Solid:	*Lbs. / Ton*		
Cows	11	7	9
Heifers	13	12	19
Liquid:	*Lbs. / 1,000 Gals.*		
Anaerobic storage	25	15	27
BEEF			
Solid:	*Lbs. / Ton*		
Cows	15	10	9
Steers	14	9	14
SWINE			
Solid:	*Lbs. / Ton*		
Gestation	22	27	14
Finishing	22	22	17
Liquid:	*Lbs. / 1,000 Gals.*		
Farrowing	27	27	15
Nursery	34	25	18
Gestation	40	42	18
Finishing	53	39	29
POULTRY			
	Lbs. / Ton		
Turkeys	44	63	34

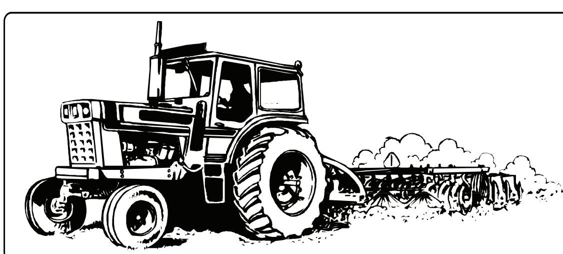
Numbers taken from Minnesota Extension Service publications.

Manure Nitrogen Availability and Loss as Affected by Method of Application and Animal Species

	Broadcast - Incoporated[1]			*Injection*	
	% Total N				
	None	**0-1/2 day**	**1/2-4 days**	**Sweep**	**Knife**
Dairy					
Av. Yr. 1	20	55	40	55	50
Av. Yr. 2	40	35	40	40	40
Lost[2]	40	10	20	5	10
Beef					
Av. Yr. 1	25	60	45	60	50
Av. Yr. 2	35	35	35	35	40
Lost	40	5	20	5	10
Swine					
Av. Yr. 1	35	75	55	80	70
Av. Yr. 2	15	15	15	15	15
Lost	50	10	30	5	15
Poultry					
Av. Yr. 1	45	70	55	NA	NA
Av. Yr. 2	25	25	25		
Lost	30	5	20		

[1] The categories refer to the length of time between manure application and incorporation.

[2] Lost refers to estimated volatilization and dentrification processes.



Nitrogen Credits from Legumes

for Corn, Wheat and Barley grown the first and second years after legume crop

LEGUME	CORN 1st Year	CORN 2nd Year	WHEAT & BARLEY 1st Year	WHEAT & BARLEY 2nd Year
	Lbs. Nitrogen / Acre			
Soybeans	40	0	20	0
Edible beans field peas, harvested sweet clover	20	0	10	0
Harvested alfalfa[1] or nonharvested sweet clover (plants / ft.^{2}):				
• 4 or more	150	75	75	35
• 2-3[2]	75	50	50	25
• 1 or less	40	0	0	0
Red clover	75	35	35	20

[1]For wheat and barley, where the 3rd and 4th cutting of legume was not harvested, add 20 lbs. Nitrogen to given figures.

[2]Values given also apply to alsike clover and birdsfoot trefoil. For other crops, see Minnesota Extension Services publications.

Numbers taken from Minnesota Extension service publications.

Soil Testing Information

SOIL TESTS (All Crops)

	V. Low	Low	Med.	High	V. High
P Test	*Rating (ppm P)*				
Bray	0- 5	6-10	11- 15	16- 20	21 +
Olsen	0- 3	4- 7	8- 11	12- 15	16 +
	Rating (ppm K)				
K Test	0-40	41-80	81-120	121-160	161 +

AMOUNTS OF P_2O_5 AND K_2O TO APPLY[1]

Corn

Amount of P_2O_5 = [0.7 - 0.035 (Bray P ppm)] (yield goal); or
[0.7 - 0.044 (Olsen P ppm)] (yield goal)
None if soil is > 25 ppm (Bray) or > 20 ppm (Olsen)

Amount of K_20 = [1.166 - 0.0073 (K Test, ppm)] (yield goal)
None of soil is $\geq$ 175 ppm for K Test

Wheat

Amount of P_2O_5 = [1.071 - 0.54 (Bray P ppm)] (yield goal); or
[1.071 - 0.067 (Olsen P ppm)] (yield goal)
None of soil is > 21 ppm (Bray) or > 16 ppm (Olsen)

Amount of K_20 = [2.71 - 0.017 (K Test, ppm)] (yield goal)
None of soil is $\geq$ 161 ppm for K Test

Alfalfa

Amount of P_2O_5 = [18.57 - 0.93 (Bray P ppm)] (yield goal); or
[18.57 - 1.16 (Olsen P ppm)] (yield goal)
None of soil is > 25 ppm (Bray) or > 20 ppm (Olsen)

Amount of K_20 = [55.7- 0.38 (K Test, ppm)] (yield goal)
None of soil is $\geq$ 161 ppm for K Test

Soybeans

Amount of P_2O_5 = [1.55 - 0.10 (Bray P ppm)] (yield goal); or
[1.55 - 0.14 (Olsen P ppm)] (yield goal)
None if soil is > 16 ppm (Bray) or > 12 ppm (Olsen)

Amount of K_20 = [2.20 - 0.0183 (K Test, ppm)] (yield goal)
None if soil is $\geq$ 121 ppm for K Test

[1]For tabulated amounts of fertilizer, see Minnesota Extension Service publications.

Numbers taken from Minnesota Extension Service publications.

Weights of Crops Per Bushel

CROP	LBS./BU.
Corn	56
Sorghum	56
Soybeans	60
Wheat	60
Barley	48
Oats	32
Rye	56
Sudangrass	40
Potatoes	60
Sweet Potatoes	55
Sunflower	25

Fertilizer Conversion Factors

P_2O_5 X 0.44 = P
P X 2.29 = P_2O_5
K_2O X 0.83 = K
K X 1.20 = K_2O
1 gal. water = 8.33 lbs.
1 gal. UAN = 10.6 lbs.

Length/Weight Conversion Factors

LENGTH:

1 inch = 2.54 cm
1 yard = 0.915 meters
1 mile = 5,280 feet = 1,610.7 meters = 1.61 km
1 meter = 100 cm = 1,000 mm = 0.001 km
1 chain = 66 feet = 100 links = 20.1 meters
= 4 rods

WEIGHT:

1 pound = 454 gm = 0.454 Kg = 16 ounces
1 ton (short) = 2,000 pounds
1 ton (long) = 2,240 pounds

Area/Volume Conversion Factors

AREA:

1 acre = 43,560 feet^2 = 0.405 hectare
1 hectare = 10,000 meter^2
1 yard^2 = 0.836 meter^2
1 chain^2 = 0.10 acres = 16 rods^2
1 mile^2 = 640 acres

VOLUME:

1 bushel (level) = 1.244 feet^3 = 8 gallons (dry)
= 9.31 gallons (liquid) = 35.24 liters
1 liter = 1,000 mL or cm^3
1 gallon (liquid) = 3.78 liters = 128 fluid ounces
= 4 quarts = 8 pints
1 acre-foot = 43,560 feet^3 = 1,613 yards^3
= 325,851 gallons
1 cup = 236.6 cm^3 = 0.236 liters
= 8 ounces = 16 tablespoons

More Conversion Factors

SPEED:

1 mile per hour = 1.467 feet per second
= 88 feet per minute = 26.8 meters per hour

OTHER:

1 pound per acre = 1.12 Kg/ha
1 pound per gallon = 0.119 Kg/L
Parts per million (ppm) = ug/g = mg/L
1 gallon per acre = 9.35 L/ha

LIQUID MANURE DENSITY:
1 gallon = 8.33 lbs

Soil Testing Conversions

Plow layer (6-7 inches) = ppm X 2 = lb./acre
Top 12 inches = ppm X 4 = lb./acre

Minnesota Department of Agriculture (10/99)
(651) 215-9097

RE: Chapter 7 in Biosolids Manual – Rule stated on p. 103

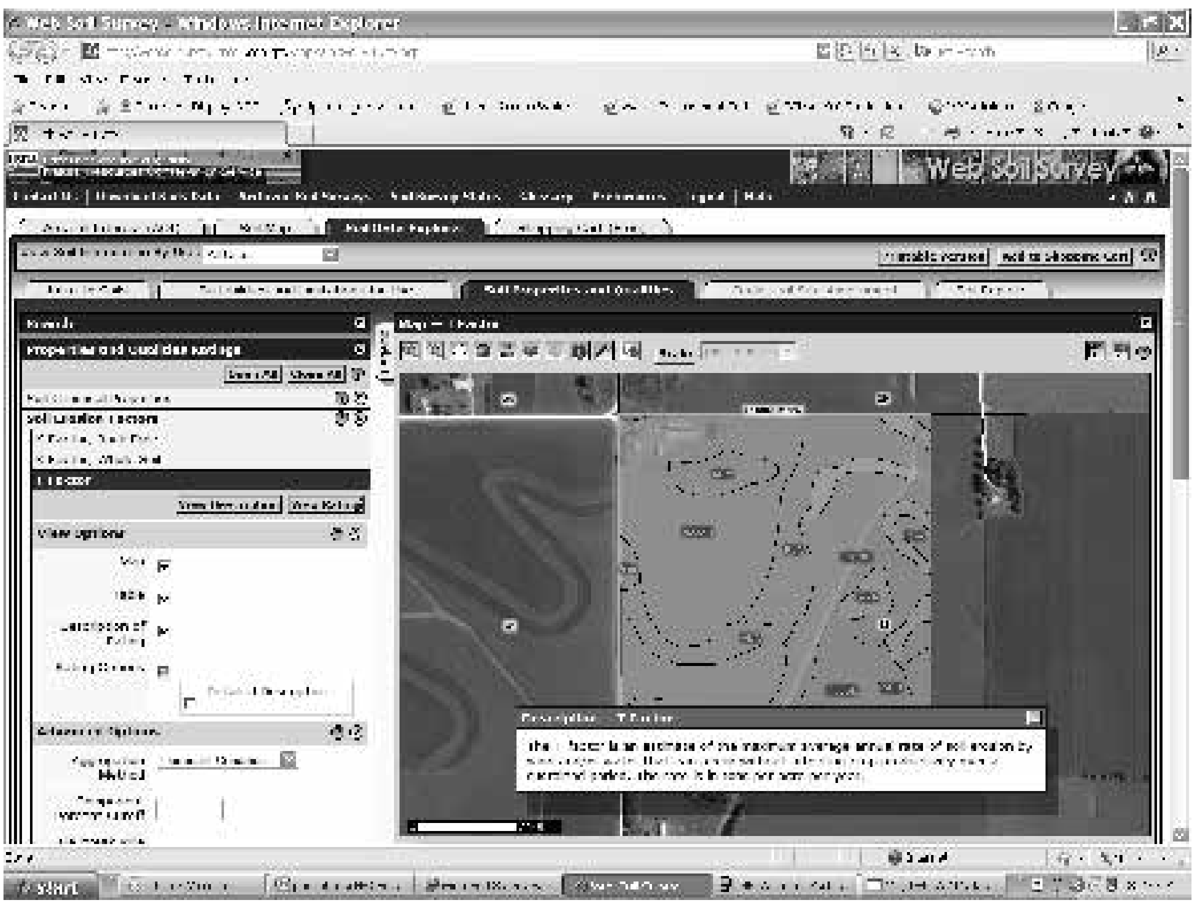
How do I communicate regulatory requirements to the NRCS regarding soil phosphorus values over 200 ppm Bray-1 phosphorus?

The rule reads as follows: …**"all resource management system level erosion control practices as determined necessary by the NRCS are in place and maintained".**

The question is, how do I present this issue to NRCS so they understand what I need? If you have a site that is over the 200 ppm limit, contact the NRCS about it and present the issue by stating the following:

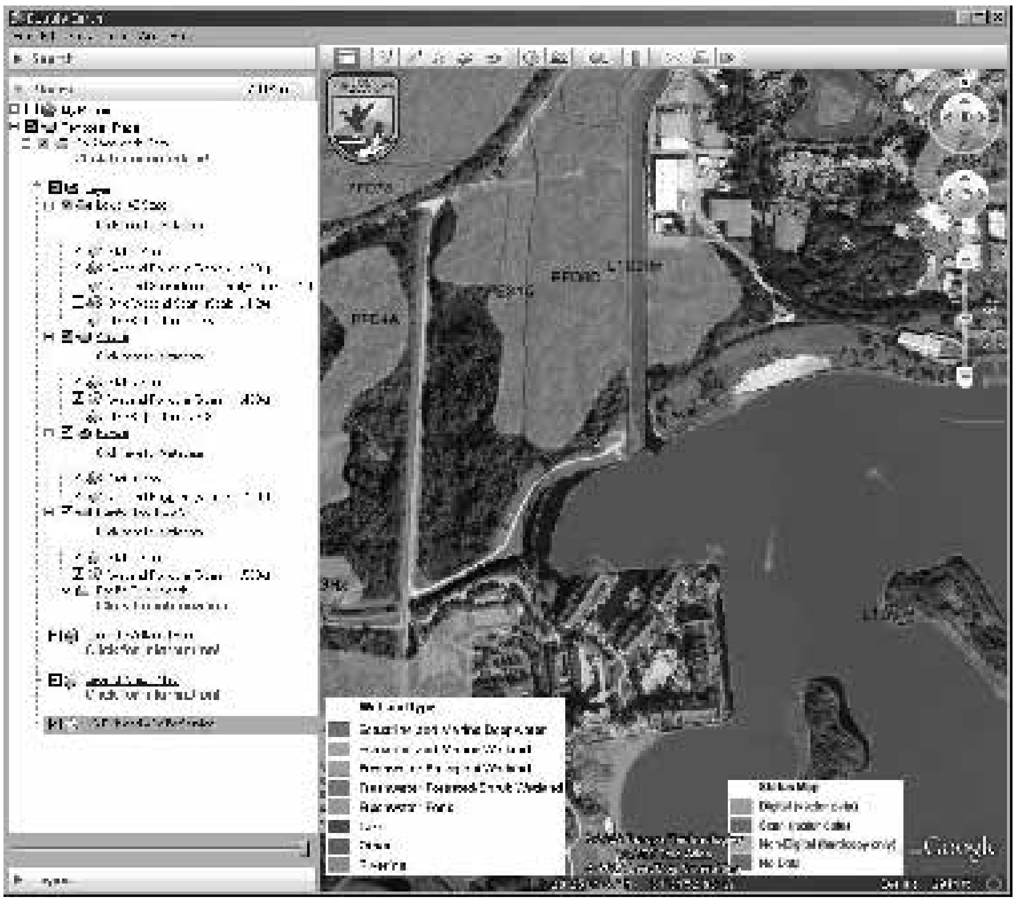
Are the current crop rotations, tillage practices or other conservation practices sufficient so that the "T" values are met on the site? If "T" values are not met, what management practices would have to be put in place to meet the "T" values?

Notes: The NRCS will need to know current farming practices such as crop rotations and the various tillage practices the farmer uses in order to run the soil loss program - RUSLE2. If the farmer does not want to use the chosen/prescribed methods, then the site cannot be used for biosolids application unless the soils test values drop to below 200 ppm P. You can view soil "T" values in the Web Soil survey.



U.S. Fish And Wildlife Service

Viewing Wetlands with Google™ Earth[1]



A Keyhole Markup Language file has been created to view Wetlands Data with Google Earth[2]. To ensure that you use the latest version, it is recommended that you load the file and open Google Earth by starting your internet browser and navigating to the following HTML link:

(http://www.fws.gov/wetlands/data/GoogleEarth.html)

Once you navigate to the previously mentioned web page, select the link:

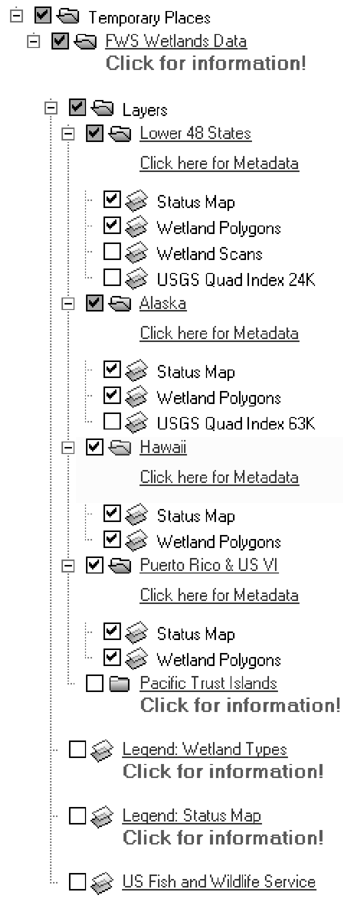
WetlandsData.KMZ

If Google Earth fails to launch automatically, the file can also be used by first launching the Google Earth application. Select the menu option File, Open, and then locate the previously downloaded file (WetlandsData.KMZ); then click the Open button.

Google Earth maps the surface of the Earth by superimposing images from satellites and aerial photography. Most land areas, except for islands, are shown using satellite imagery with a resolution of about 15 meters per pixel or better. In this application, Google Earth imagery can be used as a backdrop for viewing the wetlands digital data.

Notes:

- Double click any layer title to zoom into its area.
- Click on any layer or legend checkbox to view or hide it.
- The Lower 48 States Wetland Scans layer is hidden by default. To view the image layer, first zoom into an area that has Wetland Scans information, then turn on the layer.
- Important: Do not leave the Wetland Scans layer on (checked) while viewing areas that do not have scanned data. A large red **X** will appear if you do so.
- To remove the Wetlands KMZ file from Google Earth, right-click on the FWS Wetlands Data folder located under Places (Google Earth left panel), then select **Delete**.
- Please visit our Map Creation and Mapper Display web page (http://www.fws.gov/wetlands/data/MapperTips.html) for more tips and technical information.



- This data is available through an OGC compliant Web Map Service[3].

Digital data available on this source represent the latest, most accurate information available from the U.S. Fish and Wildlife Service. These data are also available on The National Map (http://nationalmap.gov/).

U.S. Fish and Wildlife Service
800/344-WILD
http://www.fws.gov

November 2008

[1] The use of trade, product, industry or firm names or products is for informative purposes only and does not constitute an endorsement by the U.S. Government or the Fish and Wildlife Service. Links to non-Service Web sites do not imply any official U.S. Fish and Wildlife Service endorsement of the opinions or ideas expressed therein or guarantee the validity of the information provided. Base cartographic information used as part of the Wetlands Mapper has been provided through a collaborative effort with the U.S. Geological Survey and The National Map.
[2] Please note that Google Earth version 4.2, or higher, is required to run this script.
[3] Follow this link for more information about Web Map Service: http://www.fws.gov/wetlands/data/WebMapServices.html