Chapter 5
Class B Pathogen Requirements and Requirements for Domestic Septage Applied to Agricultural Land, a Forest, or a Reclamation Site

5.1 Introduction

Class B pathogen requirements can be met in three different ways. The implicit objective of all three alternatives is to ensure that pathogenic bacteria and enteric viruses are reduced in density, as demonstrated by a fecal coliform density in the treated sewage sludge (biosolids) of 2 million MPN or CFU per gram total solids biosolids (dry weight basis)[1]. Viable helminth ova are not necessarily reduced in Class B biosolids.

Unlike Class A biosolids, which are essentially pathogen free, Class B biosolids may contain some pathogens. Site restrictions that restrict crop harvesting, animal grazing, and public access for a certain period of time are required. This allows environmental factors to further reduce pathogens. Where appropriate, these restrictions are designed to ensure sufficient reduction in viable helminth ova, one of the hardiest of pathogens, since these pathogens may not have been reduced during sewage sludge treatment.

The Class B requirements apply to bulk biosolids that are land applied to such areas as agricultural land, forests, public contact sites, or reclamation sites. Biosolids that are placed on a surface disposal site also must meet the Class B pathogen requirements, unless the active biosolids unit on which the biosolids are placed is covered at the end of each operating day (see Table 3-1). Because the use of Class B biosolids must be closely monitored, Class B biosolids cannot be given away or sold in bags or other containers.

Domestic septage applied to agricultural land, forest, or a reclamation site must meet all of the Class B site restrictions under 503.32(b)(5) unless the domestic septage has met specific pH requirements (see Section 5.6).

Class B biosolids and domestic septage also must meet one of the vector attraction reduction requirements (see Chapter 8). Note that the choice of vector attraction options may affect the duration of site restrictions in some cases. Specifically, if Option 9 or 10 (injection or incorporation) is used to reduce vector attraction, the restriction on harvesting for food crops grown below the soil surface (potatoes, carrots, etc.) is increased from 20 months to 38 months.

Sections 5.2 to 5.4 discuss the three alternative Class B pathogen requirements for sewage sludge. Section 5.5 discusses the site restrictions for land applied Class B biosolids, and Section 5.6 presents the requirements for domestic septage applied to agricultural land, forests, or reclamation sites. The title of each section provides the number of the Subpart D requirement discussed in the section. A copy of Subpart D can be found in Appendix B. Chapters 9 and 10 provide guidance on the sampling and analysis necessary to meet the Class B microbiological requirements.

5.2 Sewage Sludge Alternative 1: Monitoring of Fecal Coliform [503.32(b)(2)]

Alternative 1 requires that seven samples of treated sewage sludge (biosolids) be collected and that the geometric mean fecal coliform density of these samples be less than 2 million CFU or MPN per gram of biosolids (dry weight basis). This approach uses fecal coliform density as an indicator of the average density of bacterial and viral pathogens. Over the long term, fecal coliform density is expected to correlate with bacterial and viral pathogen density in biosolids treated by biological treatment processes (EPA, 1992).

Use of at least seven samples is expected to reduce the standard error to a reasonable value. The standard deviation can be a useful predictive tool. A relatively high standard deviation for the fecal coliform density indicates a wide range in the densities of the individual samples. This may be due to sampling variability or variability in the laboratory analysis, or it may indicate that the treatment process is not consistent in its reduction of pathogens. A high standard deviation can therefore alert the preparer that the sampling, analysis, and treatment processes should be reviewed.

[1]Farrell et al. (1985) have shown that if a processed sewage sludge is processed by aerobic or anaerobic digestion it has a fecal coliform density of 2 million MPN or CFU per gram, enteric viruses and bacteria are significantly reduced. A comparison of suspended solids densities in entering wastewater to suspended solids densities in treated sewage sludge shows that this density of fecal coliform in treated sewage sludge represents a 100-fold (Z-log) reduction in fecal coliform density, and is expected to correlate with an approximately 1.5 log (approximately 32-fold) reduction in *Salmonella* sp. density and an approximately 1.3 log (20-fold) reduction in the density of enteric viruses.

Each of the multiple samples taken for fecal coliform analysis should be taken at the same point in the process so that treatment of each sample has been equal. Samples must be handled correctly and analyzed within 24 hours in order to minimize the effect of the holding time of the sample on the microbial population.

Laboratory sampling should follow Standard Methods as outlined in the Appendix of this document. Standard QA/QC practices, including duplicates to verify laboratory protocols should be followed. Generally a log standard deviation between duplicate samples under 0.3 is acceptable for lab analyses.

Calculating the Geometric Mean for Class B Alternative 1

- Take seven samples over a 2-week period.
- Analyze samples for fecal coliform using the membrane filter or MPN dilution method.
- Take the log (Base 10) of each result.
- Take the average (arithmetic) of the logs.
- Take the anti-log of the arithmetic average. This is the geometric mean of the results.

Example: The results of analysis of seven samples of sewage sludge are shown below. The second column of the table shows the log of each result.

	Fecal Coliform (MPN/dry gram sewage sludge)	Log
Sample 1	6.4×10^6	6.81
Sample 2	4.8×10^4	4.68
Sample 3	6.0×10^5	5.78
Sample 4	5.7×10^5	5.76
Sample 5	5.8×10^5	5.76
Sample 6	4.4×10^6	6.64
Sample 7	6.2×10^7	7.80
Average (Arithmetic)		6.18
Antilog (geometric mean)		1.5×10^6
Log standard deviation		1.00*

Note that this sewage sludge would meet Class B fecal coliform requirements even though several of the analysis results exceed the 2.0×10^6/dry gram limit.
*Duplicate analyses on the same sample would give a much lower standard deviation. Variability is inflated by differences in feed and product over a 2-week sampling period.

Process parameters including retention time and temperature should be examined in order to verify that the process is running as specified. Monitoring equipment should be calibrated regularly.

The seven samples should be taken over a 2-week period in order to represent the performance of the facility under a range of conditions. For small facilities that are required to sample infrequently, sampling should be performed under worst case conditions, for example, during the winter when the climatic conditions are the most adverse.

It has been found that* for *Class B compliance, the MPN dilution method for fecal coliform analysis is more appropriate than the membrane filtration test. This is because colloidal and suspended solids may interfere with media transport through the membrane filter. Furthermore, concentration of toxic or inhibitory substances at the filter surface may affect results. It is therefore recommended that the membrane filter procedure be used *only after demonstrating comparability between the membrane filter test and the MPN method for a given sewage sludge.*

Example of Meeting Class B Pathogen Vector Attraction Reduction Requirements

Type of Facility	Extended Aeration
Class	B
Pathogen Reduction	----------
Testing	Quarterly testing for pollutants and for fecal coliform to determine if Class B Alternative 1 requirements are met.
Vector Attraction Reduction	The SOUR test is used to demonstrate compliance with VAR Option 4
Use or Disposal	The Class B biosolids are delivered to farmers along with information regarding analysis and site restrictions

5.3 Sewage Sludge Alternative 2: Use of a Process to Significantly Reduce Pathogens (PSRPs) [503.32(b)(3)]

The PSRP Class B alternative provides continuity with the 40 CFR Part 257 regulation. Under this Alternative, treated sewage sludge (biosolids) is considered to be Class B if it is treated in one of the "Processes to Significantly Reduce Pathogens" (PSRPs) listed in Appendix B of Part 503. The biological PSRP processes are sewage sludge treatment processes that have been demonstrated to result in a 2-log reduction in fecal coliform density. See Chapter 7.

The PSRPs in the Part 503 are reproduced in Table 5-1 and described in detail in Chapter 6. They are similar to the PSRPs listed in the Part 257 regulation, except that all conditions related to reduction of vector attraction have been removed. Under this alternative, sewage sludge treated by processes that are PSRPs under 40 CFR Part 257 are Class B with respect to pathogens. Unlike the comparable Class A requirement (see Section 4.8), this Class B alternative does not require microbiological monitoring.

However, monitoring of process requirements such as time, temperature, and pH is required.

Table 5-1. Processes to Significantly Reduce Pathogens (PSRPs) Listed in Appendix B of 40 CFR Part 503

1. Aerobic Digestion	Sewage sludge is agitated with air or oxygen to maintain aerobic conditions for a specific mean cell residence time (i.e., solids retention time) at a specific temperature. Values for the mean cell residence time and temperature shall be between 40 days at 20°C (68°F) and 60 days at 15°C (59°F).
2. Air Drying	Sewage sludge is dried on sand beds or on paved or unpaved basins. The sewage sludge dries for a minimum of 3 months. During 2 of the 3 months, the ambient average daily temperature is above 0°C (32°F).
3. Anaerobic Digestion	Sewage sludge is treated in the absence of air for a specific mean cell residence time (i.e., solids retention time) at a specific temperature. Values for the mean cell residence time and temperature shall be between 15 days at 35°C to 55°C (131°F) and 60 days at 20°C (68°F).
4. Composting	Using either the within-vessel, static aerated pile, or windrow composting methods, the temperature of the sewage sludge is raised to 40°C (104°F) or higher and remains at 40°C (104°F) or higher for 5 days. For 4 hours during the 5 day period, the temperature in the compost pile exceeds 55°C (131°F).
5. Lime Stabilization	Sufficient lime is added to the sewage sludge to raise the pH of the sewage sludge to 12 for ≥2 hours of contact.

5.4 Sewage Sludge Alternative 3: Use of Processes Equivalent to PSRP [503.32(b)(4)]

The Part 257 regulation allowed the sewage sludge to be treated by a process determined to be equivalent to a PSRP. Under Class B Alternative 3, sewage sludge treated by any process determined to be equivalent to a PSRP is considered to be Class B biosolids. A list of processes that have been recommended as equivalent to PSRP are shown in Table 11.1.

Part 503 gives the regulatory authority responsibility for determining equivalency. The Pathogen Equivalency Committee is available as a resource to provide guidance and recommendations on equivalency determinations to the regulatory authorities (see Chapter 11).

5.5 Site Restrictions for Land Application of Biosolids [503.32(b)(5)]

Potential exposure to pathogens in Class B biosolids via food crops is a function of three factors: first there must be pathogens in the biosolids; second, the application of Class B biosolids to food crops must transfer the pathogens to the harvested crop, and third, the crop must be ingested before it is processed to reduce the pathogens. Elimination of one of these steps eliminates the pathway by which public health may be affected. The use of Class A biosolids protects public health by reducing pathogens in sewage sludge to below detectable levels. Biosolids that meet the Class B requirements may contain reduced but still significant densities of pathogenic bacteria, viruses, protozoans, and viable helminth ova. Thus, site restrictions are to allow time for further reduction in the pathogen population. Harvest restrictions are imposed in order to reduce the possibility that food will be harvested and ingested before pathogens which may be present on the food have died off. Harvest restrictions vary, depending on the type of crop, because the amount of contact a crop will have with biosolids or pathogens in biosolids varies.

The site restrictions are primarily based in the survival rates of viable helminth ova, one of the hardiest of pathogens that may be present on sewage sludge. The survival of pathogens, including the helminth ova, depends on exposure to the environment. Some of the factors that affect pathogen survival include pH, temperature, moisture, cations, sunlight, presence of soil microflora, and organic material content. On the soil surface, helminth ova has been found to die off within 4 months, but survival is longer if pathogens are within the soil. Helminth ova have been found to survive in soil for several years (Smith, 1997; Kowal 1985). Site restrictions take this into account by making a distinction between biosolids that are applied to the land surface, biosolids that are incorporated into the soil after at least 4 months on the soil surface, and biosolids that are incorporated into the soil within 4 months of being applied.

Site restrictions also take the potential pathways of exposure into account. For example, crops that do not contact the soil, such as oat or wheat, may be exposed to biosolids, but pathogens on crop surfaces have been found to be reduced very quickly (30 days) due to exposure to sunlight, desiccation, and other environmental factors. Crops that touch the soil, such as melons or cucumbers, may also come into contact with biosolids particles, but pathogens in this scenario are also subject to the harsh effects of sunlight and rain and will die off quickly. Crops grown in soil such as potatoes are surrounded by biosolids amended soil, and pathogen die-off is much slower below the soil surface.

These pathways should be considered when determining which site restriction is appropriate for a given situation. The actual farming and harvesting practices as well as the intended use of the food crop should also be considered. For example, oranges are generally considered a food crop that does not touch the ground. However, some oranges grow very low to the ground and may come into contact with soil. If the oranges that have fallen to the ground or grew touching the ground are harvested for direct consumption without processing, the 14-month harvest restriction for crops that touch the soil should be followed. Orange crops which do not touch the ground at all would not fall under the 14-month harvest restriction; harvest would be restricted for 30 days under 503.32(b)(5)(iv)

which covers food crops that do not have harvested parts in contact with the soil. For similar situations, the potential for public health impacts must be considered. Harvest practices such as the use of fallen fruit or washing or processing crops should be written into permits so that restrictions and limits are completely clear. Figure 5-1 illustrates the steps of exposure that should be considered when making a decision about harvest and site restrictions. In addition, several examples of permit conditions are included. The site restrictions for land applied Class B biosolids are summarized below. The regulatory language is given in italics. Note that the restrictions apply only to the harvesting of food crops, but not to the planting or cultivation of crops.

Food Crops with Harvested Parts That Touch the Sewage Sludge/Soil Mixture

503.32(b)(5)(i): Food crops with harvested parts that touch the sewage sludge/soil mixture and are totally above the land surface shall not be harvested for 14 months after application of sewage sludge.

This time frame is sufficient to enable environmental conditions such as sunlight, temperature, and desiccation to further reduce pathogens on the land surface. Note that the restriction applies only to harvesting. Food crops can be planted at any time before or after biosolids application, as long as they are not harvested within 14 months

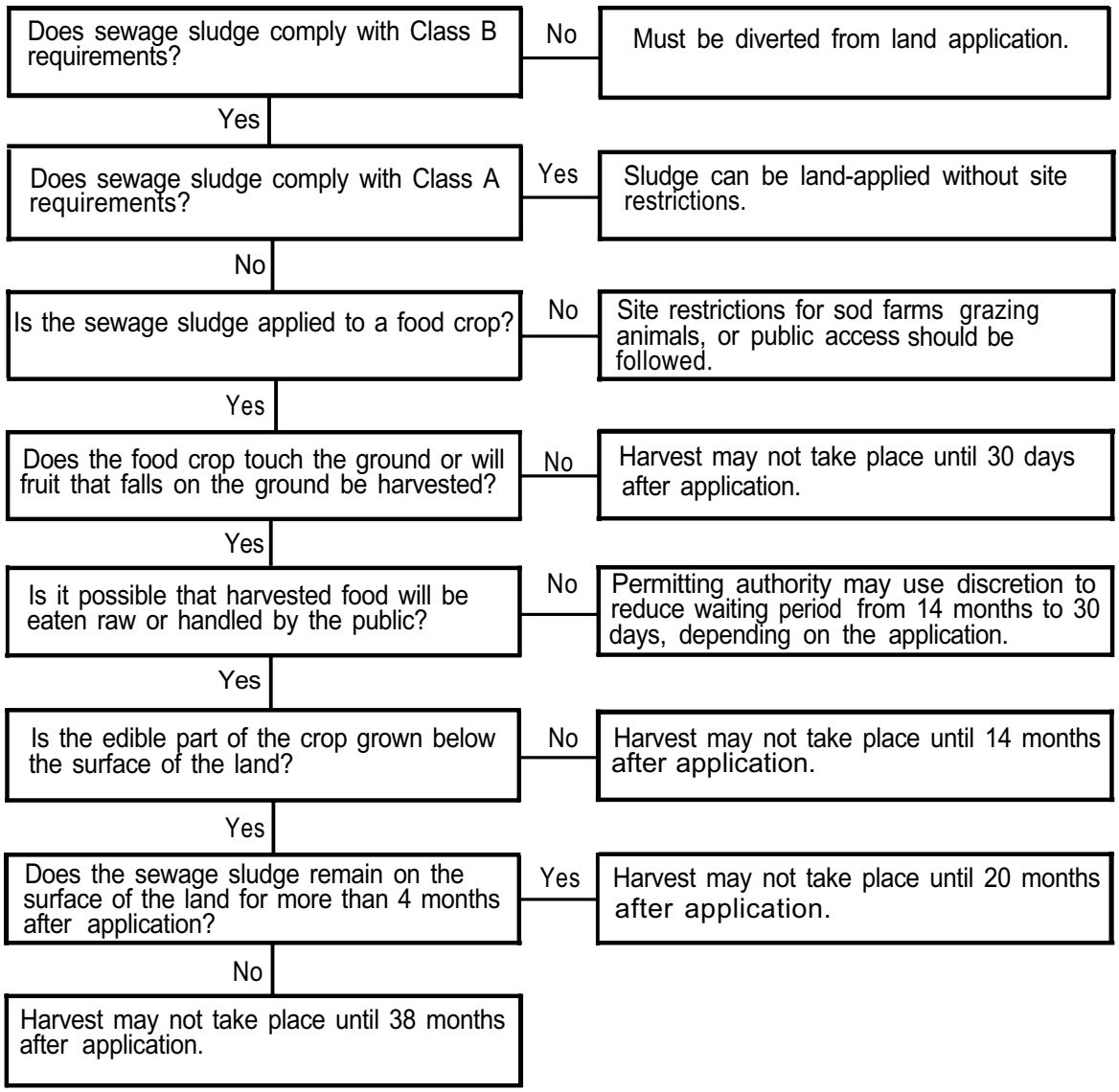

Figure 5-1. Decision tree for harvesting and site restrictions.

after sludge application. Examples of food crops grown on or above the soil surface with harvested parts that typically touch the sewage sludge/soil mixture include lettuce, cabbage, melons, strawberries, and herbs. Land application should be scheduled so that crop harvests are not lost due to harvest restrictions.

Food Crops with *Harvested Parts Below the Land Surface*

503.32(b)(5)(ii): Food crops with harvested parts below the surface of the land shall not be harvested for 20 months after application of sewage sludge when the sewage sludge remains on the land surface for 4 months or longer prior to incorporation into the soil.

Pathogens on the soil surface will be exposed to environmental stresses which greatly reduce their populations. Helminth ova have been found to die off after 4 months on the soil surface (Kowal, 1994). Therefore, a distinction is made between biosolids left on the soil surface for 4 months and biosolids which are disced or plowed into soil more quickly.

For a September 1999 harvest, biosolids could be applied to the soil surface up to the end of December 1997, plowed or disced into the soil in April 1998, and the crop planted in order to allow it to be harvested in September 1999. Examples of crops with harvested parts below the land surface are potatoes, radishes, beets, onions and carrots.

Examples of Site Restrictions for Questionable Food Crop Situations

Tree Nut Crops - Nuts which are washed hulled, and dehydrated before being distributed for public consumption must follow the 30-day restriction. Nuts which are harvested from the ground and sold in their shell without processing are subject to the 14-month restriction.

Sugar Beets - Sugar beets aren't expected to be eaten raw. If the beets are transported off site and considerable biosolids amended soil is carried off with them, the restrictions apply. If biosolids are left on the soil surface for 4 months or longer before being incorporated, the 20-month restriction applies. If biosolids are incorporated within 4 months of application, the 38-month restriction applies.

Tomatoes (and peppers) - Fruit often comes in contact with the ground. Tomatoes are sold both to processors and to farm stands. Tomatoes may be eaten raw by the public without further processing. The 14-month restriction applies.

503.32(b)(5)(iii): Food crops with harvested parts below the surface of the land shall not be harvested for 38 months after application of sewage sludge when the sewage sludge remains on the land surface for less than 4 months prior to incorporation into the soil.

Exposure of the surface of root crops such as potatoes and carrots to viable helminth ova is a principal concern under these circumstances. Four months is considered the minimum time for environmental conditions to reduce viable helminth ova in biosolids on the land surface. Class B biosolids incorporated into the soil surface less than 4 months after application may contain significant numbers of viable helminth ova. Once incorporated into the soil, die-off of these organisms proceeds much more slowly; therefore, a substantially longer waiting period is required to protect public health. Thirty-eight months after biosolids application is usually sufficient to reduce helminth ova to below detectable levels.

Food Crops, Feed Crops, and Fiber Crops

503.32(b)(5)(iv): Food crops, feed crops, and fiber crops shall not be harvested for 30 days after application of sewage sludge.

This restriction covers food crops that are not covered by 503.32(b)(I-iii). This would include crops with harvested parts that do not typically touch the biosolids/soil mixture and which are not collected from the ground after they have fallen from trees or plants. The restriction also applies to all feed and fiber crops. These crops may be exposed to pathogens when biosolids are applied to the land. Harvesting of these crops could result in the transport of biosolids pathogens from the growing site to the outside environment. After 30 days, however, any pathogens in biosolids that may have adhered to the crop during application will likely have been reduced to non-detectable levels. Hay, corn, soybeans, or cotton are examples of a crop covered by this restriction.

Animal Grazing

503.32(b)(5)(v): Animals shall not be allowed to graze on the land for 30 days after application of sewage sludge.

Biosolids can adhere to animals that walk on biosolids amended land and thereby be brought into potential contact with humans who come in contact with the animals (for example, horses and milking cows allowed to graze on a biosolids amended pasture). Thirty days is sufficient to substantially reduce the pathogens in surface applied biosolids, thereby significantly reducing the risk of human and animal contamination.

Turf Harvesting

503.32(b)(5)(vi): Turf grown on land where sewage sludge is applied shall not be harvested for 1 year after application of the sewage sludge when the harvested turf is placed on either land with a high potential for public exposure or a lawn, unless otherwise specified by the permitting authority.

The 1-year waiting period is designed to significantly reduce pathogens in the soil so that subsequent contact

of the turf layer will not pose a risk to public health and animals. A permitting authority may reduce this time period in cases in which the turf is not used on areas with high potential for public access.

Public Access

503.32(b)(5)(vii): Public access to land with a high potential for public exposure shall be restricted for 1 year after application of the sewage sludge.

As with the turf requirement above, a 1-year waiting period is necessary to protect public health and the environment in a potential high-exposure situation. A baseball diamond, playground, public park, or a soccer field are examples of land with a high potential for public exposure. The land gets heavy use and contact with the soil is substantial (children or ball players fall on it and dust is raised which is inhaled and ingested).

503.32(b)(5)(viii): Public access to land with a low potential for public exposure shall be restricted for 30 days after application of the sewage sludge.

A farm field used to grow corn or soybeans is an example of land with low potential for public exposure. Even farm workers and family members walk about very little on such fields. Public access restrictions do not apply to farm workers, but workers should be aware of the public health implications of land application and the land application schedule, and should follow good hygiene practice during the 30-day period. For example, workers should be instructed to wash their hands after handling soil or crops that come into contact with soil. Protective clothing and footwear are recommended for workers who work on fields that have recently been applied with Class B biosolids. More safety recommendations for workers handling biosolids are included in Section 2.2.

5.6 Domestic Septage [503.32(c)]

Under Part 503.32(c), pathogen reduction in domestic septage applied to agricultural land, forest, or reclamation sites[2] may be reduced in one of two ways:

- Either all the Class B site restrictions under 503.32(b)(5) --see Section 5.5--must be met,
- Or the pH of the domestic septage must be raised to 12 or higher by alkali addition and maintained at pH 12 or higher for 30 minutes without adding more alkali, and the site restrictions on crop harvesting in 503.32(b)(5)(I-iv) must be met (see Section 5.5). The Part 503 regulation uses the term alkali in the broad sense to mean any substance that causes an increase in pH.

Vector attraction reduction can be met with Option 9, 10, or 13. Domestic septage can be incorporated or injected into the soil to prevent vector attraction, or the pH of the domestic septage can be adjusted as outlined in Option 12 (see Section 8). pH adjustment can fulfill both pathogen and vector attraction reduction.

The pH requirement applies to every container of domestic septage applied to the land, which means that the pH of each container must be monitored. The first alternative reduces exposure to pathogens in land applied domestic septage while environmental factors attenuate pathogens. The second alternative relies on alkali treatment to reduce pathogens and contains the added safeguard of restricting crop harvesting, which prevents exposure to crops grown on domestic septage amended soils.

References and Additional Resources

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[2] Class B sewage sludge requirements apply to domestic septage applied to all other types of land. No pathogen-related requirements apply to domestic septage placed on a surface disposal site.

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