NPDES Compliance Inspection Manual

Chapter 10

EPA Publication Number: 305-K-17-001
Interim Revised Version, January 2017

CHAPTER 10 – SEWAGE SLUDGE (BIOSOLIDS)

Contents

List of Tables

List of Exhibits

Associated Appendices

P. Sludge Inspection Checklists

Related Websites

Office of Wastewater Management (OWM) home page: http://www.epa.gov/owm
Office of Science and Technology (OST) home page: https://www.epa.gov/aboutepa/about-office-water#science

A. REVIEW OF THE SEWAGE SLUDGE REGULATIONS (BIOSOLIDS)

In addition to materials in this chapter, inspectors must be familiar with Chapter 1, "Introduction," and Chapter 2, "Inspection Procedures."

Section 405 of the Clean Water Act (CWA) mandated the development of a federal sludge management program. On February 19, 1993, the Environmental Protection Agency (EPA) promulgated technical standards for the final use or disposal of sewage sludge (see Title 40 *Code of Federal Regulations* (CFR) Part 503, Volume 58 *Federal Register* (FR) 9248). These regulations contain technical standards for three sewage sludge use or disposal practices:

- Land Application (Subpart B)
- Surface Disposal (Subpart C)
- Incineration (Subpart E)

The regulations at 40 CFR Part 503 also include pathogen and alternative vector attraction reduction requirements for sewage sludge applied to the land or placed on a surface disposal site (Subpart D).

The federal and state sludge management programs currently regulate the final use and disposal of sewage sludge, the residual generated from the treatment of domestic sewage in a treatment works. Although the regulations refer to the residual generated from the treatment of domestic sewage as sewage sludge, the term "biosolids" is the current term in general use for those sewage sludges that have been treated and conditioned through biological, chemical, and/or physical processes for beneficial reuse as a soil amendment for growing plants and trees.

In preparation for the issuance of the final technical standards, the National Pollutant Discharge Elimination System (NPDES) regulations were revised to include sludge use or disposal requirements. EPA considers the sludge regulations at 40 CFR Part 503 as the minimum requirements applicable to and enforceable against any facility engaged in a regulated sludge use or disposal practice, regardless of whether that facility's NPDES permit contains sludge use or disposal conditions. EPA has the authority to issue a notice of violation or take other appropriate enforcement actions against facilities that do not comply with 40 CFR Part 503 regulations.

Facilities that are subject to NPDES permit requirements for aqueous discharges to surface waters, such as Publicly Owned Treatment Works (POTWs), are also subject to 40 CFR Part 503 regulations as generators and preparers of sewage sludge. Additionally, facilities that may not have previously been permitted under the NPDES program and are subject to 40 CFR Part 503 regulations will be required to apply for an NPDES permit. Regulated facilities include:

- Facilities designated by the permitting authority as treatment works treating domestic sewage.[6]
- Industrial facilities that separately treat domestic sewage and generate biosolids regulated by 40 CFR Part 503.
- All surface disposal site owners/operators.
- Septage haulers who land apply septage.
- All biosolids incinerator owners/operators.
- Facilities changing the quality of biosolids regulated by 40 CFR Part 503.

The regulations at 40 CFR Part 503 only apply to use and disposal of sewage sludge (including domestic septage), which replaces only a portion of the original 1979 regulations on land application and surface disposal of sludge in 40 CFR Part 257. The land application of industrial sludge continues to be regulated by 40 CFR Part 257. However, disposal of sewage sludge in Municipal Solid Waste Landfills (MSWLFs) is regulated in 40 CFR Part 258 and the operations and air emissions of sewage sludge incinerators is regulated by the Clean Air Act (CAA) under 40 CFR Part 60 and 40 CFR Part 129.

In general, the regulations at 40 CFR Part 503 apply the following types of requirements to the three practices for sewage sludge use or disposal:

- Pollutant limits—9 pollutants under land application (40 CFR 503.13), 3 pollutants under surface disposal (40 CFR 503.23), and 7 pollutants under incineration (40 CFR 503.43).
- Pathogen and vector attraction reduction requirements.
- Nitrogen application rate requirements.
- Management practices for siting and operation of sludge use or disposal activities.
- Minimum monitoring requirements.
- Specific recordkeeping and reporting requirements.

A brief explanation of the requirements that apply to each sewage sludge use or disposal practice is provided below. Pathogen and alternative vector attraction reduction requirements in Subpart D are included in the descriptions for land application (Subpart B) and surface disposal (Subpart C) of sewage sludge and are not described separately in this document.

[6] *Treatment works* is either a federally owned, publicly owned, or privately owned device or system used to treat (including recycle and reclaim) either domestic sewage or a combination of domestic sewage and industrial waste of a liquid nature. *Domestic sewage* is waste and wastewater from humans or household operations that is discharged to or otherwise enters a treatment works. *Domestic septage* is 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 (and does not receive either commercial wastewater or industrial wastewater and does not include grease removed from a grease trap at a restaurant). Note the Part 503 regulations also include simplified requirements for the land application of domestic septage.

LAND APPLICATION REQUIREMENTS (40 CFR PART 503, SUBPART B)

Land application consists of the spreading, spraying, injection, or incorporation of biosolids, including material derived from sewage sludge (e.g., compost, sewage sludge pellets), onto or below the surface of the land to take advantage of the soil-enhancing qualities of the sewage sludge.

General

The general requirements in 40 CFR Part 503, Subpart B prohibit the land application of sewage sludge to agricultural land, forest, a public contact site, or a reclamation site if the sludge does not meet the pollutant limits or ceiling concentrations established in 40 CFR 503.13(b)(1). The person who prepares bulk sewage sludge for land application is responsible for providing the applicator of the sewage sludge a written notification of the concentration of total nitrogen (as N, on a dry weight basis) in the bulk sewage sludge. The preparer of the sewage sludge is responsible for obtaining this information and disseminating this information to respective owners or lease holders to comply with 40 CFR 503.7 regulations.

For sewage sludge that is applied to land in a state other than the state in which the bulk sewage sludge is prepared, the applicator will also provide written notice, prior to the initial application, to the permitting authority for the state in which the bulk sewage sludge is proposed to be applied. The notice shall include:

- The location, by either street address or latitude and longitude, of each land application site.
- The approximate time period bulk sewage sludge will be applied to the site.
- The name, address, telephone number, and NPDES permit number (if appropriate) for the person who prepares the bulk sewage sludge.
- The name, address, telephone number, and NPDES permit number (if appropriate) for the person who will apply the bulk sewage sludge.

Pollutant Limits

The regulations establish four types of limits for nine pollutants. Exhibit 10-1 at the end of this section illustrates which limits apply, based on the final sludge use; conversely, Exhibit 10-2 illustrates which requirements apply, based on the level of treatment achieved.

- Ceiling Concentration Limits—Maximum limits as milligram of pollutant per kilogram of sludge on a dry weight basis for bulk sewage sludge or sewage sludge sold or given away in a bag or other container that can be land applied (listed in Table 1 of 40 CFR 503.13).
- Cumulative Pollutant Loading Rates (CPLRs)—Total amount of pollutant (kilograms) in sludge that does not meet pollutant concentration limits that can be applied to a hectare of agricultural land, forest, public contact site, or reclamation site. When this loading rate is reached, no additional sludge can be applied to the site. CPLRs are listed in Table 2 of 40 CFR 503.13.

- Pollutant Concentration Limits—Monthly average concentration of pollutant as milligram per kilogram of sludge on a dry weight basis (listed in Table 3 of 40 CFR 503.13). They apply to sewage sludge sold or given away in a bag or other container that can be applied to land and as an alternative limit to CPLRs for bulk sewage sludge.
- Annual Pollutant Loading Rates—The amount of pollutant (kilograms) in a bagged product that can be applied in a 365-day period on an area (hectare) of land, calculated as the product of the concentration of each pollutant in the sewage sludge (kilograms of pollutant per kilograms of sludge) and the annual whole sludge application rate for the sewage sludge (kilograms sludge per year). The loading rates (listed in Table 4 of 40 CFR 503.13) are alternative limits to pollutant concentration limits for sewage sludge sold or given away in a bag or other container on a dry weight basis that can be applied each year.

Management Practices

The regulations at 40 CFR 503.14 lists five management practices that supplement the pollutant limits and provide additional protection to endangered species and their habitats, surface water, wetlands, groundwater, and human exposure to the sludge. Four of these practices are applicable to the land application of bulk sludge; one practice is applicable to the labeling or reporting of the bag or other container in which sewage sludge is sold or given away for land application.

Operational Standards: Pathogen and Vector Attraction Reduction Requirements

Prior to land application, sludge must meet both pathogen reduction (i.e., reduction of disease-causing organisms) and vector attraction reduction (i.e., reduction of rodents, flies, mosquitoes, or other organisms capable of transporting infectious agents, ultimately to humans) requirements.

The 1993 40 CFR Part 503 regulations (58 FR 9387) retained substantially the same pathogen reduction requirements as the original 1979 40 CFR Part 257 (44 FR 53460) requirements for land applied sludge. Land-applied sludge must meet one of two categories of pathogen reduction requirements:

- Class A requirements (40 CFR 503.32(a)) must be met when applying bulk sewage sludge to a lawn or home garden or when sewage sludge is sold or given away in a bag or other container to be applied to land. Class A requirements result in a pathogen reduction of the sludge to at or below the detection limits of the method. Class A sewage sludge may be used without site restrictions or limiting public access. Six alternative pathogen reduction approaches are available for achieving Class A sludge in Subpart D.
- Class B requirements (40 CFR 503.32(b)) significantly reduce (but do not eliminate) the pathogens in the sludge and require a waiting period before the land on which the sludge was applied may be used for certain activities. Site restrictions limit the application of Class B sewage sludge to agricultural land, forest, public contact site, or a reclamation site. To meet pathogen reduction requirements, land-applied domestic septage must meet site restriction requirements in 40 CFR 503.32(b)(5) or meet pH

requirements at 40 CFR 503.32(c)(2) and a subset of the site restriction requirements (40 CFR 503.32(b)(5)(i)–503.32(b)(5)(iv)). Three pathogen reduction alternatives (with specific site restrictions for use of the treated sludge) are provided for achieving Class B sludge in Subpart D.

The regulations at 40 CFR Part 503 also require compliance with one of eight vector attraction reduction treatment alternatives if the sludge will be sold or given away in a bag or other container (40 CFR 503.33(a)(3)). Bulk sewage sludge applied to lawns or home gardens must also meet one of eight vector attraction reduction treatment alternatives (40 CFR 503.33(a)(2)). Bulk sewage sludge applied elsewhere must meet one of ten treatment alternatives (40 CFR 503.33(a)(1)).

Monitoring, Recordkeeping, and Reporting Requirements

The regulations at 40 CFR Part 503 requires a minimum monitoring frequency for pollutants and pathogen and vector reduction parameters based on the annual amount of sewage sludge generated by a facility (as shown in Table 1 of 40 CFR 503.16). As with other NPDES provisions, the permitting authority may reduce monitoring frequencies based upon consistent demonstrated performance for at least two years. Land application of domestic septage requires monitoring for pathogen and vector attraction reduction parameters to ensure compliance with those requirements.

The recordkeeping requirements at 40 CFR Part 503 differ depending on the type of pollutant limits applied. Recordkeeping requirements, including certification statements specified in 40 CFR Part 503, are imposed on generators/preparers of sewage sludge and on appliers of domestic septage. The regulations require the facility to retain the specific information for 5 years, except that some information on applicable cumulative pollutant loading rates must be retained by the facility indefinitely.

While all facilities must maintain records, only a subset must report under the regulations at 40 CFR Part 503. Facilities should verify reporting requirements with the permitting authority. Those facilities that must report at least once per year are listed below.

- Class I sludge management facilities[7]
- POTWs with a design capacity equal to or greater than 1 Million Gallons per Day (MGD)
- POTWs serving a population of 10,000 or more

[7] *Class I sludge management facility* is any publicly owned treatment works (POTW), as defined in 40 CFR 501.2, required to have an approved pretreatment program under 40 CFR 403.8(a) (including any POTW located in a state that has elected to assume local program responsibilities pursuant to 40 CFR 403.10(e)) and any treatment works treating domestic sewage, as defined in 40 CFR 122.2, classified as a Class I sludge management facility by the EPA Regional Administrator, or, in the case of approved State programs, the Regional Administrator in conjunction with the State Director, because of the potential for its sewage sludge use or disposal practice to affect public health and the environment adversely.

SURFACE DISPOSAL REQUIREMENTS (40 CFR PART 503, SUBPART C)

A surface disposal site is an area of land that contains one or more active sewage sludge units (i.e., land on which only sewage sludge is placed for final disposal). This does not include land on which sewage sludge is either stored or treated. Surface Disposal includes monofills (sewage sludge-only landfills), dedicated disposal surface application sites, piles or mounds, impoundments, or lagoons.

General

Subpart C requires that sewage sludge shall not be placed on an active sewage sludge unit unless the pollutant limits in 40 CFR 503.23 are met. If an active unit is located within 60 meters of a geologic fault with displacement in Holocene time, located in an unstable area, or located in a wetland, the unit must be enclosed. The operator/owner must notify the permitting authority 180 days prior to closing a unit. Prior owners are required to notify the subsequent owner of the presence of sewage sludge.

Pollutant Limits

The surface disposal regulations at 40 CFR 503.23 control three pollutants. Limits apply to sewage placed at a surface disposal site that does not have a liner and leachate collection system. There are no pollutant limits on sewage sludge placed in sewage sludge units equipped with a liner and leachate collection system. The distance between the active sewage sludge unit and the site property line/boundary determine the specific pollutant limits that apply; the closer to the boundary, the more stringent the limits (see Table 10-3). An owner/operator can request site-specific pollutant limits; the permitting authority establishes these limits through a permit.

Management Practices

The regulations at 40 CFR 503.24 establish a total of 14 management practice requirements. Many are one-time surface disposal site location restrictions. Others address operational activities (e.g., liner, leachate and runoff collection systems, methane gas monitoring) and post-closure activities.

Operational Standards

Prior to surface disposal, sludge must meet both pathogen reduction and vector attraction reduction requirements. Sludge that is placed at a surface disposal site must meet one of the Class A or Class B pathogen reduction alternatives, unless the sewage sludge is covered daily with soil or other material. The inspector should note, however, that the site restrictions included in the Class B pathogen reduction alternatives only apply to land applied sewage sludge, not to surface disposal. In addition to pathogen reduction, surface disposed sludge must also meet one of eleven vector attraction reduction alternatives specified in 40 CFR Part 503, Subpart D. Although domestic septage does not have pathogen reduction requirements, one of four vector attraction reduction requirements must be met prior to placing it on an active sewage sludge unit.

Monitoring, Recordkeeping, and Reporting Requirements

The regulations at 40 CFR Part 503 require a minimum monitoring frequency for pollutants and pathogen and vector reduction parameters based on the annual amount of sewage sludge disposed by a facility (as shown in Table 1 of 40 CFR 503.26). Like land application requirements for monitoring, the permitting authority may reduce monitoring frequencies based upon consistent demonstrated performance for at least two years. Surface disposal of domestic septage requires monitoring for vector attraction reduction parameters to ensure compliance with those requirements.

Recordkeeping requirements (40 CFR 503.26 to 503.28) include certification statements specified for the sludge generator or final preparer and/or the owner/operator of the surface disposal site. The facility must maintain all records for 5 years. While all facilities must maintain records, only a subset must report under the sewage sludge regulations. Facilities should verify reporting requirements with the permitting authority. Those facilities that must report at least once per year are listed below.

- Class I sludge management facilities
- POTWs with a design capacity equal to or greater than 1 Million Gallons per Day (MGD)
- POTWs serving a population of 10,000 or more

INCINERATION REQUIREMENTS (SUBPART E)

Incineration of sewage sludge is the firing of sludge at high temperatures in an enclosed device.

General

Sewage sludge incineration must be in compliance with the requirements in this subpart.

Pollutant Limits

The sewage sludge regulations impose pollutant limits on seven pollutants in the exit gas from a sewage sludge incinerator stack. Beryllium and mercury must comply with the national emissions standards in subparts C and E of 40 CFR Part 61. Limits on the five remaining metals are calculated by the permitting authority based on-site-specific factors using the equations specified in 40 CFR 503.43. Lead limits factor in the National Ambient Air Quality Standard for lead. Limits for arsenic, cadmium, chromium, and nickel are based on chemical-specific risk-specific concentrations. Limits for the remaining two pollutants (mercury and beryllium) are derived from air emission standards promulgated under 40 CFR Part 61. These limits appear in the permit issued to the owner/operator of the sewage sludge incinerator.

Management Practices

The seven management practices in 40 CFR 503.45 ensure that certain detection and measurement instruments are correctly installed, calibrated, operated, and maintained; that incinerator maximum combustion temperature and air pollution control equipment operating standards are established; and that endangered species and their habitats are protected. The permitting authority is required to include specific management practice requirements based on-site-specific factors and these should appear in the incinerator's permit.

Operational Standards

The sewage sludge regulations establish an average monthly standard on the total hydrocarbons (THC) or carbon monoxide (CO) concentration in the exit gases (i.e., stack gas) of an incinerator to protect from excessive emissions of organic pollutants. The owner/operator must correct the measured concentrations to account for variations in moisture and oxygen content in the stack gas. The monthly standards must be normalized to 0 percent moisture and 7 percent oxygen in the stack gas. Monthly average concentrations of 100 parts per million (ppm) for TCH or CO must be met.

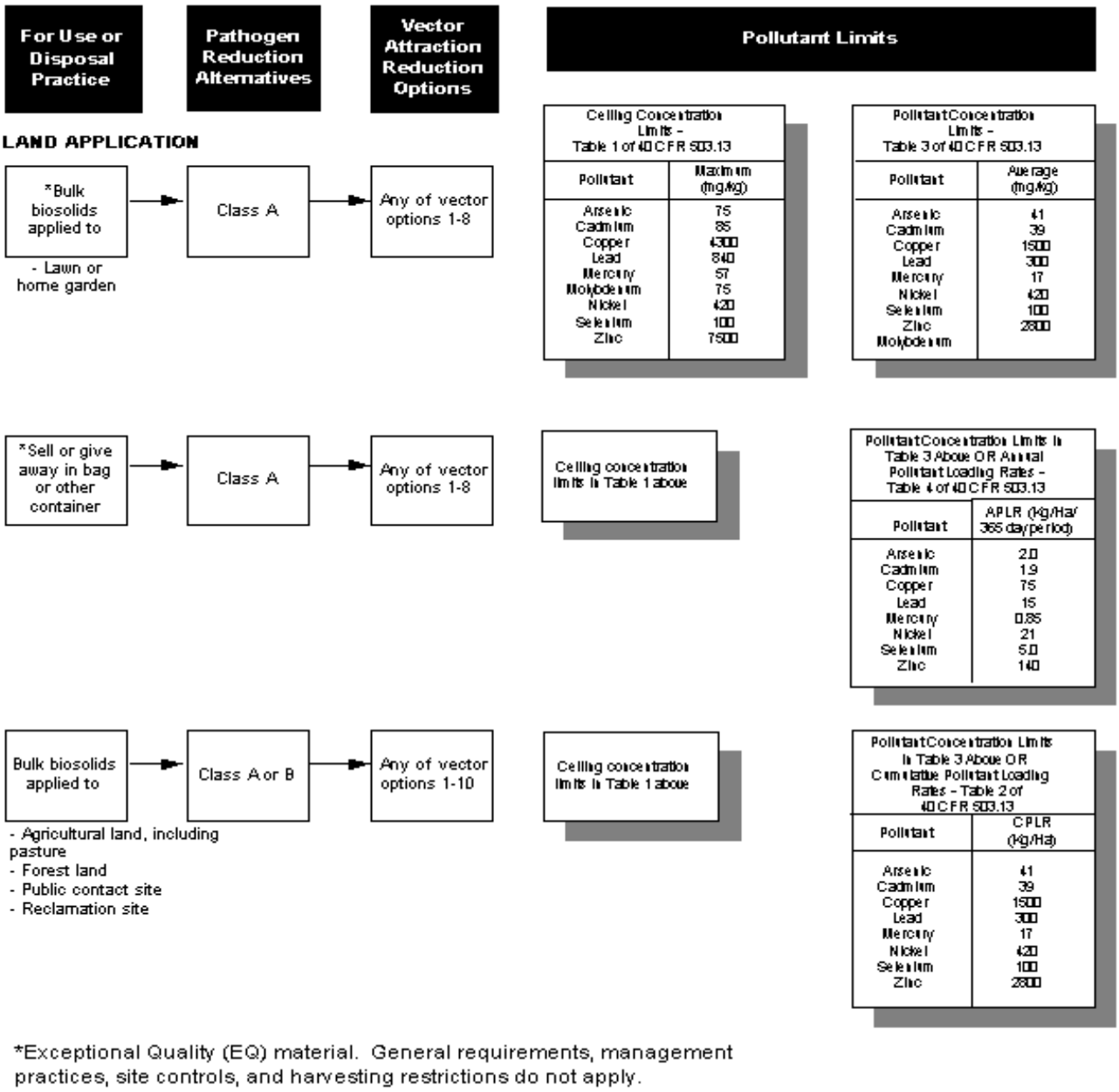
Monitoring, Recordkeeping and Reporting Requirements

The regulations at 40 CFR 503.47 and 503.48(a) impose monitoring requirements on the incinerator owner/operator. Sections 503.46 to 503.48 of the sludge regulations require monitoring of (a) sewage sludge for pollutant (i.e., seven metals) concentrations; (b) incinerator stack exit gases for total hydrocarbon or, alternatively, carbon monoxide (CO), oxygen concentrations and moisture content; and (c) incinerator combustion temperatures and air pollution control equipment operating parameters. Monitoring requirements to demonstrate compliance with Part 61 beryllium and mercury standards are also imposed on owners/operators of sewage sludge incinerators (40 CFR 503.47(d)–(e)).

Records required to be maintained by owners/operators of incinerators are specified both in 40 CFR 503.47 and site-specific conditions in the NPDES or sludge permit. Owners/operators must keep records for a minimum of five years and include information on sludge pollutant limits, management practices, and monitoring requirements.

While all facilities must maintain records, only a subset must report under the sewage sludge regulations. Facilities should verify reporting requirements with the permitting authority. Those facilities that must report at least once per year are listed below.

- Class I sludge management facilities
- POTWs with a design capacity equal to or greater than 1 million gallons per day (MGD)
- POTWs serving a population of 10,000 or more



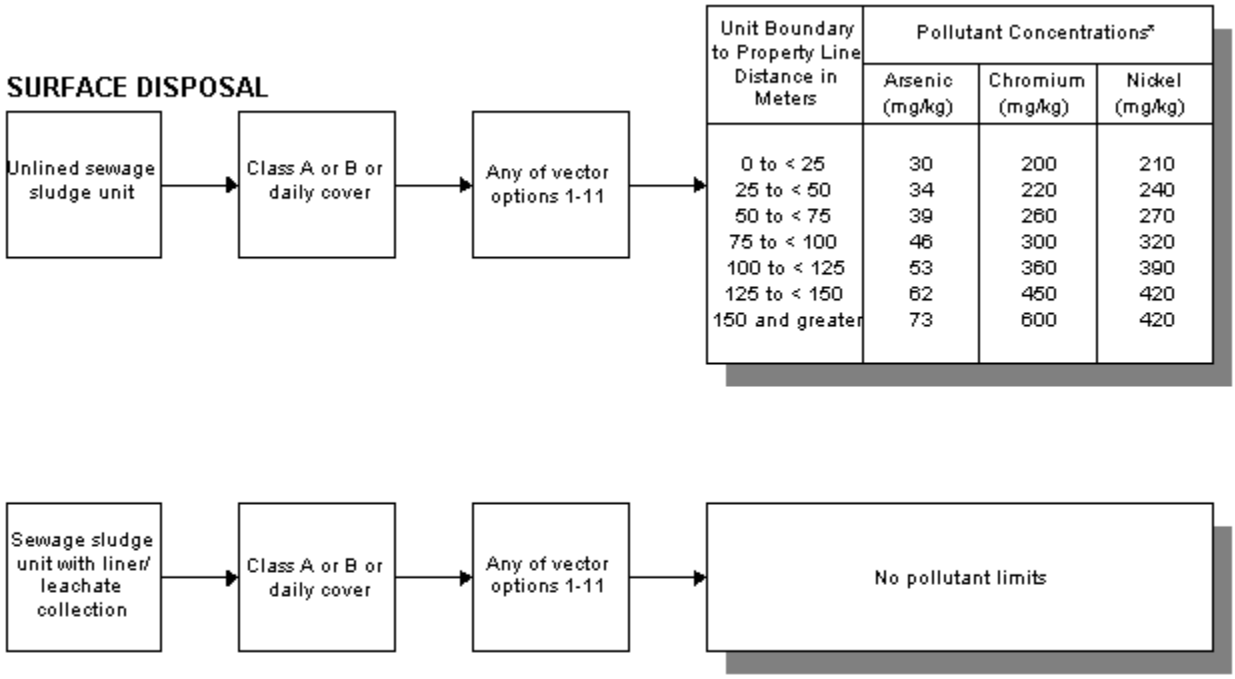
*Exceptional Quality (EQ) material. General requirements, management practices, site controls, and harvesting restrictions do not apply.

Exhibit 10-1. Sludge Quality Requirements for Land Application Uses

SLUDGE TYPE	RESULTING REQUIREMENTS
Exceptional Quality (EQ)	
1) Meets all pollutant concentration limits (Table 2-1, p. 29) 2) Meets any of the Class A alternatives (Table 2-5, p. 37) 3) Meets any of V.A.R. Options 1-8 (Table 2-6, p. 37)	Unregulated for Use Monitoring, Recordkeeping, and Reporting Requirements
Pollutant Concentration (PC)	
1) Meets all pollutant concentration limits (Table 2-1, p. 29) 2) Meets any of the Class B alternatives (Table 2-5, p. 37) 3) Meets any of V.A.R. Options 1-10 (Table 2-6, p. 37)	Site Restrictions (Fig. 2-4, p. 38) Management Practices (Fig. 2-9, p. 45) General Requirements (Fig. 2-8, p. 44) Monitoring, Recordkeeping, and Reporting Requirements
OR	
1) Meets all pollutant concentration limits (Table 2-1, p. 29) 2) Meets any of the Class A alternatives (Table 2-5, p. 37) 3) Meets V.A.R. Option 9 or 10 (Table 2-6, p. 37)	Management Practices (Fig. 2-9, p. 45) General Requirements (Fig. 2-8, p. 44) Monitoring, Recordkeeping, and Reporting Requirements
Cumulative Pollutant Loading Rate (CPLR)	
1) Meets ceiling concentration limits (Table 2-1, p. 29) 2) Meets any Class A or Class B alternative (Table 2-5, p. 37) 3) Meets any of V.A.R. Options 1-10 (Table 2-6, p. 37)	Site Restrictions (Fig. 2-4, p. 38) Management Practices (Fig. 2-9, p. 45) General Requirements (Fig. 2-8, p. 44) Monitoring, Recordkeeping, and Reporting Requirements CPLR Loading Rate Limits (Table 2-1, p. 29)
Annual Pollutant Loading Rate (APLR) **(For solids sold or given away)**	
1) Meets ceiling concentration limits (Table 2-1, p. 29) 2) Meets any of the Class A alternatives (Table 2-5, p. 37) 3) Meets any of V.A.R. Options 1-8 (Table 2-6, p. 37)	Site Restrictions (Fig. 2-4, p. 38) Management Practices (Fig. 2-9, p. 45) General Requirements (Fig. 2-8, p. 44) Monitoring, Recordkeeping, and Reporting Requirements APLR Loading Rate Limits (Table 2-1, p. 29)

Note: Tables and pages numbers reference above are from EPA's *A Plain English Guide to the EPA Part 503 Biosolids Rule*, September 1994

Exhibit 10-2. Land Applied Sludge Requirements Based on Level of Treatment Achieved



Unit Boundary to Property Line Distance in Meters	Pollutant Concentrations*		
	Arsenic (mg/kg)	Chromium (mg/kg)	Nickel (mg/kg)
0 to < 25	30	200	210
25 to < 50	34	220	240
50 to < 75	39	260	270
75 to < 100	46	300	320
100 to < 125	53	360	390
125 to < 150	62	450	420
150 and greater	73	600	420

** Site-specific limits may be approved by the permitting authority, if requested.*

Exhibit 10-3. Sludge Quality Requirements for Surface Disposal

B. SLUDGE (BIOSOLIDS) INSPECTION PROCEDURES

SCOPE OF INSPECTION ACTIVITIES

Inspectors should verify compliance with the following general activities:

- Sludge monitoring, recordkeeping, and reporting
- Sludge treatment operations and maintenance
- Sludge sampling and laboratory Quality Assurance (QA)

EPA intends for the evaluation of sludge management activities to be incorporated into the existing NPDES inspection structure so that inspection resources can be used most efficiently. The inspector can identify and investigate problems that might contribute to noncompliance with sludge requirements during any inspection site visit. The Pretreatment Compliance Inspection (PCI), the Compliance Evaluation Inspection (CEI), the Compliance Sampling Inspection (CSI), and the Performance Audit Inspection (PAI) are the most likely vehicles for evaluating compliance with sludge requirements. Examples of how the NPDES inspector may use existing NPDES inspections when evaluating sludge requirements are presented below.

- PCI—During a PCI, the inspector evaluates a POTW's compliance with its pretreatment program, which includes consideration of whether any pollutants from non-domestic sources are passing through the treatment processes and accumulating in the sludge.
- CEI—The inspector has historically looked at sludge treatment as part of the CEI because of its effect on wastewater treatment. Evaluation of sludge treatment during a CEI should be expanded to include a review of sludge monitoring, reporting, and record-keeping, and a more comprehensive evaluation of the Operation and Maintenance (O&M) of sludge treatment processes, to evaluate compliance with sludge permit requirements.
- CSI—The CSI is used if the inspector decides that sludge sampling is necessary to determine compliance with applicable requirements.
- PAI—The PAI may evaluate compliance with sludge monitoring requirements, and evaluate the permittee's sludge sampling and analytical procedures.

While NPDES inspectors are not required to conduct an in-depth compliance assessment of sludge final use and disposal practices when such practices occur away from the wastewater treatment plant (WWTP), it can help ascertain the vector reduction compliance status at these sites rather than at the WWTP. In situations where final use and disposal requirements have been established in the facility's NPDES permit (e.g., management practices such as 10-meter buffer zones between the sludge application site and surface waters) and the activity is off-site, the inspector should verify compliance with those requirements through a records review at the facility. As part of a sampling inspection, the inspector may need to sample the sludge to determine compliance with pollutant limits.

EPA intends to focus sludge inspection activities on those aspects of sludge management that the inspector can easily evaluate during an existing NPDES compliance or pretreatment inspection. Inspectors will rely on an evaluation of sludge treatment operations, the observation of on-site sludge storage and disposal activities, and the review of sludge monitoring and disposal records to identify actual and potential noncompliance with sludge requirements. Inspectors should document compliance or noncompliance with sludge final use or disposal requirements in accordance with standard NPDES compliance inspection procedures. An optional inspection checklist is useful for documenting that all necessary information has been collected. Sludge Inspection checklists are included in Appendix P of this manual. These checklists are based on the checklists in EPA's *Guidance for NPDES Compliance Inspector: Evaluation of Sludge Treatment Processes* (EPA, 1991a) and *Guidance for NPDES Compliance Inspector: Verifying Compliance with Sludge Requirements* (EPA, 1991b), as modified by EPA Region 8. The checklists should be used in conjunction with the checklist questions found in the 1991 guidance manuals. However, sludge permits may contain additional sludge permit conditions based on case-by-case considerations that are not included on the checklist. The inspector should identify additional permit requirements and verify compliance with these conditions as well. To accomplish this, it is recommended that the inspector expand the checklist, if necessary, to ensure that it is specific to the NPDES permit and the sludge final use or disposal activity. The inspector should complete the checklist and should incorporate his/her findings and conclusions in the final inspection report prepared for the facility.

The NPDES compliance inspector should also consult EPA's *Guidance for NPDES Compliance Inspector: Evaluation of Sludge Treatment Processes* (EPA, 1991a) when preparing to conduct a sludge inspection. This technical reference presents a detailed examination of sludge unit processes and contains extensive technical checklists that summarize the most critical elements of sludge thickening, stabilization, conditioning, dewatering, and disinfection. A technical understanding of the proper design and operation of the sludge treatment processes is essential for conducting thorough and informed sludge inspections.

INSPECTION PREPARATION

On preparing for the inspection, the inspector should:

- Review the NPDES permit (or the facility's sludge permit, if applicable). When reviewing the NPDES permit file in preparation for the inspection, identify:
  - Permit conditions applicable to sludge including treatment; general requirements; management practices; and monitoring, reporting, and recordkeeping requirements.
  - Any additional requirements in the NPDES permit that may reflect state regulations. Additionally, the NPDES permit may incorporate a separate state permit by reference, in which case the state permit is also enforceable under the federal CWA.
- Review sludge self-monitoring data.
- Become familiar with the sludge disposal practices used.

- Review appropriate federal regulations (i.e., 40 CFR Part 503, or 40 CFR Part 258 if sludge is disposed of in a municipal solid waste landfill, and any other applicable state or local regulations).
- Review relevant guidance for background information and implementation procedures (e.g., guidelines on calculating agronomic rate, EPA's Process Design Manuals (EPA, 1975; EPA, 1979; EPA, 1982; EPA, 1995a)).
- Verify that records kept by the permittee help in evaluation of compliance with sludge requirements.

RECORDS REVIEW

The sewage sludge regulations contain recordkeeping and reporting requirements. The facility's NPDES or sludge permit may have additional recordkeeping or reporting requirements. The inspector should conduct an evaluation of the sludge records and reports found at the facility to determine compliance with these recordkeeping and reporting requirements. The inspector may find sampling records and files containing sludge feed rate measurements from several different wastestreams. The inspector should use the procedures listed below for these routine inspections. If suspected violations are uncovered during the routine evaluation, a more intensive investigation should be conducted.

The inspector should evaluate compliance by asking the following questions:

- Does the facility have all required information available for review?
- Does the facility address all regulated pollutants and sludge use and disposal practices?
- Does the facility have all the current sludge information?
- Does the facility maintain sludge records for at least 5 years?
- Does the facility's information contained in the sludge records support the data submitted to the permitting authority?
- Do the facility's records indicate areas needing further investigation?

The inspector should also identify whether violations of sludge-related permit requirements (e.g., concentration limits and/or management practices) have been reported to the control authority, as required by the permit. Finally, the inspector should verify that the permittee has notified EPA of any changes to sludge use or disposal practices.

Evaluation Procedures

The inspector should first review the permit and fact sheet and list all sludge recordkeeping requirements.

Table 10-1 is a list of records that may be relevant for sludge. This list is supplemented by Table 10-2, which describes records relevant to the operation of specific sludge treatment unit processes. Throughout the inspection, compare the facility's operations with the permit conditions to verify that required permit activities for sludge are correct, current, and complete.

An evaluation of sludge self-monitoring records and/or procedures involves the same elements as an evaluation of their wastewater monitoring data; however, there are some special considerations inherent in sludge sampling. In evaluating the permittee's records, inspectors should look for documentation regarding:

- Regulated pollutants—As identified in the NPDES permit or applicable federal or state regulations.
- Monitoring frequency—As identified in the NPDES permit or applicable federal or state regulations. The inspector should note that 40 CFR Part 503 establishes minimum monitoring frequencies based on the quantity of sewage sludge used or disposed of.
- Sample location—The appropriate sampling point is the final treatment process the sludge goes through before leaving the treatment plant for use or disposal. For example, if a composted sludge is land applied, the finish compost pile/distribution pile should be sampled. If digested sludge is land applied, the sludge should be sampled as it is transferred from the digester or dewatering to the truck prior to being hauled off-site. Table 10-3 identifies sludge sampling points appropriate for the various types of treated sludge.
- Sample types—Grabs or composites may be appropriate depending on the situation, but it is important to note that a grab sample from a lagoon, drying bed, compost pile, or truck must consist of numerous samples collected from various places in the lagoon, bed, pile, or truck and must be combined to make a representative sample.
- Sample volume—If evaluating the sample collection process or taking samples, the inspector must ensure that the container is not filled completely. Some space should be left to allow for expansion of the sample due to gas production. Rapid cooling of the sample will also reduce gas production.
- Sample containers—Sample containers are generally the same types as those used for collection of wastewater samples.
- EPA sample identification methods—Same as for wastewater sampling.
- Preservation and holding times—The primary difference in sludge preservation is that samples should not be chemically preserved in the field because the sludge matrix makes it difficult to thoroughly mix the preservative into the sample. However, samples should be iced.
- Chain-of-custody—Same as for wastewater sampling.
- Quality control—Same as for wastewater sampling.
- Analytical procedures used by lab—The analytical methods used for sludge are different from those used for wastewater. Approved analytical methods are listed in 40 CFR 503.8 or 40 CFR Part 136, where 40 CFR Part 503 does not require a specific method. For example, 40 CFR Part 503 requires that analyses for inorganic pollutants use the procedures in *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (EPA, 1980a). The inspector should note the information recorded regarding sample

handling and analysis at the laboratory and verify that it is correct. If evaluating the laboratory, the procedures are the same as those followed in a PAI. The inspector should look at:

  - Analytical procedures
  - Laboratory services
  - Instruments and equipment
    - Calibration
    - Maintenance
  - Supplies
  - Quality Assurance/Quality Control (QA/QC)
    - Precision and accuracy of measurement process
    - Data handling and reporting
    - Records retention
    - Personnel qualifications

- Analytical results—Verify that results documented in the files are consistent with those reported.

The inspector should verify that reporting requirements are fulfilled according to the permit and applicable regulations. The NPDES permit may or may not have specific reporting requirements; however, the 40 CFR Part 503 sludge standards have specific reporting requirements that apply regardless of whether they appear in the NPDES permit. The May 1989 revisions to the NPDES regulations (54 FR 18716) established standard permit conditions regarding notification of change and at least annual reporting of sludge monitoring results. As NPDES permits are reissued, they will contain, at a minimum, these standard conditions as well as conditions specified in 40 CFR Part 503. Based on the applicable requirements, the inspector should verify that:

- Reports contain all required information.
- Reports are submitted at the required frequency.
- Data are reported in the Discharge Monitoring Report (DMR) or other approved form.

Inspectors should review unit operation records to verify compliance with pathogen and vector attraction reduction requirements. Table 10-4, Table 10-5, and Table 10-6 list the records and operating requirements for the 40 CFR Part 503, Class A pathogen reduction alternatives, the Class B pathogen reduction alternatives, and the vector attraction reduction options, respectively. Inspectors are not expected to review each monitoring record, but rather to verify that records are being maintained and are available for review. If a permittee has problems meeting either its pathogen or vector attraction reduction requirements (e.g., fecal coliform or percent volatile solids reduction), the inspector should review treatment operating records to identify potential noncompliance with the operating requirements specified in 40 CFR Part 503 for the pathogen and vector reduction process employed by the permittee. For example, an

inspector might check a treatment facility's pH or temperature records to determine whether the sludge has been maintained at the appropriate pH or temperature for the required duration during treatment.

The inspector should verify that records are available for all disposal practices:

- Volume of sludge disposed of.
- Sludge quality data.
- Specific records appropriate for demonstrating compliance with the general requirements, management practices, and operational standards.

The inspector should verify whether records are maintained in accordance with permit requirements. Federal regulations provide that all permits must include a provision requiring that sludge records be kept by the appropriate entity for five years. The regulations establish specific recordkeeping requirements for each party involved in the sewage sludge use or disposal process. During records review, the inspector may observe:

- Records not organized or placed in different areas throughout the facility.
- Non-representative sampling of disposed sludge.
- Incorrect reporting of sludge, e.g., failure to report on a dry weight basis.
- Inaccurate recordkeeping to determine pathogen and vector attraction reduction.
- Process control parameters that are not maintained.

FACILITY SITE REVIEW

In the facility site review, the inspector should include any area where sludge is generated, treated, stored, dewatered or disposed. A visual inspection can determine where monitoring devices are place and whether they are appropriate.

Inspection of Solids Handling Unit Processes

Sludge processing arguably poses the greatest challenges in wastewater treatment from the standpoints of design, operation, and maintenance.

When conducting the walk-through visual inspection of the facility, the inspector should be aware of, and look for, physical conditions that are indicative of potential or existing problems. The inspector should also note any out of service equipment and the general conditions of the area and equipment. Some of the more common indicators of potential problems are listed in Table 10-7. The presence of these conditions may warrant a more in-depth inspection of the sludge treatment processes. An optional checklist is provided at the end of this chapter to assist the inspector during the facility site review. The questions on this checklist are sludge-specific and should be asked in conjunction with the Facility Site Review checklist. In addition, many of the questions in the NPDES checklist relate to the overall operation of the facility and therefore, can also be applied to sludge evaluations (e.g., treatment units properly operated and maintained).

The inspector should determine whether the facility is operating its sludge treatment and disposal processes in a manner consistent with the requirements established in its NPDES permit. If the inspector discovers conditions at the facility that threaten public health or the environment (e.g., contaminating groundwater or surface water, exposing the public to pathogens or disease vectors, or compromising public safety), the inspector should inform the enforcement staff so that appropriate action can be taken. If known endangerment is discovered, the criminal investigations unit should be informed.

Many large-scale operations are conducted outside, such as sludge drying, composting, temporary and long-term storage, and loading and hauling. Inspectors should note these outside operations' exposure to rainfall and runoff collection and treatment methods. If stormwater collection devices have been constructed, the inspector should evaluate the performance and maintenance of these devices as well as their design capacity (e.g., the 10-year, 24-hour storm event or the 25-year, 24-hour storm event). Visual observations can detect obvious problems that may contribute to the contamination of surface water or groundwater such as erosion, breaches of dikes or berms, or cracks in the concrete or asphalt. The inspector should inquire as to whether the capacity of the collection devices has ever been exceeded during any storm event.

The sludge loading area should be inspected to determine how the sludge is being hauled or transported. The inspector should note the size of the truckloads and the number of truckloads hauled over a 1-day period (or another time period). Table 10-4, Table 10-5, and Table 10-6 are useful to the inspector in verifying the permittee's records and reports on the volume of sludge generated and disposed of.

Sludge Storage

The inspector should also verify that the permittee has adequate storage capacity for its sludge in the event that its preferred disposal method is interrupted for any reason (e.g., noncompliance with cumulative loading rates on the land application site). There are no federal requirements specifying a minimal storage capacity; the appropriate capacity will vary depending on the amount of sludge generated and the facility's use or disposal option(s). Storage capacity should address normal, routine storage prior to disposal and should anticipate emergency conditions, such as:

- Equipment malfunction
- Inclement weather
- Unanticipated loss of disposal site:
  - Farmer decides to discontinue use of sewage sludge
  - Landfill violates requirements and may no longer accept sludge or must close

Some states have developed storage capacity requirements. If the permittee cannot dispose of its sludge in the preferred manner, it should have either adequate storage capacity for its sludge or clearly established plans for alternative methods of disposal.

SAMPLING AND LABORATORY QUALITY ASSURANCE (QA)

The sludge inspection should evaluate the nature, scope, and adequacy of sludge sampling and analysis conducted by the permittee. The most likely existing inspection vehicle for conducting this evaluation is the PAI, since it involves a detailed assessment of the permittee's self-monitoring activities, including sample collection and laboratory analysis (likely completed by an off-site laboratory). The findings of the sampling and laboratory QA review should be summarized by the inspector and included in the final inspection report for the facility.

Sampling Procedures and Techniques

The inspector's evaluation of the permittee's sludge sampling procedures will address similar criteria as those evaluated in the context of wastewater sampling. The sampling procedure elements that should be evaluated during the inspection include:

- Sample collection techniques:
  - Selection of representative sampling sites
  - Sample types
  - Sample volume
  - Sample containers
- EPA sample identification methods
- Sample preservation and holding time
- Chain-of-custody and shipment of samples
- Quality control (QC):
  - Duplicates
  - Blanks
- Data handling and reporting

A detailed discussion on evaluating these elements can be found in Chapter 5. While many of these elements are evaluated using the same criteria, regardless of the media being sampled, sludge sample collection techniques and sample preservation are different. The inspector should review EPA's sewage sludge sampling video and refer to EPA's *POTW Sludge Sampling and Analysis Guidance Document* (EPA, 1989) for detailed information regarding sludge sampling procedures. Additionally, the inspector can review 40 CFR Part 136 for additional methods. Table 10-3 of this manual summarizes appropriate sample locations. Lists of approved biosolids analytical methods, sample containers, preservation techniques, and holding times for biosolids samples can be found on EPA's website at: https://www.epa.gov/biosolids/additional-information-biosolids-managers#analytical. In addition to these references, a few special sludge sampling considerations are described below.

- Equipment. The equipment used to collect sludge samples is different from that used to collect wastewater samples. The automatic composite samplers used to collect wastewater cannot be used to collect sludge samples because the high solids content of the sludge fouls the tubing. The type of equipment used to collect samples of soil or

other solid waste material is more appropriate for the collection of sludge samples. Stainless steel buckets, trowels, and augers are typically used to collect solid sludge cake. Graduated glass or plastic pitchers or cylinders, or plastic or stainless steel buckets are used to collect liquid sludge samples.

- Sample Location. If the permit does not identify a specific sludge sampling location, the inspector must select one. See EPA's 1993 sewage sludge sampling video for an overview of this process (EPA, 1993a). The inspector can review 40 CFR Part 136 for additional methods. EPA's *POTW Sludge Sampling and Analysis Guidance Manual* (EPA, 1989) states that for purposes of enforcement, sludge samples must come from the treatment unit process immediately prior to sludge disposal or end use. Often, the last unit process is one of the dewatering processes described in the accompanying technical guidance. Table 10-3, EPA's *POTW Sludge Sampling and Analysis Guidance Manual* (EPA, 1989a), suggests appropriate sampling points for a variety of unit processes.

Table 10-1. Records Relevant for Sludge Operations

Sludge Use/Disposal Records
• Volume • Type of use and/or disposal options used • Use/disposal sites
Sludge Operating Records
• Daily operating log • Equipment maintenance scheduled and completed
Sludge Monitoring Records
• Constituents/pollutants in sludge • Mass of sludge generated and disposed of (in dry metric tons per year)
Sludge Sampling and Analytical Data
• Dates, times, and locations of sampling • Sampling protocols and analytical methods • Results of analyses • Dates and times of analyses • Name(s) of analysis and sampling personnel
Sludge Laboratory Records
• Calibration and maintenance of equipment • Laboratory bench sheets or logs and calculations • Quality Assurance/Quality Control (QA/QC) records

Table 10-2. Operating Records for Specific Unit Processes

THICKENING PROCESSES		
Gravity Thickening	**Dissolved Air Flotation**	**Centrifuge**

• Overflow volume/rate
• Influent flow
• Percent solids
  - Sludge feed
  - Thickened sludge
  - Overflow
• Sludge blanket depth
	• Sludge feed rate
	• Recycle flow
	• Daily operating time
	• Percent solids
	  - Sludge feed
	  - Thickened sludge
	  - Subnatant
	• Floating sludge depth
	• Air flow rate
	• Retention tank pressure
	• Percent solids capture
	• Detention time
	• Air to solid ratio
		• Influent sludge flows
		• Volume cake produced
		• Percent solids
		  - Sludge feed
		  - Centrate
		  - Sludge cake
		• Daily operating time

STABILIZATION PROCESSES (Pathogen and/or Vector Attraction Reduction)		
Aerobic Digestion	**Anaerobic Digestion**	**Incineration**

• Air supply
• Solids retention time
• Temperature
• DO level
• pH
• Feed sludge
  - TS, TVS, and pH
  - Flow rate
• Digested sludge
  - SOUR
  - TS, TVS, and pH
  - Flow rate
• Supernatant
  - Flow rate and BOD
  - TSS and pH
	• Detention time
	• Temperature
	• pH and alkalinity
	• Gas production and quality
	• Volatile acids
	• Feed sludge
	  - TS, TVS, and pH
	  - Flow rate
	• Digested sludge
	  - TS, TVS, and pH
	  - Flow rate
	• Supernatant
	  - Flow rate and BOD
	  - TSS and pH
	• Cleaning frequency
		• Operating schedule
		• Sludge feed
		  - Solids content
		  - Feed rate
		  - Volatile solids
		• Combustion temperature
		• Sludge residence time
		• Fuel flow
		• Off-gas oxygen content
		• Air feed rate
		• Emission control equipment
		  - Pressure drop
		• Type of fuel
		• Volume of ash produced
		• Stack gas monitoring

Heat Temperature	**Composting**	**Chemical Conditioning/Stabilization**

• Temperature/time
• Pressure
• Detention time
• Feed sludge
  - TS and TVS
  - Flow rate
  - Percent solids
• End product volatile solids
	• Oxygen concentration
	• Temperature and time
	• Turning frequency
	• Percent sludge solids
	• Type and amount of bulking agent(s)
	• Header pressure
		• Chemical types and dosage
		• Mixing
		• pH
		• Temperature

Electron Irradiation	**Gamma Irradiation**	
• Sludge feed rate • Electron dosage • Temperature	• Sludge feed rate • Gamma ray source strength	
DEWATERING PROCESS		

Table 10-2. Operating Records for Specific Unit Processes

Vacuum Filter	Pressure Filter	Belt Filter Press

• Sludge feed
  - Total solids
• Sludge cake
  - Total solids
• Filtrate
  - Flow
  - BOD
  - TSS
• Maintenance
• Spare parts
	• Sludge feed percent solids
	• Sludge cake percent solids
	• Volume of sludge processed
	• Cycle length
	• Volume conditioning chemicals
	• Filtrate
	  - Flow
	  - BOD
	  - TSS
		• Loading rate
		• Operating speed
		• Feed slurry
		  - Total solids and flow
		• Dewatered sludge
		  - Total solids
		  - Flow
		• Filtrate and wash water
		  - BOD and SS
		  - TSS and flow
		• Preventive maintenance
		• Polymer

Drying Bed	**Drying Lagoons**	**Heat Drying**

• Sludge loading rate
• Quantity in bed
• Depth of sludge in bed
• Date deposited
• Detention time
• Ambient temperature
• Drying bed construction (i.e., lined)
• Undertrain destination
• Percent solids of the sludge feed and of the dewatered sludge
	• Sludge loading rate
	• Percent solids
	  - Sludge
	  - Decant
	• Quantity in lagoon
	• Depth in lagoon
	• Date deposited
	• Drying time
	• Rainfall
		• Operating schedule
		  - Start-up
		  - Shut down
		• Sludge feed rate
		• Percent solids
		  - Sludge feed
		  - Dried/Pelletized product
		• Fuel consumption
		• Air flow
		• Drying temperature
		• Detention time
		• Stack gas monitoring
		  - Oxygen
		  - Particulates
		  - Carbon monoxide
		  - Carbon dioxide

LEGEND:
DO = Dissolved Oxygen
TS = Total Solids
TVS = Total Volatile Solids
BOD = Biochemical Oxygen Demand
TSS = Total Suspended Solids
SS = Suspended Solids
SOUR = Specific Oxygen Uptake Rate

Table 10-3. Sludge Sampling Points

Sludge Type	Sampling Point
Anaerobically Digested	Sample from taps on the discharge side of positive displacement pumps.
Aerobically Digested	Sample from taps on the discharge lines from pumps. If batch digester is used, sample directly from the digester. Two cautionary notes regarding this practice: • If aerated during sampling, air entrains in the sample. Volatile organic compounds may purge with escaping air. • When aeration is shut off, solids separate rapidly in well-digested sludge.
Thickened	Sample from taps on the discharge side of positive displacement pumps.
Heat Treated	Sample from taps on the discharge side of positive displacement pumps after decanting. Be careful when sampling heat treatment sludge because of: • High tendency for solids separation. • High temperature of samples (frequently >60°C) can cause problems with certain sample containers due to cooling and subsequent contraction of entrained gases.
Dewatered by Belt Filter Press, Plate and Frame Press, Centrifuge, or Vacuum Filter Press	Sample from sludge cake discharge chute and conveyor.
	Alternatively, sample from collection container or storage bin for the dewatered sludge; sample from many locations within the storage bin and at various depths, collect equal samples from each point, and combine them to form one sample of the total storage bin.
Dewatered or Air Dried in Drying Beds, or Bin or Truck Bed	Divide bed into four quadrants, collect equal sample volume from the center of each quadrant, and combine them to form one sample of the total bed. Each grab sample should include the entire depth of the sludge (down to the sand).
Composted	Collect full core samples from randomly selected sites in the pile. Sample directly from front-end loader or other conveyance device as the sludge is being loaded into trucks to be hauled away.

- Sample Collection Techniques. Obtaining a representative sample of sludge is difficult when the sludge is not flowing through a pipe or along a conveyer. To obtain a representative sample of sludge from a sludge bed or lagoon, a compost pile, or a truck, several samples must be taken from various places in the pile and "combined" to make a representative sample.
- Sample Preservation. Samples of solid sludge are not usually preserved in the field because it is difficult to thoroughly mix the preservative throughout the sludge sample. It is best to preserve sludge samples that are high in solids at the laboratory. Use the appropriate field preservative to chill the sample to 4°C. Note, some exemptions do exist such as a sample for the Specific Oxygen Uptake Rate (SOUR), which should be

kept at the same temperature as the aerobic digester and analyzed within 30 minutes of sample collection.

Laboratory Analysis and Quality Assurance

During a PAI, the inspector is already conducting an in-depth evaluation of the permittee's laboratory analytical techniques and QA/QC procedures. The following elements are evaluated during this inspection:

- Permittee sample handling procedures in the laboratory.
- Laboratory analysis techniques:
  - Permittee laboratory analytical procedures (analytical methods specified by 40 CFR Part 503 or other methods established in the permit).
  - Laboratory services.
  - Instruments and equipment.
  - Supplies.
- QA/QC:
  - Precision and accuracy of the measurement process.
  - Data handling and reporting.
  - Sludge records retention (for 5 years).
  - Personnel qualifications.

Again, many of these elements are evaluated according to the same criteria regardless of the sample being analyzed. The inspector is referred to Chapter 7 and EPA's *NPDES Compliance Monitoring Inspector Training Module: Laboratory Analysis* (EPA, 1990a) for general guidance on inspecting the permittee's laboratory procedures. There are some differences in sample preparation and analytical techniques for sludge with which the inspector should be familiar.

In conducting the sludge component of the PAI, the inspector should closely evaluate the permittee's sample preparation procedures. The sludge matrix is more complex and variable than the wastewater matrix; therefore, the laboratory's development of sample preparation techniques is of particular concern.

The NPDES permit may require the permittee to analyze sludge for conventional pollutants, inorganic pollutants, metals, and pathogens (depending on the ultimate sludge disposal practice). For example, sludge that is going to be land applied will be analyzed for nine metals and nitrogen to determine the appropriate application rate. Table 10-8 lists the constituents required to be monitored by 40 CFR 503. The regulations at 40 CFR 503.8 contain a listing of approved analytical methods and volatile solids reduction calculations that must be used for monitoring sludge quality.

Lists of approved biosolids analytical methods, sample containers, preservation techniques, and holding times for biosolids samples can be found on EPA's website at: https://www.epa.gov/biosolids/additional-information-biosolids-managers#analytical.

The inspector should keep the following points in mind when reviewing the permittee's lab and analytical results:

- The sewage sludge standards are expressed on a dry weight basis. Laboratory results for sludge are typically reported in one of two forms, wet weight (i.e., mg/L) or dry weight (i.e., mg/kg). Watch out for mg/kg units that are wet weight rather than dry weight. The laboratory should be providing the results on a dry weight basis. If the laboratory results are reported on a wet weight basis (i.e., in mg/L), the results for each pollutant in each sample must be recalculated to determine the dry weight concentration. To accomplish this conversion, the percent total solids in the sludge sample must be known. Thus, the lab must analyze the sample for percent solids using Method 2540G of *Standard Methods for the Examination of Water and Wastewater*, 22nd Edition (American Public Health Association (APHA), American Water Works Association (AWWA), and World Economic Forum (WEF), 2013) or by another approved method in 40 CFR Part 136.

  The following equation can be used to determine the dry weight concentration because the equation uses the assumption that the specific gravity of water and sewage sludge are both equal to one. However, this assumption holds true only when the solids concentration in the sludge is low. The calculated dry weight concentration may vary slightly from the actual concentration as the solids content increases because the density of the sewage sludge may no longer be equal to that of water. This concern does not arise when the solids content of sludge is usually low. EPA is aware of this potential problem and may decide regarding this matter at a later date.

  Determine the pollutant concentration on a dry weight basis using the following abbreviated conversion (EPA, 1988):

$$\text{PC (dry, mg/kg)} = \frac{\text{PC (wet, mg/L)}}{\text{(\% total solids)}}$$

In this formula, PC = Pollutant concentration, and % total solids is in decimal format.

A unit conversion is incorporated into the equation.

- For metals, a common analytical error is that labs conduct the metals analyses using analytical methods developed for water and wastewater. Analytical methods for water and wastewater are found in 40 CFR Part 136. Additional information can be found in *Standard Methods for the Examination of Water and Wastewater* (American Public Health Association (APHA), American Water Works Association (AWWA), and World Economic Forum (WEF), 2013), while the solid waste analytical methods are found in latest version of *Test Methods for Evaluating Solid Wastes: Physical/Chemical Methods* (EPA, 2014). If non-detects are found for the metal concentrations, it is likely that the laboratory is not following the method requirement of digesting equivalent to one gram of dry weight of solid.

- For sludge samples, all metals must be analyzed according to the methods presented in 40 CFR Part 136. Note that more than one method is provided for each pollutant. The difference between the methods is usually the equipment used (i.e., direct aspiration, furnace, or Inductively Coupled Plasma (ICP) scan) and the level of detection desired. Each of the methods is EPA-approved, but certain sample characteristics may require one to be used instead of another.
- Methods for analyzing additional inorganic parameters (e.g., nitrite, Total Kjeldahl Nitrogen (TKN)) are also found in 40 CFR Part 136, as well as in *Standard Methods for the Examination of Water and Wastewater*.

EPA's *Control of Pathogens and Vector Attraction in Sewage Sludge* (EPA, 2003) is a primary reference for regional, state, and local regulatory authorities and their constituents for successful compliance with 40 CFR Part 503, Subpart D requirements. Several new equivalencies have been recommended by the Pathogen Equivalency Committee (PEC) since the latest edition of EPA's *Control of Pathogens and Vector Attraction in Sewage Sludge* (EPA, 2003) and are updated at EPA's Principal Biosolids Guidance website for processes to significantly reduce pathogens (PSRPs) and processes to further reduce pathogens (PFRPs) (accessible at: http://www.epa.gov/biosolids). Also note that EPA finalized pathogen reduction methods for fecal coliform (EPA Methods 1680 or 1681) and *Salmonella* (EPA Method 1682) in June 2005. EPA recommends that facilities testing under 40 CFR Part 503 use the new methods; however, these methods are not required by federal regulations.

Table 10-4. Recordkeeping Requirements for Class A Pathogen Reduction Alternatives[a]

Alternative A1—Time and Temperature
• Analytical results for density of *Salmonella sp*. bacteria or fecal coliform (most probable number).
• Sludge temperature at representative locations.
• Time (days, hours, minutes) temperature maintained.
Alternative A2—Alkaline Treatment
• Analytical results for density of *Salmonella sp*. bacteria or fecal coliform (most probable number).
• Sludge pH.
• Time (hours) pH maintained above 12 (at least 72 hours).
• Sludge temperature.
• Percent solids in sludge 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 of total solids, on a dry weight basis) prior to pathogen reduction and, when appropriate, after treatment.
• Analytical results for density of viable helminth ova (number/4 grams of total solids, dry weight) 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, dry weight basis).
• Analytical results for density of enteric viruses (plaque forming unit/4 grams of total solids, dry weight).

Table 10-4. Recordkeeping Requirements for Class A Pathogen Reduction Alternatives[a]

<table>
<tr><td colspan="2">• Analytical results for density of viable helminth ova (number /4 grams of total solids, dry weight).</td></tr>
<tr><td colspan="2">Alternative A5—Processes to Further Reduce Pathogens (PFRP)</td></tr>
<tr><td>• Heat Drying:
- Analytical results for density of Salmonella sp. bacteria or fecal coliform (most probable number).
- Moisture content of dried sludge <10 percent.
- Logs documenting temperature of sludge particles or wet bulb temperature of exit gas exceeding 80°C.
• Thermophilic Aerobic Digestion:
- Analytical results for density of Salmonella sp. bacteria or fecal coliform (most probable number).
- Dissolved oxygen concentration in digester ≤>1 mg/L.
- Logs documenting temperature maintained at 55–60°C for 10 days.
• Heat Treatment:
- Analytical results for density of Salmonella sp. bacteria or fecal coliform (most probable number).
- Logs documenting sludge heated to temperatures > greater than 180°C for 30 minutes.
• 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.</td><td>• 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.
- Logs documenting temperature maintained at or above 55°C for 15 days if windrow compost method.
- Logs documenting compost pile turned at least five times per day during the 15day period, 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.
• Beta Ray Irradiation:
- Analytical results for density of Salmonella spp. bacteria or fecal coliform (most probable number).
- Beta ray dosage at least 1.0 megarad.
- Ambient room temperature log.</td></tr>
<tr><td colspan="2">Alternative A6—PFRP Equivalent</td></tr>
<tr><td colspan="2">• 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).</td></tr>
</table>

[a] Note that several new equivalencies have been recommended by PEC since 2003, when EPA revised the principal biosolids guidance document. Also, EPA recommended new methods in 2005 for the analysis of fecal coliform and *Salmonella*.

Table 10-5. Recordkeeping Requirements for Class B Pathogen Reduction Alternatives[a]

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 sludge in digester and the corresponding method used to calculate this value. - Logs showing temperature was maintained for sufficient period of time (ranging from 60 days at 15°C to 40 days at 20°C).
• Air Drying: - Description of drying bed design. - Depth of sludge on drying bed. - Drying time in days. - Daily average ambient temperature.
• Anaerobic Digestion: - Volatile solids content before and after digestion. - Mean residence time of sludge in digester and the corresponding method used to calculate this value. - Logs showing temperature was maintained for a sufficient period of time (ranging from 15 days at 35°C to 55°C and 60 days at 20°C). - Temperature logs of sludge in digester.
• Composting: - Description of composting method. - Daily temperature logs documenting sludge maintained at 40°C for 5 days. - Hourly readings showing temperature exceeded 55°C for 4 consecutive hours.
• Lime Stabilization: - pH of sludge immediately and then 2 hours after addition of lime, without any further addition of lime.
Alternative B3—PSRP Equivalent
• Operating parameters or pathogen levels as necessary to demonstrate equivalency to PSRP.

[a] Note that several new equivalencies have been recommended by PEC since 2003, when EPA revised the principal biosolids guidance document. Also, EPA recommended new methods in 2005 for the analysis of fecal coliform and *Salmonella*.

Table 10-6. Recordkeeping Requirements for Vector Attraction Reduction Sludge Processing Options

Option 1—Volatile Solids (VS) Reduction	**Option 5—Aerobic Processing (Thermophilic Aerobic Digestion/Composting)**
• Volatile solids concentration of raw and final sludge streams (mg/kg). • Calculations showing 38 percent reduction in volatile solids.[a]	• Sludge detention time in digester/composting. • Temperature logs showing average temperature above 45°C and minimum temperature above 40°C for 14 consecutive days.

Table 10-6. Recordkeeping Requirements for Vector Attraction Reduction Sludge Processing Options

Options 2 and 3—Bench-Scale VS Reduction	Options 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 sludge). • Temperature logs showing temperature maintained at 20°C for aerobically or between 30°C and 37°C for anaerobically digested sludge. • Volatile solids concentration of sludge (mg/kg) before and after bench-scale digestion.	• Logs demonstrating the hours that pH of sludge/alkaline mixture was maintained (12 for 2 hours and 11.5 for an additional 22 hours). • Amount of alkaline added to sludge (lbs. or gals). • Amount of sludge treated.
Option 4—Specific Oxygen Uptake Rate for Aerobically Digested Sewage Sludge	**Options 7 and 8—Drying**
• Dissolved oxygen readings for sludge sample over 15-minute intervals (mg/L). • Temperature logs showing test was corrected to conducted at 20°C. • Total solids for sludge sample (g/L). • SOUR calculations (mg/g).	• Results of percent solids (dry weight) test. • Presence of unstabilized solids generated during primary treatment.

[a] Methods for calculating VS reduction under Option 1 can be found in Appendix C of EPA's *Control of Pathogens and Vector Attraction in Sewage Sludge*. EPA-625-R 92-013.

Table 10-7. Sludge Handling Process Evaluation

General Indicators of Problems
• Inadequate sludge removal from clarifiers or thickeners. • Poor dewatering characteristics of thermal treated sludge. • Thickened sludge too thin. • Fouling of overflow weirs on gravity thickeners. • Air flotation skimmer blade binding on beaching plate. • Substantial downtime of sludge treatment units. • Sludge disposal inadequate to keep treatment system in balance. • Mass balance inappropriate (ratio of sludge wasted should be 0.65–0.85 lbs. of sludge per lb. of BOD removed). • Sludge decant or return flows high in solids.[a] • Odors. • Improper loading rates.
Anaerobic Digestion Problems

Table 10-7. Sludge Handling Process Evaluation

- Inoperative mechanical or gas mixers.
- Inoperative sludge heater or low temperature.[a]
- Floating cover of digester tilting.
- Inadequate gas production.[a]
- Inoperative gas burner.
- Supernatant exuding sour odor from either primary or secondary digester.[a]
- Excessive suspended solids in supernatant.
- Supernatant recycle overloading the WWTP.
- pH problems.[a]

Aerobic Digestion Problems

- Excessive foaming in tank.[a]
- Objectionable odor in aerobically digested sludge.[a]
- Insufficient dissolved oxygen in digester.
- Digester overloaded.
- Clogging of diffusers in digester.
- Mechanical aerator failure in digester.
- Inadequate supernatant removal from sludge lagoons.
- Solids accumulation in tank.

Sludge Dewatering Problems

Drying Beds

- Poor sludge distribution on drying beds.
- Vegetation in drying beds (unless reed design).
- Dry sludge remaining on drying beds.
- Inadequate drying time on drying beds.[a]
- Some unused drying beds.
- Dry sludge stacked around drying beds where runoff may enter navigable waters.
- Filtrate from sludge drying beds returned to front of plant.

Centrifuge

- Excessive solids in fluid phase of sample after centrifugation.[a]
- Inadequate dryness of centrifugal sludge cake.[a]
- Excessive vibration or other mechanical problems.

Filter Press

- High level of solids in filtrate from filter presses or vacuum filters.[a]
- Thin filter cake caused by poor dewatering.
- Vacuum filter cloth binding.
- Low vacuum on filter.
- Improperly cleaned vacuum filter media.
- Sludge buildup on belts and/or rollers of filter press.
- Excessive moisture in belt filter press sludge cake.[a]
- Difficult cake discharge from filter presses.
- Filter cake sticks to solids conveying equipment of filter press.
- Frequent media binding of plate filter press.
- Sludge blowing out of filter press.
- Insufficient run time of sludge dewatering equipment.

Sludge Stabilization Problems

Lagoon

Table 10-7. Sludge Handling Process Evaluation

- Objectionable odor from sludge lagoon.
- Damage to dikes around sludge drying lagoons.
- Unlined sludge lagoons.
- Sludge lagoons full, overflowing sludge back to plant or to natural drainage.
- Deep rooted vegetation on dikes or berms.

Composting

- Piles that give off foul odor.
- Inoperable blower.
- Temperature does not reach 122–140°F (50–60°C) or is above 158°F (70°C).
- Uncontrolled stormwater runoff.

Heat Drying/Pelletizing

- Excess moisture in sludge feed.
- Insufficient air flow or drying temperature achieved.
- Inadequate drying of final product (excess moisture in final product).
- Excess odors associated with treatment area.
- Excess odors associated with treated product.

Alkaline Stabilization

- Insufficient amount of lime (or other alkaline additive) used to assure pH is raised sufficiently.
- Inadequate mixing provided to assure good contact of lime (or other alkaline additive) with sludge solids.
- pH problems.[a]
- Excess odors associated with treatment area.
- Excess odors associated with treated product.
- Excessive lime dust around treatment equipment.

Incineration

- Objectionable odors associated with treatment area.
- Evidence of excessive dust (ash) around unit.
- Visible smoke or dust exhaust from unit.
- Lack of compliance with air permit parameters.
- Spilling or leaking sludge from dewatered sludge transfer equipment.

Sludge Disposal Problems

- Sludge constituents not analyzed before disposal.
- Sludge not transported in appropriate and approved vehicle.
- Surface runoff of sludge at land application site.
- Liquid sludge (i.e., less than 10 percent solids) applied to landfill site.
- Sludge fails paint filter test.
- Inadequate coverage of sludge in subsurface plow injection system.
- Objectionable odors generated at land application site.[a]
- Slow drying of soil-sludge mixture in subsurface injection system.
- Sludge ponding at land application sites.
- Flies breeding, vectors, and/or odors at landfill site.
- Inadequate burial of sludge at landfill site.
- Excessive erosion at sludge sites.
- Sludge disposed of in non-permitted sites.
- Disposal not in accordance with federal, state, or local regulations.
- Sludge lagoons full and overflowing.[a]
- Inadequate runoff control at landfill or land application sites.

[a] Indicates serious problems with the sludge handling process.

Table 10-8. Pollutants Monitored for Land Application, Surface Disposal, and Incineration

Pollutant	Land Application	Surface Disposal (Unlined Units)	Incineration
Arsenic	✓	✓	✓
Beryllium			✓
Cadmium	✓		✓
Chromium		✓	✓
Copper	✓		
Lead	✓		✓
Mercury	✓		✓
Molybdenum	✓		
Nickel	✓	✓	✓
Selenium	✓		
Zinc	✓		
Nitrogen series	✓		

Organism to Be Monitored	Allowable Level in Sludge
Fecal Coliform[a]	1,000 Most Probable Number (MPN) per gram (Class A) of total solids (dry weight).
Salmonella sp.[a] Bacteria (in lieu of fecal coliform)	3 MPN per 4 grams of total solids (dry weight).
Enteric Viruses[b]	Less than one plaque-forming unit per 4 grams of total solids (dry weight).
Viable Helminth[b] Ova	Less than one viable helminth ovum per 4 grams of total solids (dry weight).
Fecal Coliform[c]	Less than 2 × 106 MPN or less than 2 × 106 colony-forming units per gram of total solids (dry weight) (expressed as geometric mean of the results of 7 individual samples).

[a] All Part 503 Class A Alternatives 1, 2, 3, 4, 5, 6.
[b] Class A Alternatives 3 and 4 only.
[c] Class B, Alternative 1.

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