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## PART 1 C BIOSOLIDS REGULATIONS

Federal regulations newly published in the *Federal Register* can be difficult to understand. Therefore, an "easy-to-read" summary of 40 CFR Part 503 has been developed by EPA and has been included in this handbook for your use (Section 1.1). See also *Part 503 Implementation Guidance* (EPA 833-R-95-001), 1995.

All of the information and requirements found in 40 CFR Part 503 are included in the provided summary. However, special attention should be paid to the Land Application and Surface Disposal sections and to the corresponding Pathogen and Vector Attraction Reduction requirements, since these practices are the most commonly used in EPA Region 8.

Section 1.2 is a paper that was presented at an international conference in 1994. It provides the recent history of biosolids management, improvements in biosolids quality, and improvements made in equipment, processes and management practices. With this background in place, the author discusses the implementation of the 503 regulations, the problems associated with the aging infrastructure in the U.S., and some predictions for future biosolids management trends.

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# SECTION 1.1 C SUMMARY OF 40 CFR PART 503 STANDARDS FOR THE USE OR DISPOSAL OF SEWAGE SLUDGE

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The U.S. Environmental Protection Agency has been in the process of developing comprehensive federal sewage sludge (biosolids) use and disposal regulations for many years. The proposed regulation was published for public comment on February 6, 1989, and in final form in the *Federal Register* on February 19, 1993 (58 *FR* [32]:9248-9415).

The final regulation is organized into the following subparts: general provisions; land application; surface disposal; pathogens and vector attraction reduction; and incineration.

Subparts addressing standards for land application, surface disposal and incineration practices consist of sections covering: applicability and special definitions; general requirements; pollutant limits; operational standards; management practices; frequency of monitoring, recordkeeping, and reporting requirements.

The following summary of the 40 CFR Part 503 regulation is based on the final regulation. It is a simplified summary of the regulation and does not contain all details, requirements, or exceptions.

## GENERAL PROVISIONS AND IMPLEMENTATION PLANS

The Part 503 addresses the use and disposal of sewage sludge generated from the treatment of domestic sewage and includes domestic septage. It does not apply to materials such as grease trap residues or other non-domestic wastewater residues pumped from commercial facilities, sludges produced by industrial wastewater treatment facilities, or grit and screenings from publicly owned treatment works (POTWs). Sewage sludge and other wastewater solids disposed of in municipal solid waste landfills for bulk disposal or used as landfill cover material are required to comply with the requirements of the 40 CFR Part 258 municipal solid waste landfill regulation (56 *FR* [196]:50978-51119; October 1991), which was co-promulgated under the Clean Water Act and the Resource Conservation and Recovery Act.

By statute compliance with the Part 503 standards is required within 12 months of publication of the regulation (*i.e.*, February 19, 1994). However, if new pollution control facilities need to be constructed to achieve compliance, then compliance is required within 2 years of publication (*i.e.*, February 19, 1995). Compliance with monitoring, recordkeeping and reporting requirements is required within 150 days of publication of the rule (*i.e.*, July 20, 1993).
For the most part, the rule is written to be "self implementing," which means that citizen suits or EPA can enforce the regulation even before permits are issued. As a result, treatment works must start monitoring and keeping records of sludge quality (and in many cases land appliers must start keeping records of loading rates and locations receiving sewage sludge), and must comply with pollutant limits and other technical standards, even in the absence of a federal permit.

The standards will be incorporated into National Pollution Discharge Elimination System (NPDES) permits issued by EPA or permits issued by states with approved sewage sludge management programs in accordance with 40 CFR Parts 122, 123, and 501 (promulgated in May 1989 {54 FR [83]:18716-18796}, and revised and published with the Part 503 rule in February 1993). EPA will work closely with the states to encourage their adoption of sewage sludge management programs that can be approved to carry out the federal program and avoid the need for separate EPA permits, compliance monitoring and enforcement activities. However, until a state applies for and is approved to carry out a delegated program, all involved parties will be dealing directly with their EPA Regional Office regarding federal permits, compliance monitoring and enforcement issues associated with the implementation of the Part 503 requirements--in addition to dealing with their state regulatory authorities and requirements.

Sewage sludge permitting requirements apply to "Treatment Works Treating Domestic Sewage" (TWTDS)--*i.e.*, facilities that generate, treat, or provide disposal of sewage sludge, including non-discharging and sludge-only facilities. A TWTDS must apply for a federal sewage sludge permit from EPA (or an approved state sludge program) if it manages a sewage sludge that is ultimately subject to Part 503--that is, it is land applied, placed on a surface disposal unit, incinerated, or sent to a municipal solid waste landfill. TWTDS with existing NPDES permits get to apply for a sewage sludge permit as a part of their next NPDES permit renewal application, while facilities without existing NPDES permits must submit limited screening information (but not necessarily a full permit application) by February 19, 1994. All TWTDS involving sludge incinerators and certain surface disposal facilities seeking site specific limits were to have applied for permits by August 18, 1993.

While disposal facilities such as sewage sludge incinerators and surface disposal sites are clearly TWTDS and are required to apply for permits, commercial handlers that only distribute or land apply the sewage sludge without changing its quality are not automatically considered TWTDS and are not required to submit permit applications unless specifically requested to do so by the permitting authority -- EPA or an approved state. Also the TWTDS definition does not extend automatically to areas such as farm land where sewage sludge is beneficially used; only under an unusual situation (such as a clear potential risk to human health and the environment) would the permitting authority designate such an area as a TWTDS. The permitting authority has the flexibility to cover both the generator and the treatment, use, or disposal facility in one permit or in separate permits (including general permits).

Due to the large number of potential permit applications that will be submitted under this program, EPA plans to initially focus on TWTDS required to have, or requesting, site-specific pollutant limits under Part 503. The permitting authority may request that permit applications be submitted earlier than the times noted above, with permit applications being due 180 days after such a request.

Annual reporting is required of all Class I sewage sludge management facilities (*i.e.*, the ~1,600 pretreatment POTWs and ~400 other "designated" TWTDS) and other "major" POTWs - those with a design flow $\geq$1MGD or serving a population of $\geq$10,000 people.

## LAND APPLICATION

Land application includes all forms of applying bulk or bagged sewage sludge to land for beneficial uses at agronomic rates (rates designed to provide the amount of nitrogen needed by the crop or vegetation grown on the land while minimizing the amount that passes below the root zone). These beneficial use practices include application to: agricultural land such as fields used for the production of food, feed and fiber crops, pasture and range land; non-agricultural land such as forests; public contact sites such as parks and golf courses; disturbed lands such as mine spoils, construction sites and gravel pits; and home lawns and gardens. The sale or give away of sewage sludge products (such as composted or heat dried products) is addressed under land application, as is land application of domestic septage.

### General Requirements

Responsibility for complying with the rule rests with the person who prepares sewage sludge for land application or applies sewage sludge to the land. These parties must obtain and provide the information necessary to comply with the rule. For example, the person who prepares bulk sewage sludge that is land applied must provide the person who applies it to the land all information necessary to comply with the rule, including the total nitrogen concentration of the sewage sludge.

The regulation establishes two levels of sewage sludge quality with respect to heavy metal concentrations--pollutant Ceiling Concentrations and Pollutant Concentrations ("high quality" sewage sludge); and two levels of quality with respect to pathogen densities--Class A and Class B; and two types of approaches for meeting vector attraction reduction--sewage sludge processing or the use of physical barriers. Under the Part 503 regulation, fewer restrictions are imposed on the use of higher quality sewage sludge.

To qualify for land application, sewage sludge or material derived from sewage sludge must meet at least the pollutant Ceiling Concentrations, Class B requirements for pathogens and vector attraction reduction requirements. Cumulative Pollutant Loading Rates are imposed on sewage sludge that meet the pollutant Ceiling Concentrations but not the Pollutant Concentrations. A number of general requirements and management practices apply to sewage sludge that is land applied unless it meets three criteria for "Exceptional Quality"--sewage sludge or derived material which meet the Pollutant Concentration limits, Class A pathogen requirements, and vector attraction reduction sewage sludge processing. However, in all cases the minimum frequency of monitoring, recordkeeping, and reporting requirements must be met.

## Pollutant Limits

Pollutant limits for land application are listed in the following table:

**Land Application Pollutant Limits**
(all limits are on dry weight basis)

| Table in 503 Rule | Table #1 | Table #2 | Table #3 | Table #4 |
|---|---|---|---|---|
| Pollutant | Ceiling Concentration Limits* (mg/kg) | Cumulative Pollutant Loading Rates (kg/ha) | "High Quality" Pollutant Concentration Limits** (mg/kg) | Annual Pollutant Loading Rates (kg/ha/yr) |
| Arsenic | 75 | 41 | 41 | 2.0 |
| Cadmium | 85 | 39 | 39 | 1.9 |
| Copper | 4,300 | 1,500 | 1,500 | 75 |
| Lead | 840 | 300 | 300 | 15 |
| Mercury | 57 | 17 | 17 | 0.85 |
| Molybdenum | 75 | C | C | C |
| Nickel | 420 | 420 | 420 | 21 |
| Selenium | 100 | 100 | 100 | 5.0 |
| Zinc | 7,500 | 2,800 | 2,800 | 140 |

* absolute values
** monthly averages

To be land applied, bulk sewage sludge must meet the pollutant Ceiling Concentrations and Cumulative Pollutant Loading Rates or Pollutant Concentration limits. Bulk sewage sludge applied to lawns and home gardens must meet the Pollutant Concentration limits. Sewage sludge sold or given away in bags or other containers must meet the Pollutant Concentration limits or meet the Ceiling Concentrations and be applied at an annual sewage sludge product application rate that is based on the Annual Pollutant Loading Rates.

## Pathogen and Vector Attraction Reduction

Sewage sludge is classified into two categories, Class A and Class B, based upon the pathogen reduction criteria described later in this article. Restrictions placed on end uses of sewage sludge are impacted by the pathogen reduction classification of the sewage sludge. Bulk sewage sludge applied to agricultural and non-agricultural land (e.g., forest, public contact sites, and reclamation sites) must meet at least Class B requirements.

Bulk sewage sludge applied to lawns and home gardens, and sewage sludge sold or given away in bags or other containers must meet the Class A criteria and one of the vector attraction reduction sewage sludge processing options. One of the ten vector attraction reduction options described later also must be met when bulk sewage sludge is applied to the agricultural or non- agricultural land.

## Management Practices

The following management practices apply to land applied sewage sludge (other than "Exceptional Quality" sewage sludge or sludge-derived products):

1) Bulk sewage sludge shall not be applied to flooded, frozen or snow-covered ground so that the sewage sludge enters wetlands or other waters of the U.S. unless authorized by the permitting authority.

2) Bulk sewage sludge shall not be applied at rates above agronomic rates, with the exception of reclamation projects when authorized by the permitting authority.

3) Bulk sewage sludge shall not be applied if likely to adversely affect a threatened or endangered species.

4) Bulk sewage sludge shall not be applied less than 10 meters from waters of the U.S., unless authorized by the permitting authority.

5) Sewage sludge sold or given away in a bag or other container shall have either a label affixed to the bag/container, or an information sheet shall be provided to the person who receives the sewage sludge for application to the land that provides information on proper use, including the annual whole sludge application rate that does not cause any of the annual pollutant loading rates to be exceeded.

Furthermore, when sewage sludge that meets Class B pathogen reduction requirements, but not Class A, is applied to the land, the following site restrictions have to be met:

1) Food crops with harvested parts that touch the sewage sludge/soil mixture (such as melons, cucumbers, squash, etc.) shall not be harvested for 14 months after application.

2) Food crops with harvested parts below the soil surface (root crops such as potatoes, carrots, radishes) shall not be harvested for 20 months after application if the sewage sludge is not incorporated for at least 4 months.

3) Food crops with harvested parts below the soil surface (root corps such as potatoes, carrots, radishes) shall not be harvested for 38 months after application if the sewage sludge is incorporated in less than 4 months.

4) Food crops, feed crops, and fiber crops shall not be harvested for 30 days after sewage sludge application.

5) Animals shall not be grazed on a site for 30 days after sewage sludge application.

6) Turf shall not be harvested for 1 year after sewage sludge application if the turf is placed on land with a high potential for public exposure or a lawn, unless otherwise specified by the permitting authority.

7) Public access to land with high potential for public exposure shall be restricted for 1 year after sewage sludge application.

8) Public access to land with a low potential for public exposure shall be restricted for 30 days after sewage sludge application.

## Monitoring

Monitoring for pollutants, pathogen densities and vector attraction reduction requirements shall be at a minimum frequency based on annual sewage sludge amounts used or disposed as listed in the table on the following page.

The permitting authority may impose more frequent monitoring requirements on permittees. In addition, After two years of monitoring at these frequencies, the permitting authority may allow the monitoring frequencies (for pollutants and pathogen densities in some cases) to be reduced to no less than once per year.

### Monitoring Frequency

| Sewage Sludge Amounts (dry metric tons* per year) | Monitoring Frequency |
|---|---|
| >0 to <290 | Once per year |
| 290 to <1,500 | Once per quarter |
| 1,500 to <15,000 | Once per 60 days |
| $15,000 | Once per month |

* Note: 1.0 metric ton = 1.1 English tons

## Recordkeeping

The recordkeeping requirements vary depending on which pollutant limits are met and the end use of the sewage sludge or sewage sludge derived material. In general the person who prepares the sewage sludge or product is responsible for certifications and maintaining records concerning pollutant concentrations and processing of the material to meet pathogen and vector attraction reduction requirements, while the applier is responsible for certifications and maintaining records concerning field operations, application rates, management practices, and site restrictions. Except as noted, records must be kept for five years. These requirements are summarized below.
If the sewage sludge or resulting product meets the pollutant Ceiling Concentration limits (Table 1 values), Pollutant Concentration limits (Table 3 values), Class A pathogen requirements, and one of the first 8 vector attraction reduction (process) requirements, the person preparing the "Exceptional Quality" sewage sludge (whether a bulk or bagged product) must certify through periodic sampling that the material meets these criteria and keep records describing the methods used to meet the Class A pathogen reduction and vector attraction reduction requirements.
However, if a bulk sewage sludge that meets the Pollutant Concentration limits and Class A pathogen requirements is injected or surface applied followed by incorporation to meet the vector attraction reduction requirements, the person applying the sewage sludge must certify that appropriate management practices have been followed and that vector attraction reduction has been performed in accordance with the rule. The person applying the sewage sludge must also describe how each of the applicable management practices and vector attraction reduction barrier requirements have been met for each site on which sewage sludge has been applied.

If a bulk sewage sludge meets the Pollutant Concentration limits but only Class B pathogen reduction requirements, the person preparing the sewage sludge must certify that the material meets these criteria and keep records describing the methods used to meet them. The person applying the sewage sludge must certify and keep records describing how the applicable management practices and the site restrictions have been met.

For bulk sewage sludges that meet the pollutant Ceiling Concentration limits, but do not meet the Pollutant Concentration limits, the person applying the sewage sludge must certify that the requirements to obtain information needed to determine the cumulative amount of each pollutant on each site were met (note that the Table 2 values for Cumulative Pollutant Loading Rates are not to be exceeded), as well as record and keep indefinitely a record of the cumulative amount of each pollutant applied to each site, information on the location of each application site, its size, the date and time of each sewage sludge application, amount of sludge applied, and how the requirements to obtain necessary pollutant loading rate information were met.

If a sewage sludge meets the Class A requirements and the Ceiling Concentrations, but not the Pollutant Concentration limits, <u>and</u> is to be sold or given away in a bag or other container, the person who prepares the sewage sludge shall determine and record the annual whole sludge application rate that does not cause the material to exceed the Annual Pollutant Loading Rates (Table 4 values). The concentration of each pollutant listed in Table 4 shall also be recorded. Furthermore, the preparer shall keep a record describing how the Class A pathogen reduction and vector attraction reduction requirements have been met.

### Reporting

The information contained in the required records shall be submitted to the permitting authority annually for all Class I sludge management facilities and POTWs with a design flow rate ≥1 MGD or a service population of ≥10,000 people. In addition, for sites where recordkeeping is required, the same group of facilities shall report annually when any cumulative metal loading reaches 90% of the allowed Cumulative Pollutant Loading Rates (Table 2 values).

### Distributed and Marketed (D&M) Products

The regulation of products that are distributed and marketed is addressed as a part of land application rather than as a separate practice under Part 503. As outlined above, the sale or giveaway of sewage sludge in bulk, bags or other containers is regulated under land application in the final Part 503 rule. Bulk sewage sludge is frequently applied to farmland, forest and reclamation sites in liquid or dewatered cake forms at little or no cost to the land owner. At a minimum these materials must meet the pollutant Ceiling Concentrations, Class B pathogen reduction and vector attraction reduction criteria, and can be applied using the Cumulative Pollutant Loading Rates if they do not meet the Pollutant Concentration limits.

On the other hand, sewage sludge or material derived from sewage sludge that is considered suitable for distribution and marketing for uses on lawns and home gardens, either in bulk or bags and other containers, must meet the Class A pathogen reduction requirements, a vector attraction reduction processing option, and the Pollutant Concentration limits (with the exception that sewage sludge which meets the pollutant Ceiling Concentrations, but not the Pollutant Concentration limits, can be sold in bags or other containers for use at product application rates prescribed on a label that are based on not exceeding the Annual Pollutant Loading Rates). The Class A pathogen reduction requirements must be met at the time the bulk or containerized products are "sold or given away."

If sewage sludges or sludge derived products are of "Exceptional Quality"--meet the Pollutant Concentration limits, Class A pathogen reduction requirements and a vector attraction reduction sludge processing option--they are usually not subject to the general requirements and management practices applicable to land application practices.

*Composted Sewage Sludge Products*

Composting can achieve compliance with Class A pathogen reduction requirements by operating under the PFRP conditions (included as Appendix B of Part 503, but originally issued under the Part 257 regulations) and monitoring for regrowth:

- With Invessel Composting or Static Aerated Pile systems, the temperature of the sewage sludge is maintained at 55°C or higher for 3 days.

- With Windrow Composting, the temperature of the sewage sludge is maintained at 55°C or higher for 15 days or longer, during which the windrow will be turned a minimum of 5 times.

Other operating conditions may be able to meet Class A pathogen reduction requirements based on meeting time/temperature or pathogen testing requirements. Careful monitoring of process operations will be necessary to ensure that pathogen reduction requirements are achieved. For vector attraction reduction only, composting must achieve temperatures of greater than 40°C for 14 days and achieve an average temperature during that period of 45°C. These are well within the typical composting facility operating parameters and should be achievable by properly designed and operated facilities.

*Heat Dried Sewage Sludge Products*

There are few aspects of the new rule that will cause changes to established heat dried sewage sludge D&M programs. The temperatures used in sewage sludge drying systems which aim at producing a marketable product are typically in excess of 50°C, and retention times in the dryer are 30 minutes or longer. Using the equations provided and a nominal processing temperature of 80°C (the PFRP definition for sewage sludge drying), the product residence time in the dryer required to meet the Class A pathogen reduction is in the order of magnitude of seven seconds, while the rule requires a minimum residence time in the dryer of 15 seconds. Vector attraction reduction will similarly be easily met by dryers that produce a product for marketing. The degree of dryness required is >75% solids if the product does not contain unstabilized primary sewage sludge, and >90% solids if the product does contain unstabilized primary sewage sludge. The marketplace is typically looking for products of >90% solids so that the sewage sludge product is compatible with other dry fertilizer products.

*Alkaline Stabilized Sewage Sludge Products*

Certain alkaline stabilization practices comply with the Class A pathogen reduction requirements, which include a combination of elevating pH to above 12 for 72 hours and temperature to above 52°C for 12 hours or longer during the period that pH is above 12, along with air drying to >50% solids. Other alkaline stabilization approaches may qualify the sewage sludge as Class A based on meeting the elevated time/temperature criteria alone or PFRP equivalency.

## SURFACE DISPOSAL

### Types of Disposal Operations

The Surface Disposal subpart of the regulation applies to sewage sludge and domestic septage disposal operations such as the following:

> Monofills (sewage sludge-only landfills). This could be a trench system, area-fill system, or similar bulk disposal operation, usually involving a cover material over the deposited sewage sludge.
>
> Dedicated disposal surface application sites. At some sites, sewage sludge pollutants are applied at higher than the Cumulative Pollutant Loading Rates (Table 2 values) for disposal purposes even though there also may be beneficial use aspects. Application of sewage sludge nitrogen at higher-than-acceptable agronomic rates may also be included as surface disposal sites. Potential pollutant leaching to groundwater or excessive plant uptake levels are controlled in a site-specific manner. Such sites are usually owned or leased by the wastewater authority and are highly controlled for access and operations.
>
> Piles or mounds. At many treatment plants, sewage sludges have been placed in piles or otherwise mounded on a portion of the property as final disposal.
>
> Impoundments or lagoons. At many treatment plants sewage sludge or domestic septage has been discharged to lagoons or impoundments as final disposal, with the excess liquid evaporated or recycled for treatment.

This subpart deals with surface disposal sites and sewage sludge placed on such sites for final disposal. Surface Disposal does not include sewage sludge placement for storage or treatment purposes.

EPA does not intend to regulate under Part 503 wastewater treatment lagoons in which sewage sludge is generated during treatment or lagoons in which sewage sludge is being treated. However, when such sewage sludges are removed from wastewater treatment lagoons or sewage sludge treatment lagoons, their use or disposal will be regulated under Part 503, if applicable.

There are many sewage sludge lagoons or places where sewage sludges have been piled that no longer are receiving sewage sludge (*i.e.*, they are no longer "active" units). These would probably not be regulated under Part 503, especially if they have been "closed" in a proper manner. However, If these sites or operations are still active in 1993, the date they become inactive could be critical in determining whether they are regulated under Part 503. If sites that were inactive have the old sewage sludge removed from them in the future, the use or disposal of the sewage sludge at that time would likely fall within the jurisdiction of Part 503 if the material is used or disposed of through a practice covered by Part 503. Of course if previously closed sites become active again and receive sewage sludge after the Part 503 requirements became effective, such facilities would be subject to Part 503.

### Storage vs. Disposal

The Part 503 regulation allows sewage sludge to be stored for up to two years without any restrictions or control. However, if sewage sludges remain on the land beyond 2 years, EPA may consider this "disposal" and regulate it as a surface disposal site. If the wastewater authority can provide an adequate explanation concerning why the material has to remain on the land for longer than 2 years, EPA will not regulate these operations as surface disposal sites. A common example would be a sewage sludge lagoon that has a 4 or 5 year cycle time between sludge cleanout operations. In this example, the lagoon may be considered "treatment" or "storage," and not "disposal."

### General Requirements

There are a few general requirements that apply to surface disposal of sewage sludge on active sewage sludge units. These include compliance with all applicable Part 503 requirements; closure by [one year after the effective date of the rule] of active sewage sludge units located within 60 meters of a fault with displacement in Holocene time, in an unstable area, or in a wetland, unless authorized by the permitting authority; and the need for closure and post-closure plans at least 180 days prior to closing any active sewage sludge unit. Also, site owners are required to provide written notification to the subsequent owner that sewage sludge was placed on the land.

### Pollutant Limits

Where surface disposal sites use liners and leachate collection systems, there are no pollutant concentration limits because pollutants leaching from the solids mass will be collected in the leachate and treated as necessary to avoid a pollution problem. For the site liner to qualify, it must have a hydraulic conductivity of #1 x $10^{7}$ centimeters per second.

For surface disposal sites with no liner and leachate collection system, limits on 3 pollutants are established in the rule. While these vary based on the distance of the active sewage sludge unit boundary from the site property line, the most extreme values allowed are listed in the following table.

**Maximum Allowable Pollutant Concentrations in Sewage Sludge for Disposal in Active Sewage Sludge Units without a Liner and Leachate Collection System**

| Unit Boundary to Property Line | Pollutant Concentrations* | | |
|---|---|---|---|
| Distance (meters) | 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 |

| Unit Boundary to Property Line | Pollutant Concentrations* | | |
|---|---|---|---|
| Distance (meters) | Arsenic (mg/kg) | Chromium (mg/kg) | Nickel (mg/kg) |
| $ 150 | 73 | 600 | 420 |

* Dry weight basis

The three pollutants listed present the greatest threat of leaching to groundwater and causing exceedances of the Maximum Contaminant Level (MCL) for that pollutant. The allowable concentrations of the 3 pollutants are reduced if the active sewage sludge unit boundary is less than 150m from the site property line. The table shows the worst case limits if the site boundary is located from 0 to <25m from the disposal site property line. Different limits for these 3 pollutants can be developed through a site-specific assessment, as specified by the permitting authority, that shows the site has different parameters than the ones EPA used in establishing the maximum allowable concentration limits.

### Nitrate Contamination

As a management practice, the rule requires that surface disposal operations not cause the groundwater MCL for nitrate to be exceeded or to cause the existing concentration to be exceeded if it already exceeds the MCL. Either results of groundwater monitoring or a statement from a qualified groundwater scientist must be used to demonstrate compliance.

### Other Management Practices

There are several other management practices dealing with siting/ location, construction/design, and operation/maintenance that must be met for surface disposal facilities including but not limited to the following:

- Active disposal sites shall not be located within 60m of a Holocene-period fault or in a wetland unless authorized by the permitting authority; when located in a seismic impact zone, an active disposal site shall be designed to withstand the maximum recorded horizontal ground level acceleration.

- Surface runoff from a 24-hr, 25-yr storm event shall be controlled according to an NPDES permit.

- Active disposal sites shall not restrict flow of a base flood, adversely affect threatened or endangered species, or be located in a structurally unstable area.

- The leachate collection system for active surface disposal units with a liner and leachate collection systems shall be operated and maintained, and the leachate collected shall be disposed of in accordance with applicable requirements, during the period the unit is active and for 3 years after the unit is closed.

- If cover is placed on active units, methane gas concentrations must be monitored in all site structures and at the property line at the surface disposal site to avoid explosive conditions; if final cover is placed on the site, this monitoring continues for 3 years after site closure.

- Crops shall not be grown, nor animals grazed, on such sites unless the permitting authority specifically authorizes this based on site specific management practices to be implemented.

- Public access is restricted during operations and for 3 years following site closure.

### Pathogen and Vector Attraction Reduction Requirements

Surface disposal of sewage sludge requires that one of the Class A or Class B pathogen control alternatives be met unless the sewage sludge is covered with soil or other material daily. One of the first 11 vector attraction reduction options is also required for surface disposal. While there are no specific pathogen reduction requirements for domestic septage placed on surface disposal sites, it must be incorporated or injected into the soil, covered with material daily, or treated with alkaline materials to raise the pH to 12 or higher for at least 30 minutes to meet vector attraction requirements.

### Monitoring, Recordkeeping and Reporting

Monitoring for the 3 pollutant concentrations, pathogen densities and vector attraction reduction is required on the same minimum frequency based on annual sewage sludge amounts involved as required for land application and incineration. Methane gas monitoring of air in any on-site structures and at the property site boundary is required continuously if the surface disposal site contains an active disposal unit that is covered daily and for 3 years after a disposal unit that is covered is closed.

Records must be kept for at least 5 years. Certification statements are required by the person who prepares the sewage sludge for disposal and/or by the site owner/operator. The statements certify that the various management practices have been met and that the monitoring data have been collected properly. Data, information, and certification need to be submitted annually to the permitting authority for all Class I sludge management facilities and POTWs with a design flow rate $\geq$1MGD or that serve $\geq$10,000 population.

## PATHOGENS AND VECTOR ATTRACTION REDUCTION

The pathogen reduction requirements (which apply only to land application and surface disposal practices) are operational standards for two classes of pathogen reduction: Class A and Class B. All sewage sludges that are to be sold or given away in a bag or other container for application to the land, or applied to lawns or home gardens must meet Class A pathogen requirements. All sewage sludge that is land applied or placed on surface disposal sites must meet at least the Class B pathogen requirements, except sewage sludge placed on a surface disposal site that is covered with soil or other material daily. The specific requirements for the two classes of pathogen reduction and the rationale for these requirements are noted in the following paragraphs.

### CLASS "A" PATHOGEN REQUIREMENTS

Class A sewage sludge must meet one of the following criteria at the time of use or disposal, when prepared for sale or give away and passes on to the user for land application or producing other products:

1) A Fecal coliform density less than 1,000 Most Probable Number (MPN) per gram of total dry solids (1,000 MPN/g TS)

**OR**

2) A Salmonella sp. density less than 3 Most Probably Number (MPN) per 4 grams of total dry solids (3 MPN/4g TS).

In Addition: The requirements of **one** of the following alternatives must be met:

1) Time/Temperature - An increased sewage sludge temperature should be maintained for a prescribed period of time according to the following guidelines:

**Time and Temperature Guidelines**

| Total Solids | Temp. (t) | Time (D) | Equation | Notes |
|---|---|---|---|---|
| $ 7% | $ 50°C | $ 20 min. | $D = \frac{131,700,000}{10^{0.14t}}$ | No heating of small particles by warmed gases or immiscible liquid. |
| $ 7% | $ 50°C | $ 15 sec. | $D = \frac{131,700,000}{10^{0.14t}}$ | Small particles heated by warmed gases or immiscible liquid. |
| < 7% | > 50°C | $ 15 sec. to < 30 min. | $D = \frac{131,700,000}{10^{0.14t}}$ | |
| < 7% | $ 50°C | $ 30 min. | $D = \frac{50,070,000}{10^{0.14t}}$ | |

* in no case would temperatures calculated using the appropriate equation be less than 50°C

**- OR -**

2) Alkaline Treatment - The pH of the sewage sludge is raised to greater than 12 for at least 72 hours. During this time, the temperature of the sewage sludge should be greater than 52°C for at least 12 hours. In addition, after the 72-hour period, the sewage sludge is to be air dried to at least 50% total solids.

**- OR -**

3) Prior Testing for Enteric Virus/Viable Helminth Ova - The sewage sludge is analyzed for the presence of enteric viruses (Plaque-forming units) and viable helminth ova. If the sewage sludge is analyzed before the pathogen reduction process and is found to have densities of enteric virus <1 pfu/4 g TS and viable helminth ova <1 /4 g TS, the sewage sludge is Class A with respect to enteric virus and viable helminth ova until the next monitoring episode. If the sewage sludge is analyzed before the pathogen reduction process and found to have densities of enteric virus ≥1 pfu/4 g TS or viable helminth ova ≥1 /4 g TS, and tested again after processing and found to meet the same enteric virus and viable helminth ova levels [as listed under 4) below], then the processed sewage sludge will be Class A with respect to enteric viruses and viable helminth ova when the operating parameters for the pathogen reduction process are monitored and shown to be consistent with the values or ranges of values documented at all times:

4) No Prior Testing for Enteric Virus/Viable Helminth Ova - If the sewage sludge is not analyzed before pathogen reduction processing for enteric viruses and viable helminth ova, the sewage sludge must meet the enteric virus and viable helminth ova levels noted below to be Class A at the time the sewage sludge is used or disposed, prepared for sale or given away in a bag or container for application to the land, or when the sewage sludge or derived material

meets "exceptional quality" requirements--Pollutant Concentration limits, Class A pathogen reduction and any of the 8 sewage sludge processing options for meeting vector attraction reduction:

- The density of enteric viruses must be less than 1 Plaque-forming unit per 4 grams of total dry solids (1 PFU/4 g TS).

- The density of viable helminth ova must be less than 1 per 4 grams of total dry solids (1/4g TS).

**- OR -**

5/6) The sewage sludge is treated by a **PFRP** or a **PFRP equivalent** process.

## CLASS "B" PATHOGEN REQUIREMENTS

Class B is the minimum level of pathogen reduction for land application and surface disposal. The only exception to achieving at least Class B occurs when sewage sludge is placed in a surface disposal unit that is covered daily. Sewage sludge that does not qualify as Class B cannot be land applied.

Class B sewage sludge must meet one of the following pathogen requirements:

1) The sewage sludge must be treated by a PSRP or PSRP equivalent process.

**- OR -**

2) At least seven sewage sludge samples should be collected at the time of use or disposal and analyzed for Fecal coliforms during each monitoring period. The geometric mean of the densities of these samples will be calculated and should meet the following criteria:

- Less than 2,000,000 Most Probably Number per gram of total dry solids (2,000,000 MPN/g TS).

**- OR -**

- Less than 2,000,000 Colony Forming Units per gram of total dry solids (2,000,000 CFU/g TS).

In addition, for any land applied sewage sludge that meets Class B pathogen reduction requirements, but not Class A, the site restrictions described on p.6 must be met.

| PATHOGEN TREATMENT PROCESSES |
|---|
| Processes to Significantly Reduce Pathogens (PSRP) |
| 1) Aerobic Digestion - Sewage sludge is agitated with air or oxygen to maintain aerobic conditions for a mean cell residence time and temperature between 40 days at 20°C and 60 days at 15°C. |
| 2) Air Drying - Sewage sludge is dried on sand beds or on paved or unpaved basins for a minimum of three months. During two of the three months, the ambient average daily temperature is above 0°C. |
| 3) Anaerobic Digestion - Sewage sludge is treated in the absence of air for a mean cell residence time and temps. between 15 days at 35 to 55°C and 60 days at 20°C. |
| 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 or higher for five days. For four hours during the five days, the temperature in the compost pile exceeds 55°C. |
| 5) Lime Stabilization - Sufficient lime is added to the sewage sludge to raise the pH of the sewage sludge to 12 after 2 |

| |
|---|
| hours of contact. |

| PATHOGEN TREATMENT PROCESSES |
|---|
| Processes to Further Reduce Pathogens (PFRP) |
| 1) Composting - Using either within-vessel or static aerated pile composting, the temperature of the sewage sludge is maintained at 55·C or higher for three days. Using windrow composting, the temperature of the sewage sludge is maintained at 55°C or higher for 15 days or longer. During this period, a minimum of five windrow turnings are required. |
| 2) Heat Drying - Sewage sludge is dried by direct or indirect contact with hot gases to reduce the moisture content of the sewage sludge to 10% or lower. Either the temperature of the gas in contact with the sewage sludge exceeds 80°C or the wet bulb temperature of the gas in contact with the sewage sludge as the sewage sludge leaves the dryer exceeds 80°C. |
| 3) Heat Treatment - Liquid sewage sludge is heated to a temperature of 180°C or higher for 30 minutes. |
| 4) Thermophilic Aerobic Digestion - Liquid dewatered sewage sludge is agitated with air or oxygen to maintain aerobic conditions and the mean cell residence time for the sewage sludge is 10 days at 55 to 60°C. |
| 5) Beta Ray Irradiation - Sewage sludge is irradiated with beta rays from an accelerator at dosages of at least 1.0 megarad at room temperature (ca. 20°C). |
| 6) Gamma Ray Irradiation - Sewage sludge is irradiated with gamma rays from certain isotopes such as $^{60}CO$ and $^{137}Ce$, (at dosages of at least 1.0 megarad) at room temperature (ca. 20°C). |
| 7) Pasteurization - The temperature of the sewage sludge is maintained at 70°C or higher for at least 30 minutes. |

### Vector Attraction Reduction Requirements

Vector attraction reduction reduces the potential for spreading of infectious disease agents by vectors (*i.e.*, flies, rodents, and birds). The alternative methods for meeting the vector attraction reduction requirement imposed by Part 503 include the following:

1) Aerobic or Anaerobic Digestion - Mass of volatile solids (VS) are reduced by 38% or more. VS reduction is measured between the raw sewage sludge prior to stabilization and the digested sewage sludge ready for use or disposal. This criterion should be readily met by properly designed and operated anaerobic digesters, but not as readily by typical aerobic digesters. POTWs with aerobic digesters may need to meet vector attraction reduction requirement through Alternative 3 or Alternative 4 below.

2) Anaerobic Digestion - If 38% VS cannot be achieved, vector attraction reduction can be demonstrated by further digesting a portion of the digested sewage sludge in a bench scale unit for an additional 40 days at 30 to 37°C or higher and achieving a further VS reduction of less than 17%.

3) Aerobic Digestion - If 38% VS cannot be achieved, vector attraction reduction can be demonstrated by further digesting a portion of the digested sewage sludge with a solids content of 2% or less in a bench scale unit for an additional 30 days at 20°C and achieving a further VS reduction of less than 15%.

4) Aerobic Digestion - Specific oxygen uptake rate (SOUR) is less than or equal to 1.5 mg $O_2$/hr-gram of total solids (TS) at 20°C. If unable to meet the SOUR criteria, POTWs may be able to satisfy Alternative 3.

5) Aerobic Processes - (e.g., composting) Temperature is kept at greater than 40°C for at least 14 days and the average temperature during this period is greater than 45°C.

6) Alkaline Stabilization - pH is raised to at least 12 by alkali addition and, without the addition of more alkali, remains at 12 or higher for 2 hours and then at 11.5 or higher for an additional 22 hours [when pH is measured at 25°C].

7/8) Drying - Total Solids (TS) is at least 75% when the sewage sludge does not contain unstabilized primary solids and at least 90% when unstabilized primary solids are included. Blending with other materials is not allowed to achieve the total solids percent.

9) Injection - Liquid sewage sludge (or domestic septage) is injected beneath the surface with no significant amount of sewage sludge present on the surface after 1 hour; sewage sludges that are Class A for pathogen reduction, must be injected within 8 hours of discharge from the pathogen reduction process. This alternative is applicable to bulk sewage sludge land applied to agricultural land, forest, public contact sites or reclamation sites; domestic septage land applied to agricultural land, forest or reclamation sites; and sewage sludge or domestic septage placed in a surface disposal site.

10) Incorporation - Sewage sludge (or domestic septage) that is land applied or placed in a surface disposal site shall be incorporated into the soil within 6 hours of application; sewage sludge that is Class A for pathogen reduction and is land applied must be applied to or placed on the land within 8 hours of discharge from the pathogen reduction process.

This alternative is applicable to bulk sewage sludge land applied to agricultural land, forest, public contact sites or reclamation sites; domestic septage land applied to agricultural land, forest or reclamation sites; and sewage sludge or domestic septage placed in a surface disposal site.

11) Surface Disposal Daily Cover - Sewage sludge or domestic septage placed in a surface disposal site shall be covered with soil or other material at the end of each operating day.

12) Domestic Septage Treatment - The pH of domestic septage is raised to 12 or higher by alkali addition, and without the addition of more alkali, remains at 12 or higher for 30 minutes. This alternative is applicable to domestic septage applied to agricultural land, forest or reclamation sites or placed in a surface disposal site.

One of the vector attraction reduction alternatives 1-10 must be met when bulk sewage sludge is applied to agricultural land, forest, public contact or reclamation sites. One of alternatives 1-8 must be met when bulk sewage sludge is applied to lawns or home gardens or when sewage sludge is sold or given away in a bag or other container for land application. One of alternatives 1-11 must be met when sewage sludge is placed in a surface disposal site. Although domestic septage can be treated the same as sewage sludge, when it is handled as "domestic septage" rather than sewage sludge, one of alternatives 9, 10 or 12 must be met when septage is applied to agricultural land, forest or reclamation sites, and one of alternatives 9-12 must be met when it is placed in a surface disposal site.

## INCINERATION

The Part 503 regulation establishes requirements for sewage sludge-only incinerators. The rule covers the sewage sludge feed, the furnace itself, the operation of the furnace and the exhaust gases from the stack. It does not apply to facilities incinerating hazardous wastewater solids (as defined by 40 CFR Part 261) or wastewater solids containing $\geq$50 ppm concentrations of PCBs. It also does not apply to facilities that co-fire sewage sludge with other wastes (although up to 30% MSW as auxiliary fuel is not considered "other wastes"). Furthermore, this rule does not apply to the ash produced by a sewage sludge incinerator.

The rule indirectly limits emissions of heavy metals and directly limits total hydrocarbon emissions from sewage sludge incinerator stacks, and establishes management practices, frequency of monitoring, recordkeeping and reporting requirements. The rule contains equations to calculate the allowable concentration of metals in the sewage sludge fed to the incinerator, and contains a limit on Total Hydrocarbons (THC) in the emissions from a sewage sludge incinerator stack. Federal permits issued to sewage sludge incinerators will include site-specific pollutant limits based upon the results of performance testing and air dispersion modeling. Permit applications for sewage sludge incinerators were due to EPA (or a delegated state) by August 16, 1993 (within 180 days of publication of the final Part 503 regulation). The frequency of monitoring, recordkeeping and reporting requirements for everything except THC become effective July 20, 1993 (150 days from the date of publication of the final rule). Notwithstanding the permitting process, sewage sludge incinerator facilities are required to be in compliance with all of the requirements of the rule within 1 year. Facilities that need to construct new pollution control facilities to comply with requirements will have two years to achieve compliance.

Preparation of permit applications requires that sewage sludge incineration facilities conduct performance tests of their existing systems to determine pollution control efficiencies for heavy metals, and to conduct air dispersion modeling for site-specific conditions. Continuous emissions monitoring equipment will also need to be installed.

### Pollutant Limits

Pollutant limits for sewage sludges fired in a sewage sludge incinerator are imposed for the following heavy metals: beryllium, mercury, lead, arsenic, cadmium, chromium, and nickel. The limits for beryllium and mercury are those that already exist under the National Emission Standards for Hazardous Air Pollutants (NESHAPS; 40 CFR Part 261). Pollutant limits for the remaining metals will be determined using site-specific performance characteristics and emission dispersion modeling results.

Incinerators must also meet a monthly average limit of 100 ppm for total hydrocarbons (THC), corrected for moisture level (for zero percent) and oxygen content (to 7%). This limit is an indicator to control toxic organic compound emissions. The limit is based on the arithmetic mean of hourly readings for the month, with a requirement for at least two readings during each hour of operation. The THC measuring device used must be a flame ionization detector with a heated sample line maintained at 150°C or higher at all times, and be calibrated at least once every 24-hour operating period using propane. Operating parameters, such as oxygen concentrations and information to determine moisture content, in the stack exhaust gases and furnace combustion temperature must be continuously monitored.

### Management Practices

The rule specifically bans sewage sludge incineration "if it is likely to adversely affect a threatened or endangered species listed under the Endangered Species Act, or its designated critical habitat." If threatened or endangered species are known to be present in the vicinity of the incinerator, an ecological risk assessment may be needed to verify lack of likely impact.

### Frequency of Monitoring

Monitoring frequencies depend on the pollutant/parameter being monitored. Minimum monitoring frequencies for arsenic, cadmium, chromium, lead, and nickel are the same as for land application, based on the incinerator's throughput of sewage sludge; those for beryllium and mercury are tied to the NESHAPS rule.

The permitting authority may impose more frequent monitoring requirements on permittees. In addition, after two years of monitoring at these frequencies, the permitting authority may allow the monitoring frequencies for arsenic, beryllium, cadmium, chromium, lead, mercury and nickel to be reduced to no less than once per year. Continuous monitoring is required for THC, oxygen content, information to determine moisture level, and combustion temperature. Monitoring frequency for air pollution control device (APCD) operating parameters (*i.e.*, scrubber pressure drop or afterburner operating temperature) will be determined by the permitting authority.

### Recordkeeping/Reporting

Sewage sludge incinerators must keep records of their operations for a five-year period. Records will include: metal content in the sewage sludge feed, THC concentrations in the exhaust, verification of compliance with NESHAPS, results from the continuous emissions monitors and APCD monitors, results from the control efficiency tests and dispersion modeling, and the calibration and maintenance logs. Many of these records have to be reported to the permitting authority each year (initially on the anniversary of the date of publication of the Part 503 rule - February 19, 1994) if the permittee is a Class I sewage sludge management facility, has a design flow of 1 MGD or more, or it serves a population of at least 10,000.

## DOMESTIC SEPTAGE

The Part 503 regulation addresses management of septage generated from domestic sources only. If commercial or industrial wastes are combined with the domestic wastes, Part 503 does not apply to the use or disposal of the resulting septage. Domestic septage is defined as "liquid or solid material removed from a septic tank, cesspool, portable toilet, Type III marine sanitation device or similar system that receives only domestic (non-commercial) septage." Substances often referred to as septage, such as grease trap residues, as well as grit and screenings, are not included in this definition.

The final Part 503 regulation provides a simplified regulatory scheme for the land application of domestic septage that is applicable only if the domestic septage application is applied to "non-public contact sites," where the potential for public exposure is minimal, such as agricultural fields, forests, and disturbed sites in need of reclamation. Allowable land application rates are based upon the nitrogen requirement of the crop grown and yield expected.

Management of domestic septage in other ways (*i.e.*, land application to public contact sites, surface disposal or incineration) must be performed in accordance with the same provisions that govern management of sewage sludge through the various options, with a major exception--there is no requirement to analyze domestic septage for pollutant concentrations for land application or surface disposal, unless the user/disposer chooses to treat it the same as sewage sludge.

### Land Application of Domestic Septage to Non-Public Contact Sites

Under the Part 503 regulation, domestic septage appliers are required to:

1) Meet (and certify) applicable pathogen and vector attraction reduction requirements
2) Follow specific management practices
3) Apply domestic septage at rates based on nitrogen requirement of the crops
4) Ensure that the septage is from domestic sources only
5) Keep site application records

Septage tank pumpers who land apply domestic septage to agricultural land, forest, or reclamation sites are generally not required to obtain federal permits for these activities, but are subject to the same enforcement actions as other "sewage sludge" use or disposal operators if they fail to comply with applicable Part 503 requirements. The Clean Water Act makes the Part 503 regulation enforceable without a permit being issued.

### Pathogen Reduction

Pathogen reduction requirements applicable to land application of domestic septage can be achieved either through strict site restrictions or through stabilization of the domestic septage with alkaline materials and less limiting site restrictions. The site restrictions (including restrictions on crop harvesting, animal grazing and public access) vary depending on how pathogens are addressed. If domestic septage is not stabilized prior to application to agricultural land, forest, or reclamation sites, the same site restrictions as imposed on Class B sewage sludge are required. If domestic septage is stabilized prior to application by mixing with enough alkali material to raise its pH to at least 12 for at least 30 minutes, only the first four crop harvesting restrictions are applicable. No pathogen reduction requirements are imposed on surface disposal of domestic septage.

### Vector Attraction Reduction

As described earlier, three vector attraction reduction options (#9 - Injection, #10 - Incorporation, or #12 - Septage Treatment) may be employed when domestic septage is applied to agricultural land, forest, or reclamation sites. Four vector attraction reduction options (#9 - Injection, #10 - Incorporation, #11 - Daily Cover, or #12 - Domestic Septage Treatment) may be employed when domestic septage is placed in a surface disposal site. The treatment of domestic septage by pH adjustment to meet pathogen and vector attraction reduction requirements involves the same treatment process - mixing with enough alkali material to raise its pH to at least 12 for at least 30 minutes to meet pathogen reduction and vector attraction reduction requirements

### Application Rate

The maximum volume of domestic septage that can be applied to agricultural land, forest or reclamation sites in any year depends on the amount of nitrogen required by the crop grown and expected yield. The following equation is provided in the regulation to calculate annual domestic septage application rates:

$$\text{Annual Application Rate (gallons per acre year)} = \frac{\text{lbs. N Required by Crop}}{0.0026^{*}}$$

* based on estimated available N (in mg/l) in domestic septage times a conversion factor

### Frequency of Monitoring/Record Keeping/Reporting

When domestic septage pathogen reduction is achieved by pH adjustment with alkali materials, pH levels in every container (truck load) must be monitored. Although there are no formal reporting requirements, the regulation does specify records that must be maintained by land appliers of domestic septage.

The following table lists the information that must be recorded and saved by the domestic septage land applier. These records must be kept for five years following application. Sample forms for recordkeeping have been developed and are available from EPA. They are included in a guidance document entitled "Simplified Federal EPA Rules for Land Application of Domestic Septage to Non-Public Contact Sites."

For domestic septage placed in surface disposal sites, if vector attraction reduction is achieved by pH adjustment, monitoring of each container is required. Methane gas monitoring requirements for covered surface disposal sites is the same as for surface disposal of sewage sludge. Also, records must be kept by the owner/operator of the surface disposal site for at least 5 years concerning the surface disposal site management practices and vector attraction reduction practices employed.

| REQUIRED RECORDS |
|---|
| 1) Location of the application site (either the street address, or the longitude and latitude of the site). |
| 2) Number of acres on which domestic septage is applied at each site. |
| 3) Date and time of each application. |
| 4) Nitrogen requirement for the crop or vegetation grown on each site during a 365-day period. |
| 5) Gallons of domestic septage applied to each site. |
| 6) Required certification statement. |
| 7) Description of pathogen reduction measures used. |
| 8) Description of vector attraction measures used. |

### Compliance

As with other provisions of the regulation, domestic septage appliers were to begin maintaining records of their activities on July 20, 1993 (within 150 days of publication of the rule in the *Federal Register*). Compliance with other provisions must be achieved within one year of publication of the rule in the *Federal Register* if no construction of new pollution control facilities is required.

# SECTION 1.2 C UNITED STATES REGULATIONS AND PRACTICAL EXPERIENCE ON BIOSOLIDS REUSE AND DISPOSAL

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A number of factors have and will likely continue to play an important role in influencing the future of biosolids management in the United States. These factors include the development of Federal policies and the new comprehensive, risk-based Federal technical regulations and Federal permitting requirements. However, other factors such as our country's aging infrastructure and funding crisis, changes in available scientific information and residuals management technologies, and the influence of public opposition and liability concerns associated with proposed projects have been and may well be even more important in shaping the future of biosolids management.

## CHANGES OVER THE PAST 10-20 YEARS

Certainly over the past 10-20 years we have seen some major changes in biosolids management practices in the U.S. These include significant changes in biosolids (formerly called "sewage sludge") processing as well as in use and disposal practices such as the following:

- expanded use of mechanical dewatering equipment and polymers,
- a movement from the use of multiple hearth to fluid bed incinerators,
- a movement away from long-term lagoon storage,
- a decrease in the use of landfilling (especially co-disposal with municipal solid waste),
- increased interest in and use of land application practices,
- increased interest in and use of heat drying/pelletizing, composting and alkaline stabilization processing of biosolids,
- a phase-out of ocean disposal practices,
- more long-distance transport of biosolids to end use/disposal sites,
- more contracted-out biosolids management operations,
- more use of multiple biosolids use/disposal practices, especially by the larger authorities.

## SOME KEY FACTORS INFLUENCING BIOSOLIDS MANAGEMENT DECISION MAKING

From my vantage point, it appears that a number of factors have greatly influenced these trends in biosolids processing and use/disposal practices:

- dramatic increases in biosolids volumes,
- improvements in biosolids quality resulting from pretreatment,
- improvements in biosolids handling equipment and processing, as well as management practices,
- escalation of urban land, labor and energy costs,
- a willingness of management agencies to pay dramatically higher prices for biosolids disposal than in the past,
- extensive new information from R&D and monitoring activities - changes in regulatory policies and requirements,
- increasing negative public reactions to siting of biosolids processing and disposal facilities.

In most cases these factors will likely continue to play a major role in influencing the future trends of biosolids management practices. Further, in at least some cases their impact on biosolids management decision making has been and can be expected to continue to be quite dramatic.

<u>Increasing Biosolids Volumes</u>

As the volumes of and levels to which water and wastewater are treated increase, the resulting volumes of residuals also increase (see Table 1). Figure 1 provides an example of the near doubling in estimated volumes of biosolids produced annually in the U.S. from 1972 to 1990. These increases include the effects of adding many new treatment plants as well as increasing treatment levels to meet secondary and higher levels of treatment. Some of the requirements calling for higher levels of water and wastewater treatment that are resulting in the production of increasing volumes of biosolids include:

- full secondary for all POTWs was scheduled to have occurred by July 1, 1988, with the exception of those receiving 301(h) waivers for ocean discharge
- phosphorus reduction for discharges to many major lakes and reservoirs
- nitrogen reduction for many estuary discharges
- many new toxics water quality and drinking water standards to be met across the country

However, since the majority of the sewage treatment plants needed have been built and are already achieving secondary or higher levels of treatment, it would be unlikely that the increases in biosolids volumes from sewage treatment will continue to increase at the rates realized over the past 10-20 years. Also, while many communities may have paid little attention to how they would manage increased biosolids volumes when planning new treatment facilities in the early 1970's, it is clear that planning for biosolids management has become a major concern and will continue to be so in future years.

**Table 1. Volumes of Biosolids Produced by Different Wastewater Treatment Processes.**

| Treatment Process | Biosolids Dry Solids, lbs/$10^3$ gal of Wastewater Treated | |
|---|---|---|
| | Range | Typical |
| Primary Sedimentation | 0.9 - 1.40 | 1.25 |
| Activated Sludge (waste sludge) | 0.6 - 0.8 | 0.7 |
| Trickling Filter (waste sludge) | 0.5 - 0.8 | 0.6 |
| Extended Aeration (waste sludge) | 0.7 - 1.0 | 0.8[a] |
| Aerated Lagoon (waste sludge) | 0.7 - 1.0 | 0.8 |
| Chemical addition to primary sedimentation tanks for phosphorus removal | | |
| Low Lime (350-500 mg/L) | 2.0 - 3.3 | 2.5[b] |
| High Lime (800-1,600 mg/L) | 5.0 - 11.0 | 6.6[b] |

[1] Metcalf and Eddy, Inc. (1991)
[a] Assumes no primary treatment.
[b] Biosolids in addition to those normally removed by primary sedimentation.

There is a large variation of biosolids per unit volume of wastewater produced by primary treatment (removal of substances from wastewater by mechanical screening or sedimentation), secondary biological treatment (oxidation of organic material by microorganisms), and chemical treatment (addition of metal salts to remove suspended solids and phosphorus) [NAS, 1977].

Improvement in Biosolids Quality

While certainly not true in all cases, it would appear that many communities have instituted quite effective pretreatment programs since the early 1970's. In at least some cases pretreatment programs have contributed to if not directly resulted in dramatic improvements in biosolids quality. Such improvements in biosolids quality have opened the door to greater consideration of beneficial uses such as land application and the production/sale of biosolids amendment products (e.g., compost, heat dried pellets, alkaline stabilized soil additives or soil substitute products). With added incentives such as "No Observed Adverse Effect Limits" (NOAEL) calculated for highly exposed individuals during EPA's risk assessment efforts and the "Exceptional Quality" sludge provisions to reduce the restrictions and record-keeping requirements of the new Part 503 sewage sludge technical regulations on land application practices (EPA, 1990; Chaney, 1990; EPA, 1993), additional improvements in biosolids quality through tighter source controls and pretreatment programs can be expected in the future. Table 2A presents a proposal for NOAEL sewage sludge quality compared with a summary of the results of EPA's National Sewage Sludge Survey (NSSS), a statistically derived sampling in 1988 of sludge quality across the U.S. In addition, Table 2B presents preliminary results of biosolids analysis from a 1992 survey of the 50 largest wastewater treatment facilities in the U.S. are presented which concluded that the quality of biosolids produced by these facilities appears to have improved in most cases since the NSSS samples were collected in 1988 (Chaney, 1990; Bailey, et al., 1994).

Improvements in Equipment, Processes and Management Practices

There are numerous examples of equipment and process changes that have become quite widely accepted by the biosolids management industry. Such changes include the movement toward the use of fluidized bed incinerators, improved mechanical dewatering equipment, better mixers and conveyor systems, larger and more efficient land application vehicles, and advancements in composting and alkaline stabilization techniques. Others include improvements in automated process control systems, aeration systems, and odor and other emission control systems. These changes were often brought about by changes in the design and performance efficiencies of previously available equipment, a true response by equipment suppliers to a perceived demand by the marketplace. In at least some cases these changes were stimulated by rising fuel and labor costs; in other cases by changes in policy or regulatory requirements.

**Table 2A. Comparison of the Proposed NOAEL Sludge Quality and a Summary of the Results of EPA's NSS Survey (from Chaney, 1990).**

| Pollutant | Proposed NOAEL Sludge Limit | Comparison with the 1990 Nat. Sewage Sludge Survey | | | | |
|---|---|---|---|---|---|---|
| | | Normal Statistics | | | Maximum Likelihood[5] | |
| | | Median | 95th | 98th | Median | 98th |
| | mg/kg DW | --- mg/kg dry sludge --- | | | | |
| As | 100[1] | 6 | 43 | 62 | 5 | 33 |
| Cd | 18 | 7 | 21 | 25 | 4 | 19 |
| Cr | 2,000[1,2] | 40 | 635 | 1,960 | 39 | 409 |
| Cu | 1,200 | 463 | 1,940 | 2,490 | 456 | 2,180 |
| Hg | 15[3] | 4 | 17 | 43 | 2 | 19 |
| Mo | 35[4] | 11 | 42 | 56 | 5 | 32 |
| Ni | 500 | 29 | 223 | 438 | 18 | 159 |
| Pb | 300 | 106 | 296 | 444 | 76 | 373 |
| Se | 32 | 5 | 28 | 51 | 3 | 16 |
| Zn | 2,700 | 725 | 4,100 | 4,760 | 755 | 3,270 |
| PCB-1248 | 2.13 | 0.21 | 0.67 | 1.5 | 0.02 | 0.21 |

1 Adjusted downward for pretreatment considerations.
2 No adverse effects reported for any $Cr^{+3}$ level in municipal sludge.
3 Valid for all sludge uses except mushroom production.
4 No limit raised because Mo slowly leaches from alkaline soil.
5 Maximum likelihood estimation procedure, assuming multicensored lognormality.

**Table 2B. Summary of Preliminary Analysis of Biosolids Quality from a 1992 Survey of the 50 Largest POTWs in the United States (from Bailey *et al.*, 1994).**

| Metal | Number of Responses | Annual Mean Concentrations (mg/kg dry weight basis) | | | Plants Exceeding 503 Table 1 Limits[1] | Plants Exceeding 503 Table 3 Limits[1] |
|---|---|---|---|---|---|---|
| | | Average | Maximum | Minimum | | |
| As | 41 | 4.92 | 17.3 | 1.15 | 0 (0%) | 0 (0%) |
| Cd | 63 | 24.86 | 199 | 1 | 5 (8%) | 7 (11%) |
| Cr | 60 | 178 | 1,655 | 21.7 | 0 (0%) | 1 (2%) |
| Cu | 62 | 616 | 1,832 | 2.18 | 0 (0%) | 1 (2%) |
| Pb | 63 | 170 | 1,304 | 31 | 1 (2%) | 8 (13%) |
| Hg | 58 | 2.33 | 8.57 | 0.18 | 0 (0%) | 0 (0%) |
| Mo | 16 | 24.93 | 50 | 3.54 | 1 (6%) | 11 (69%) |
| Ni | 60 | 70.6 | 243 | 15.6 | 0 (0%) | 0 (0%) |
| Se | 22 | 6.02 | 60.1 | 0.2 | 0 (0%) | 1 (5%) |
| Zn | 62 | 1,285 | 5,631 | 482 | 0 (0%) | 2 (3%) |

[1] All percentages are with relation to total number of responses for given parameter.

In the past some of the equipment and process technology advancements were facilitated if not underwritten by Federal grants (e.g., NSF research grants, EPA I/A technology grants, EPA research and demonstration grants, USDA research and extension projects, DOE funded projects, etc.), but there is limited prospect of this type of Federal funding in the future. Future equipment and process advancements are likely to be much more dependent upon private and industry-related funding sources (e.g., the wastewater and water supply authorities themselves, the American Water Works Association and Water Environment Federation Research Foundations, individual firms, private [including foreign] investors, etc.).

A wide range of land application practices for beneficially recycling biosolids have been investigated and employed to date, including application to many urban parks and golf courses, cropland, rangeland, forests, and a variety of disturbed and marginally productive areas (e.g., strip-mined areas, construction sites, etc.). Land application projects are underway involving biosolids from many large metropolitan areas (including Washington, D.C., New York City, Boston, Philadelphia, Pittsburgh, Chicago, Milwaukee, Denver, Seattle, Portland, and Los Angeles), as well as thousands of smaller cities and towns across the U.S., especially in the Midwest. Many of these projects are prime examples of the basic land treatment, recycling/reuse concepts that have been strongly encouraged by Congress and EPA. The extensive research and demonstration experience and guidance developed during the 1970's/1980's addressing the potential value and benefits that could be achieved through such land application practices (Sopper, 1993; Hornick et al., 1984; Page et al., 1983; EPA, 1983; Sopper et al., 1982; SSSA, 1886; Cole et al., 1986) led to the establishment of successfully operated projects in most parts of the country.
Land application practices have been implemented by many rural communities with adequate available land, and agreeable land owners and neighbors. In some cases "dedicated" or publicly owned and controlled sites have been used, but a more common practice has involved application to privately owned and managed farmland, strip mined sites, etc. The results of one survey suggests that, nationwide, well over 30 percent of the smaller communities have applied their biosolids to the land for over 40 years. For years many communities simply stockpiled dried biosolids and allowed the public to haul it away for their own use. Now there is a growing interest in the potential for marketing biosolids to farmers and others as an organic fertilizer and soil amendment. A number of communities have been heat drying, composting, or otherwise processing their biosolids prior to marketing or giving it away as a soil amendment for many years.

Others have established programs for applying liquid biosolids to cropland at carefully predetermined rates, and in at least some cases farmers pay for the biosolids or biosolids application service. At least part of the biosolids produced in Salem, Oregon, in Denver, Colorado, in Madison and Milwaukee, Wisconsin, and in Virginia Beach, Virginia, is applied to cropland as liquid "BIOGRO," "METROGRO," "AGRO-LIFE," and "NUTRI-GREEN" where there are more requests for these organic materials than can be satisfied because of the benefits being realized from biosolids use by the landowners. Seattle, Washington, applies much of its biosolids as liquid "SILVIGRO" to city and privately owned commercial timberland and privately owned cropland.

The selling or give-away of bagged or bulk, processed (composted, heat dried, alkaline stabilized) biosolids-containing products for use as soil conditioners, organic fertilizers, or potting media has been practiced for many years in several major urban areas (e.g., Los Angeles County, California and Kellogg Supply Co.'s "Nitrohumus" and other composted products; Milwaukee, Wisconsin - "Milorganite" heat dried product; Houston, Texas - "Hou-actinite" heat dried product) and have started more recently in other areas (e.g., Philadelphia, Pennsylvania - "Earthlife" compost product; Washington, D.C. metropolitan area - "Compro" compost product; Oakland, California - "CompGro" compost product). Also, various types of "give-away" programs have been operated by numerous small and large communities as a common biosolids management practice for years.

Efforts by private companies, either using their own company-owned facilities or city owned facilities, to produce and market biosolids-related products are also becoming a more common situation (e.g., systems in Boston, Massachusetts; New York City, New York; Middlesex County, New Jersey; Hagerstown, Maryland; Tampa, FL; Portland, Oregon; and Settle, Washington, sized to handle from 6 to 300 dry tons per day). The most recent Biocycle survey found a total of 321 biosolids composting projects in operation or development--182 full-scale operating facilities, 4 in start-up, 21 under construction, and the remainder either pilot projects or projects still in permitting, design and planning stages (Goldstein & Steuteville, 1993). There are also at least 10 full-scale operating thermal drying/pelletizing facilities and another 5 in start-up, under construction or in the permitting, design and planning stages. In addition, there are a growing number of alkaline stabilization facilities being established in various parts of the U.S. that produce a product acceptable for use as an agricultural lime substitute, organic fertilizer, or as an artificial soil for daily or final landfill cover, dike construction, etc.

Escalating Costs/Willingness to Pay Higher Disposal Fees

As noted above, in at least some cases changes in biosolids management equipment and processes were stimulated by rising fuel and labor costs. In many situations biosolids management authorities have been faced with accepting dramatic increases in residuals disposal costs to levels never envisioned as publicly acceptable to rate payers. In the 1970's costs for biosolids disposal were generally cited as less than $100/dry ton, although with some notable exceptions. However, by the late 1980's it wasn't unusual to see cost estimates of $500+/dry ton; some relatively recent short-term private contracts for land based alternatives for ocean dumpers have run as high as $800/dry ton.

Such increases in costs along with the increases in biosolids volumes to be disposed and difficulties in finding appropriate sites for biosolids management projects have led to situations where long distance transport to areas where land is available for use or disposal have become a reality (e.g., Los Angeles to Arizona, New Jersey to Texas, Virginia, Pennsylvania, Ohio and Indiana; New York to Arizona, Colorado, Texas, Pennsylvania, etc.). With such high biosolids management costs (often paid for with O&M funds), more serious attention may be given in the future to some of the higher capital cost systems tied to privatized funding sources.

Further, energy consumption in the U.S. is projected to increase significantly in the future and tighter controls are likely to be placed on power plants under the requirements of the recently amended Clean Air Act. As a result, it is likely that energy costs will continue to increase and be a major influence on decisions regarding the selection of biosolids management alternatives.

Changes in Technical Information

As a result of the efforts undertaken by researchers from many of the Nation's leading universities, Federal and private laboratories, considerable advancements have been realized over the past 10-20 years in our understanding of various biosolids management practices. In some cases these efforts have led to improvements in specific biosolids management technologies and equipment (e.g., a new generation of centrifuges and belt presses, vacuum assisted drying beds and paved bed drying systems, dual digestion, autothermal thermophilic aerobic digestion [ATAD], sophisticated land application and injection equipment, enhanced composting technologies and alkaline stabilization alternatives). In other cases the research has led to a better understanding of the contaminants that may be present in or associated with biosolids. This is certainly true of our ability to detect ever lower levels of contaminants of concern (e.g., dioxins and furans both in biosolids and as products of incomplete combustion) and of our understanding of the fate of heavy metals and PCBs in land applied biosolids under field as well as laboratory conditions. Such information became especially important during the development of the new risk-based Federal regulations. Today we find contaminants present in biosolids being regulated to levels that couldn't be measured twenty years ago. It would seem reasonable that such advancements in technologies and our understanding of various biosolids management practices will continue in the future.

Changes in Regulatory Policies and Requirements

For many years, biosolids were regulated under a number of different Federal statutes, with no comprehensive program at the national level. Federal regulations (see Table 3) as well as technical guidelines impacting biosolids management practices were developed independently in response to media-specific concerns. Federal policy statements and guidance documents that were very supportive of beneficial use practices were also issued (EPA/USDA/FDA, 1981; EPA, 1984). However, with the exception of ocean dumping and direct discharges to surface waters, for the most part the primary responsibility for controlling biosolids management practices was at the State and local level until recently.

Since the early 1970's the Federal regulations and technical guidelines were often used by States as the basis of their requirements, although some States were more restrictive (e.g., used lower allowable contaminant concentrations or loading rates; several States established bans on landfilling of biosolids to save limited landfill capacity; some established tighter restrictions on "imported" wastes than those generated locally, etc.) and others more liberal than the Federal requirements and guidelines. Nearly all states have some type of residuals management control program(s) in place that directly control biosolids use/disposal practices, but these programs have varied widely in their comprehensiveness and effectiveness. As a result, in at least some cases States have played a major role in facilitating or constraining certain biosolids management practices.

Greater direct Federal involvement in the control of biosolids management practices can be anticipated in the future. With the issuance of the new Federal technical regulations under 40 CFR Part 258 (new municipal solid waste landfill regulations) in October 1991, 40 CFR Part 122-124, and 501 (Federal permitting of biosolids use/disposal facilities under expanded NPDES programs or other approved State programs) in 1989, and 40 CFR Part 503 (technical standards for the use/disposal of sewage sludge) in 1993, EPA is attempting to address all biosolids use/disposal practices comprehensively, including cross-media considerations--at least to some extent. The new technical regulations are risk based in nature, and although Federal permits will now be involved in the control of biosolids management practices, the choice of use/disposal practice (with the exception of ocean disposal--ocean dumping was banned by the Ocean Dumping Ban Act of 1989 and ocean discharge is prohibited by provisions of the Clean Water Act) will continue to be up to the generator. This potentially opens the door to more consistent regulation of biosolids and could well be extended to other non-hazardous residuals in the future as a result of rulemaking under the Resource Conservation & Recovery Act. The 1991 "Interagency Policy on Beneficial Use of Municipal Sewage Sludge on Federal Lands," which supplements and reinforces the earlier EPA policies, also helps clarify concerns that have been raised over inconsistent Federal policy concerning beneficial use practices and their potential for use on Federal lands (EPA, 1991).

**Table 3. Federal Regulations Impacting Biosolids Management Before Part 503.**

| Coverage | Law | Reference | Application |
|---|---|---|---|
| Polychlorinated Biphenyls (PCBs) | TSCA | 40 CFR 761 | All residuals containing more than 50 mg/kg. |
| Ocean Dumping | MPRSA | 40 CFR 220-228 | The discharge of residuals from barges or other vessels. |
| Direct Discharge | CWA | 40 CFR 123 | The discharge of residuals to surface waters from outfalls. |
| National Ambient Air Quality Standards | CAA | 40 CFR 761 | All stationary sources emitting more than 100 tons/yr. |
| New Sources of Air Emissions | CAA | 40 CFR 60 | Incineration of biosolids at above 1,000 kg/day. |
| Hazardous Air Emission | CAA | 40 CFR 61 | Incineration and heat drying of |

| Coverage | Law | Reference | Application |
|---|---|---|---|
| Standards (Mercury & Beryllium) | | | biosolids. |
| Cadmium, PCBs, Pathogens | RCRA & CWA | 40 CFR 241, 257 | Land application of biosolids, landfills, and storage lagoons. |
| Extraction Procedure/Toxicity Characteristic Leachate Procedure | RCRA | 40 CFR 261 Appendix II | Defines whether residuals are hazardous wastes due to toxicity characteristic. |
| Environmental Impacts | NEPA | 40 CFR 1500 | Environmental impact assessments and reviews. |

MPRSA = Marine Protection, Research and Sanctuaries Act
CWA = Clean Water Act
TSCA = Toxic Substances Control Act
CAA = Clean Air Act
RCRA = Resource Conservation and Recovery Act
NEPA = National Environmental Policy Act

## THE NEW PART 503 REGULATIONS AND THEIR IMPLEMENTATION

On February 19, 1993, the final 40 CFR Part 503 "Standards for the Use or Disposal of Sewage Sludge" and revisions to the 40 CFR Parts 122, 123 and 501 "NPDES Permit Regulations; State Sludge Management Program Requirements" were published in the Federal Register (58 FR 9248-9404). The new U.S. EPA rules address beneficial use practices involving land application as well as surface disposal and incineration of biosolids. They affect generators, processors, users and disposers of biosolids--both public and privately owned treatment works treating domestic sewage (including domestic septage haulers and non-dischargers), facilities processing or disposing of biosolids, and the users of biosolids and products derived from biosolids.

The Part 503 regulation addresses the use and disposal of only biosolids, including domestic septage, derived from the treatment of domestic wastewater. It does not apply to materials such as grease trap residues or other non-domestic wastewater residues pumped from commercial facilities, sludges produced by industrial wastewater treatment facilities, or grit and screenings from POTWs.

Although facilities which dispose of biosolids in municipal solid waste (MSW) landfills or use processed biosolids as a cover material are regulated under the Part 258 rules issued in 1991, all treatment works treating domestic sewage (TWTDS), including non-dischargers and sludge-only facilities, must apply for a Federal permit from the U.S. EPA (or an approved state program). TWTDS that land apply their biosolids and have existing NPDES permits apply for their Federal "sewage sludge" permit as a part of their next NPDES permit renewal application, while those without existing NPDES permits were required to apply for their permit within 1 year of publication of the new regulation (*i.e.*, February 19, 1994). While disposal facilities such as sewage sludge incinerators, monofills and other surface disposal sites are clearly TWTDS and were required to apply for Federal permits, the definition does not extend automatically to areas such as farm land where biosolids are beneficially used; only under unusual situations would these areas be considered TWTDS by the permitting authority. The permitting authority has the flexibility to cover both the generator and the treatment, use/disposal facility in one permit or separate permits (including covering one or both under general permits).

The U.S. EPA will work closely with the States to encourage their adoption of biosolids regulatory programs that can be approved to carry out delegated programs and avoid the need for separate U.S. EPA permits, compliance monitoring and enforcement activities. However, until a State applies for and is approved to carry out a delegated program, all TWTDS in the State will be dealing directly with their U.S. EPA Regional Office regarding Federal permits, compliance monitoring and enforcement issues associated with the implementation of the Part 503 requirements--in addition to dealing with their State regulatory authorities and requirements.

By statute, compliance with the Part 503 standards is required within 12 months of publication of the new regulation (*i.e.*, February 19, 1994). If pollution control facilities need to be constructed to achieve compliance, then compliance is required within 2 years (*i.e.*, February 19, 1995) of publication. Under the new regulation, compliance with the monitoring and recordkeeping requirements was required within 150 days (*i.e.*, July 20, 1993) of publication of the rule.

For the most part the Part 503 regulation is written to be "self implementing," which means that citizen suits or U.S. EPA can enforce the regulation even before permits are issued. As a result, treatment works must start monitoring and keeping records of biosolids quality (and in many cases land appliers must start keeping records of loading rates and locations receiving biosolids), and must comply with pollutant limits and other technical standards, even in the absence of a Federal permit.

Part 503 is organized into the following subparts: general provisions, land application, surface disposal, pathogens and vector attraction reduction, and incineration. Subparts under each of the use/disposal practices generally address: applicability, general requirements, pollutant limits, management practices, operational standards, frequency of monitoring, recordkeeping, and reporting requirements.

Under Part 503, Land Application includes all forms of applying biosolids to the land for beneficial uses at agronomic rates (rates designed to provide the amount of nitrogen needed by the crop or vegetation grown on the land while minimizing the amount that passes below the root zone). These uses include: application to agricultural land such as fields used for the production of food, feed and fiber crops, pasture and range land; non-agricultural land such as forests; disturbed lands such as mine spoils, construction sites and gravel pits; public contact sites such as parks and golf courses; and home lawns and gardens. The distribution and marketing of biosolids derived materials such as composted, chemically stabilized or heat dried products is also addressed under land application, as is land application of domestic septage.

The rule applies to the person who prepares biosolids for land application or applies biosolids to the land. These parties must obtain and provide the necessary information needed to comply with the rule. For example, the person who prepares bulk biosolids that is land applied must provide the person who applies it to land all information necessary to comply with the rule, including the total nitrogen concentration of the biosolids.

The regulation establishes two levels of biosolids quality (see Table 4) with respect to ten heavy metal concentrations--pollutant Ceiling Concentrations and Pollutant Concentrations ("high quality" biosolids); two levels of quality with respect to pathogen densities, Class A and Class B (see Table 5); and two types of approaches for meeting vector attraction reduction--biosolids processing or the use of physical barriers (see Table 6). Under the Part 503 regulation, fewer restrictions are imposed on the use of higher quality biosolids. Based upon the results of the National Sewage Sludge Survey (NSSS) published in November 1991 (see summaries in Tables 2A and 4), EPA anticipates that a large percentage of the biosolids currently being produced will be capable of meeting the "high quality" pollutant concentrations.

**Table 4. Composition of Sewage Sludge <u>vs</u> Part 503 Ceiling and "High Quality" Pollutant Concentrations; Cumulative and Annual Loading Rates.**

| | Part 503 Numeric Criteria, Table in 503 Rule | | | | NSSS Results[1] | |
|---|---|---|---|---|---|---|
| | Table #1 | Table #2 | Table #3 | Table #4 | Median Values Statistical Basis | |
| Pollutant | Ceiling Conc. Limits[2] mg/kg | Cumulative Pollutant Loading Rates (kg/ha) | "High Quality" Pollutant Conc. Limits[3] mg/kg | Annual Pollutant Loading Rates (kg/ha/yr) | Normal mg/kg | Maximum[4] mg/kg |
| Arsenic | 75 | 41 | 41 | 2.0 | 5 | 5 |
| Cadmium | 85 | 39 | 39 | 1.9 | 7 | 4 |
| Chromium | ~~3,000~~[*] | ~~3,000~~[*] | ~~1,200~~[*] | ~~150~~[*] | 40 | 39 |
| Copper | 4,300 | 1,500 | 1,500 | 75 | 463 | 456 |
| Lead | 840 | 300 | 300 | 15 | 106 | 76 |
| Mercury | 57 | 17 | 17 | 0.85 | 4 | 2 |
| Molybdenum | 75 | ~~18~~[*] | ~~18~~[*] | ~~0.90~~[*] | 11 | 5 |
| Nickel | 420 | 420 | 420 | 21 | 29 | 18 |
| Selenium | 100 | 100 | ~~36~~[*] | 5.0 | 5 | 3 |
| Zinc | 7,500 | 2,800 | 2,800 | 140 | 725 | 755 |

[1] U.S. EPA. Nov. 1991. Summary of the NSSS.
[2] Absolute values
[3] Monthly averages
[4] pollutant concentrations for samples below the detection limit were incorporated into estimates through the Maximum Likelihood procedure for multiple censor points to produce a better estimate than procedures that substitute either zero or the detection limit for nondetect samples.
[*] A February 25, 1994, *Federal Register* Notice deleted the values for Molybdenum in Tables 2, 3 & 4. As of September 30, 1995, Chromium limits are anticipated to be dropped from the regulation and the Table 3 limit for Selenium is to be modified.

To qualify for land application, biosolids or material derived from biosolids must meet at least the pollutant Ceiling Concentrations (Table 4), Class B requirements for pathogens and vector attraction reduction requirements. Cumulative Pollutant Loading Rates are imposed on biosolids that meet the pollutant Ceiling Concentrations but not the Pollutant Concentrations. A number of general requirements and management practices apply to biosolids that are land applied (see Table 7) other than an "Exceptional Quality" biosolids or derived material which meets three quality requirements--the Pollutant Concentration limits, Class A pathogen requirements, and vector attraction reduction biosolids processing. However, in all cases the minimum frequency of monitoring, recordkeeping, and reporting requirements (see Table 8) must be met.

**Table 5. Part 503 Pathogen (indicator organism) Density Limits for Class A and Class B Biosolids.**

| Classification | Fecal coliforms | *Salmonella spp.* |
|---|---|---|
| Class A[1] | < 1,000 MPN/g TS -or- 3 MPN/4 g TS | |
| Class B | < 2,000,000 MPN/g TS<br>-or-<br>< 2,000,000 CFU/g TS | |

[1] In addition, density limits of >1 PFU/4 g TS for enteric virus and >1 egg/4 g TS for viable helminth ova are included for evaluating sludge treatment processes that cannot meet specific operational requirements (*i.e.*, time/temperature/pH relationships) specified in the rule.

Abbreviations:
MPN = most probable number
TS = total solids
CFU = colony forming units
PFU = plaque forming units

Under Part 503, Surface Disposal addresses biosolids and septage disposal, including sludge-only monofills; dedicated disposal surface application sites (where sludge pollutants are applied at higher than the Cumulative Pollutant Loading Rates allowed under land application); piles or mounds and impoundments or lagoons where sludge is placed for final disposal. It is not intended to include the placement of biosolids in similar locations for storage or treatment; however, the facility operator will need to provide an adequate explanation concerning why it is being stored for longer than 2 years.

For surface disposal, the regulation establishes requirements for both unlined facilities and those with liners and leachate collection systems. These include concentration limits for three heavy metals (As, Cr & Ni) that apply to biosolids disposed of in lined surface disposal sites, but no specific concentration limits for biosolids going to sites with liners and leachate collection systems. Specific management practice requirements address such areas as the location of surface disposal sites, control of surface runoff, methane gas monitoring, and restrictions on crop production, grazing and public access. A provision allowing for the establishment of site-specific limits and management practices for surface disposal sites is provided.

The Part 503 regulation requires minimum frequency of monitoring biosolids pollutant quality (but not septage) based on the annual amount of biosolids used or disposed; maintenance of records (in most cases for a minimum of 5 years) regarding such information as biosolids quality, application sites, application dates, various certification statements and descriptions of management practices, pathogen and vector reduction measures used. Annual reporting is required only for Class I biosolids facilities (the ~1,600 pretreatment POTWs and an estimated 400 other facilities likely to be designated TWTDS), and other POTWs with a design flow of ≥1 MGD or serving a population ≥10,000.

### Table 6. Vector Attraction Reduction Alternatives.

#### PROCESSING ALTERNATIVES

1) Aerobic or Anaerobic Digestion which achieve a ≥38% reduction in volatile solids (VS) measures as the difference in the raw sewage sludge prior to stabilization and the treated sewage sludge ready for use or disposal.

2) Anaerobic Digestion (if 38% VS reduction cannot be met) - demonstrated by further digesting a portion of the digested sewage sludge in a bench scale unit for an additional 40 days at 30 to 37°C or higher and achieving a further VS reduction of <17%.

3) Aerobic Digestion (if 38% VS reduction cannot be met) - demonstrated by further digesting a portion of the digested sewage sludge with a solids content of ≤2% in a bench scale unit for an additional 30 days at 20°C and achieving a further VS reduction of <15%.

4) Aerobic Digestion - Specific Oxygen Uptake Rate (SOUR) is ≤1.5 mg $O_2$/hr/gr of TS at 20°C.

5) Aerobic Processes - (e.g., composting) temperature is kept at >40°C for at least 14 days and the average temperature during this period is greater than 45°C.

6) Alkaline Stabilization - pH is raised to at least 12 by alkali addition and, without the addition of more alkali, remains at 12 or higher for 2 hours and then at 11.5 or higher for an additional 22 hours.

7&8) Drying - TS is ≥75% when the sewage sludge does not contain unstabilized primary solids and ≥90% when unstabilized primary solids are included. Blending with other materials is not allowed to achieve the total solids percent.

#### PHYSICAL BARRIER ALTERNATIVES

9) Injection - Liquid sewage sludge (or domestic septage) is injected beneath the surface with no significant amount of sewage sludge present on the surface after 1 hour; sewage sludges that are Class A for pathogen reduction shall be injected within 8 hours of discharge from the pathogen reduction process.

10) Incorporation - Sewage sludge (or domestic septage) that is land applied or placed in a surface disposal site shall be incorporated into the soil within 6 hours of application; sewage sludge that is Class A for pathogen reduction shall be incorporated within 8 hours of discharge from the pathogen reduction process.

#### ALTERNATIVE FOR SURFACE DISPOSAL OR SEPTAGE ONLY

11) Surface Disposal Daily Cover - Sewage sludge or domestic septage placed in a surface disposal site shall be covered with soil or other material at the end of each operating day.

#### ALTERNATIVE FOR SEPTAGE ONLY

12) Domestic Septage Treatment - The pH of domestic septage is raised to 12 or higher by alkali addition, and without the addition of more alkali, remains at 12 or higher for 30 minutes. This alternative is applicable to domestic septage applied to agricultural land, forest or reclamation sites or placed in a surface disposal site.

**Table 7. General Requirements and Management Practices for Land Application.**[1,2]

## GENERAL REQUIREMENTS

$ Bulk sewage sludge subject to cumulative pollutant loading rates shall not be applied to agricultural land, a forest, public contact or reclamation site if any of the cumulative pollutant loading rates have been reached.

$ Preparers of bulk sewage sludge to be applied to agricultural land, a forest, public contact or reclamation site shall provide appliers written notification of the Total Nitrogen concentration (dry wt.) in the bulk sewage sludge and other information necessary to comply with the 503 requirements.

$ Appliers shall obtain information to comply with requirements, contact the permitting authority to determine if (and how much) material subject to cumulative loadings has been applied before.

$ Appliers of bulk sewage sludge shall provide land application site owners or lease holders with notice and information necessary to comply with the 503 requirements.

$ Preparers of bulk sewage sludge to be applied in a State other than the State in which the material is prepared shall provide written notice, prior to the initial application of the bulk material to a land application site by the applier, to the permitting authority for the State in which the bulk material is proposed to be applied.

$ Appliers of bulk sewage sludge subject to cumulative loading rates shall provide written notice, prior to the initial application of bulk sewage sludge to a land application site by the applier, to the permitting authority for the State in which the bulk sewage sludge will be applied and the permitting authority shall retain and provide access to the notice.

## MANAGEMENT PRACTICES

$ Bulk sewage sludge shall not be applied to the land if it is likely to adversely affect a threatened or endangered species listed under the Endangered Species Act or its designated critical habitat.

$ Bulk sewage sludge shall not be applied to agricultural land, a forest, public contact or reclamation site that is flooded, frozen or snow-covered ground so that the sewage sludge enters a wetland or other waters of the U.S. except as provided in a permit issued under Section 402 or 404 of the CWA.

$ Bulk sewage sludge shall not be applied to agricultural land, a forest, public contact or reclamation site at above agronomic rates, with the exception of reclamation projects when authorized by the permitting authority.

$ Bulk sewage sludge shall not be applied to agricultural land, a forest or reclamation site that is <10m from waters of the U.S. unless authorized by the permitting authority.

$ For sewage sludge sold or given away, either an appropriate label shall be affixed to the material's bag or container, or an information sheet containing specific information shall be provided to the receiver of the material for land application.

[1] The permitting authority may apply any or all of the general requirements or management practices to land application of bulk Exceptional Quality (EQ) sewage sludge or a product derived from an EQ sewage sludge on a case-by-case basis if determined necessary to protect public health and the environment.

[2] In addition, when sewage sludge that meets Class B pathogen reduction requirements, but not Class A, is applied to the land, site restrictions apply regarding waiting periods before harvesting crops, grazing animals, and allowing public access.

**Table 8. Minimum Frequency of Monitoring, Recordkeeping and Reporting Requirements.**

## MONITORING FREQUENCY[1]

| Sewage Sludge Amounts (dry metric tons per year) | Monitoring Frequency |
|---|---|
| > 0 to < 290 | once per year |
| 290 to < 1,500 | once per quarter |
| 1,500 to < 15,000 | once per 60 days |
| $ 15,000 | once per month |

[1] The permitting authority may impose more frequent monitoring requirements on permittees; in addition, after two years of monitoring at these frequencies, the permitting authority may allow the monitoring frequencies to be reduced to no less than once per year.

## RECORDKEEPING[1]

Generators/Preparers .... shall develop information and retain records:

$ on the concentration of each chemical pollutant regulated under Part 405

$ certification (based on results of required periodic sampling/analysis) that the material meets the applicable pollutant concentration criteria

$ certify that applicable pathogen and vector attraction reduction requirements have been met

Appliers .... shall develop information and retain records:

$ description of how the applicable management practices and site restrictions have been met for each application site

$ for sewage sludges limited by cumulative loading limits, keep records indefinitely of the cumulative amount of each pollutant applied to each site, information of the location and size of each site, date and time of applications, etc.

$ certification that vector attraction reduction requirements have been performed in accordance with 503 if using injection or soil incorporation

[1] Recordkeeping requirements vary with the end use of the sewage sludge or derived material. Except as noted records must be kept for 5 years.

## REPORTING FREQUENCY

> Annual reporting is required of all Class I sewage sludge management facilities (*i.e.*, the ~1,600 pretreatment POTWs and ~400 other "designated" TWTDS such as sludge-only facilities) and other "major" POTWs - those with a design flow $1MGD or serving a population of $10,000 people. In addition, for sites where recordkeeping is required, the same group of facilities shall report annually when any cumulative metal loading reaches 90% of the allowed Cumulative Pollutant Loading Rates (503 Table 2 values).

For the most part, Part 503 is a risk-based regulation designed to protect public health and the environment from reasonable worst case situations. Models were established to facilitate the evaluation of fourteen major pathways of exposure (*e.g.*, sludge->soil->plant->human; sludge->soil->soil biota; etc.) associated with land application practices. Fifty pollutants of potential concern were evaluated using the available scientific data. Acceptable biosolids pollutant concentration limits and loading rates were calculated based upon conservative assumptions and endpoints previously established as adequate to protect public health and the environment. Land application pollutant limits were established for only ten metals in the final rule because the Agency determined that it would not establish numerical pollutant limits for any pollutants meeting one of the following criteria:

- the pollutant is banned or restricted by the Agency or no longer manufactured or used in manufacturing a product
- the pollutant is not present in biosolids at significant frequencies or detection based on data gathered from the NSSS
- the Agency's risk assessment for the pollutant showed no reasonably anticipated adverse effects on public health or the environment at the 99th-percentile concentration found in biosolids from the NSSS.

Concerns have been raised over some of the scientific data, assumptions and models used in developing the land application numerical limits. As required by the Clean Water Act (and several pending law suits), future rounds of rulemaking are expected to address these concerns and additional pollutants that may be present in biosolids. In materials submitted to the court during May 1993 in response to pending law suits on the final Part 503 regulation, EPA provided a list of 31 additional pollutants that the Agency intends to further evaluate via research and risk assessment, and propose for regulation no later than December 15, 1999 (see Table 9). A schedule for developing and issuing a Round II rule has been established.

Areas such as the long-term fate of some land applied pollutants in biosolids relative to plant uptake rates, surface runoff and groundwater movement, and the potential impacts (both positive and negative) on wildlife and unmanaged ecosystems are ripe for further research due to the limited amount of field data currently available. Future attempts to make the pathogen control portion of the rule more "risk-based" will also require additional research efforts.

## AGING INFRASTRUCTURE AND FUNDING CRISIS

After two years of study, the National Council on Public Works Improvement found "convincing evidence that the quality of America's infrastructure is barely adequate to fulfill current requirements, and insufficient to meet the demands of future economic growth and development." In its February 1988 "Fragile Foundations: A Report on America's Public Works," the Council further indicated that:

"Unless we dramatically enhance the capacity and performance of the nation's public works, our own generation will forfeit its place in the American tradition of commitment to the future."

"In ... smaller systems - in all categories [of infrastructure] and in nearly all regions of the country - face especially acute difficulties."

"Part of the problem is financial. Overall investment in public works has slowed in the last two decades in relation to demands of growth and environmental concerns. We have worn through the cushion of excess capacity built into earlier investments. In effect, we now are drawing down past investments without making commensurate investments of our own."

**Table 9. Pollutants Identified for Round II[1].**

- Acetic acid
- Aluminum
- Antimony
- Asbestos
- Barium
- Beryllium
- Boron
- Butanone
- Carbon disulfide
- Cresol
- Cyanides (soluble salts and complexes)
- Dioxins/Dibenzofurans (all monochloro to octochloro congeners)
- Endsulfan-II
- Fluoride
- Manganese
- Methylene chloride
- Nitrate
- Nitrite
- Pentachloronitrobenzene
- Phenol
- Phthalate (bis-2-ethylhexyl)
- Polychlorinated biphenyls (co-planar)
- Propanone
- Silver
- Thallium
- Tin
- Titanium
- Toluene
- Trichlorophenoxyacetic acid
- Trichlorophenoxypropionic acid
- Vanadium

[1] List of 31 pollutants identified in a Notice to the Court on May 14, 1993, that the Agency intends to propose for regulation no later than December 15, 1999, although the Agency retains the discretion to either add or delete pollutants from this list.

SCHEDULE FOR ROUND II PROPOSAL & FINAL ACTION

- no later than Dec. 15, 1999, propose ROUND II
- no later than Dec. 15, 2001, final ROUND II
- same use/disposal practices as ROUND I
- Administrator may determine dioxin/dibenzofurans should have a separate expedited rulemaking; if so this may delay other pollutants.

The Council's report card on the Nation's public works gave the category of wastewater treatment a "C," noting that while over 75 percent of the U.S. population is served by secondary treatment plants and despite the major Federal investment in sewage treatment since 1972 (now over $60 billion), water quality has not improved significantly in many areas, due in part to uncontrolled sources such as runoff. The report also anticipates a decline in overall productivity of secondary treatment facilities resulting in an increase in water quality violations--due at least in part to a cutback in needed financial investments in this area in the face of rising O&M and replacement costs.

Clearly the aging infrastructure and funding problems facing the wastewater treatment industry will greatly impact the biosolids management alternatives chosen by individual facilities. The more sophisticated, capital-intensive alternatives will likely continue to be avoided by many authorities unless attractive privatized funding arrangements are made available to offset the need for grants, loans or public bond issues.

## PUBLIC ACCEPTANCE/INSTITUTIONAL BARRIERS/LIABILITY ISSUES

A final area that can greatly impact the implementability of residuals management practices is addressed here as a combination of public acceptance (or opposition), institutional barriers, and liability issues. Although the technological feasibility of various improved methods for managing residuals can be repeatedly demonstrated, it has often been difficult to gain acceptance of such innovations so that they can be used by operating facilities. Public opposition and a variety of institutional barriers in the private and public sectors often lead to lengthy delays in undertaking technological advancements in biosolids management process technologies and use/disposal practices.

Technological innovations in biosolids management are often difficult "to sell" and are frequently questioned, not only by the general public but also by government policymakers and the scientific community. This has been true of a wide array of changes to common practice such as the use of new analytic and modeling techniques for tracing the actual fate of pollutants released into the environment, or the demonstration of improved treatment efficiency and cost-effectiveness of new equipment or management techniques. The reluctance to accept the results of technological innovation directly influences the numerous political, regulatory, and financial policy hurdles that biosolids management projects must clear to be declared desirable or acceptable. The skepticism and at times even violent opposition expressed toward proposed changes in the status quo of current practices and policies include legitimate concerns over protecting public health, the environment and the taxpayer's pocketbook as well as special interests based on personal preferences, past experience, or anticipation of financial, political and professional losses or gains.

In recent years, potential liability associated with biosolids management projects has become of increasing concern to project proponents and opponents. Anyone responsible for a hazardous substance release that is not federally permitted is liable for the costs of cleaning up the release and for any natural resource damages caused by the release, if deemed necessary and consistent with the National Contingency Plan (40 CFR Part 300) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or "Superfund") and the Superfund Amendments and Reauthorization Act (SARA). Along with the new Title III "right-to-know" provision increasing the public's knowledge of and access to information on the presence of hazardous chemicals in their communities and releases of these chemicals into the environment, potential Superfund liability has certainly created new concerns over the potential for future liability associated with biosolids use/disposal practices for both biosolids generators and landowners, and their willingness to accept certain use/disposal practices. These concerns are real in that waste management authorities that previously disposed of residuals in impoundments or landfills that have been designated as Superfund sites needing cleanup have become potentially responsibly parties (PRPs). Both private landowners and Federal land management agencies have raised this issue as a major concern associated with accepting any type of residuals treatment, disposal or use projects on land that they manage.

Studies of the public acceptance and institutional barriers facing changes in various biosolids management practices suggest various techniques that can be successful in changing, overcoming, or accommodating such problems. These include techniques such as providing adequate involvement in the decision-making process; resolution of concerns associated with possible nuisance problems, costs, public health and environmental impacts; use of project advisory groups and aggressive educational programs; and providing responsible project management to avoid unnecessary problems from occurring in the first place. Adding to this list providing greater clarification of the potential for (or lack of) any real CERCLA liability associated with new biosolids management practices may help gain greater acceptance of proposed projects in the future. But overcoming these "non-technical" acceptance issues may prove to be the greatest barrier facing residuals management projects in the future in the U.S.

To make the past efforts invested in developing appropriate land application practices and the Part 503 requirements effective in encouraging more beneficial use of biosolids, additional efforts will be needed in many parts of the country to improve public acceptance of these practices. Activities being undertaken by the Water Environment Federation to promote "Biosolids Recycling" (WEF, 1994) are a step in this direction. Continued efforts on the part of agricultural extension specialists, soil scientists, agronomists, etc. will be needed to help assure farmers and their neighbors, food processors, state regulators, local politicians, environmentalists and other special interest groups that treated biosolids can be safely and effectively applied to the land in a beneficial manner.

## THE LIKELY FUTURE DIRECTION OF BIOSOLIDS MANAGEMENT IN THE U.S.

The biosolids management needs of municipalities in the U.S. should offer many opportunities for innovation in the future. The actual direction that biosolids management practices will take in the future is likely to hinge on gaining public acceptance, the creativeness of the consultants and project planners, and the political will of elected officials. If the past is any sign of the future, it is likely that no one practice will dominate biosolids management. Both recycling and disposal practices will likely continue in various forms. Most municipal authorities will look for multiple methods rather than rely upon only one option. More dependence upon contracted services will likely result from efforts to reduce operating costs. Opportunities for more energy recovery programs as well as direct recycling of biosolids by land application and the production of products for marketing are likely to occur as a result of:

- municipal authorities and their rate payers becoming more comfortable with paying higher rates for the ultimate disposal of this byproduct of wastewater treatment,
- continued improvements in biosolids quality as a result of pretreatment and source control programs,
- continued improvements in available biosolids treatment processes and handling equipment (including drying, thermal processing, energy recovery, stabilization, ash handling, land application equipment, etc.),
- increased interest in and opportunities for recycling solid waste and other residuals as a result of tighter landfilling requirements and public opposition to disposal practices,
- increased regulatory attention as a result of EPA's implementation of the new Part 503 technical standards through Federal permits.

However, a failure to work with all of the interests involved in establishing acceptable biosolids recycling programs will likely lead to strong opposition to the establishment of such projects due to concerns over the potential for threats to public health, environmental contamination and future liability. Efforts to better educate the environmental groups and the general public as well as wastewater officials and their consultants, contractors, public officials and regulators of the benefits and safety of biosolids recycling practices will continue to be an important factor in determining what practices become acceptable at any given location.

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## LIST OF ABBREVIATIONS

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| CFR | Code of Federal Regulations |
| DOE | Department of Energy |
| EPA | U.S. Environmental Protection Agency |
| EQ | Exceptional Quality |
| FDA | Food & Drug Administration |
| I/A | innovative and alternative |
| MSW | municipal solid waste |
| NOAEL | No Observed Adverse Effects Level |
| NPDES | National Pollution Discharge Elimination System |
| NSF | National Science Foundation |
| NSSS | National Sewage Sludge Survey |
| O&M | operation and maintenance |
| POTW | Publicly Owned & Operated Treatment Works |
| R&D | research and development |
| TWTDS | treatment works treating domestic sewage |
| USDA | U.S. Department of Agriculture |