Chapter 9 – Non-Agricultural Uses

This chapter contains specific information relative to non-agricultural land application of biosolids. This does not, however, negate the need for biosolids managers to familiarize themselves with the information contained in Chapter 8, Agricultural Land Application. Many of the controls in Chapter 8 apply equally to non-agricultural settings, and should be included in operational plans for both types of programs. As was the case for agricultural programs, this chapter assumes that class B biosolids will be applied to the land to improve soil properties and enhance plant growth with varying objectives for the use of plants grown on different types of sites. This chapter will discuss the most common types of areas to which biosolids have been applied for soil enrichment. These are not all-inclusive and biosolids managers are urged to base their selection of non-agricultural application sites on a good understanding of the needs, characteristics and inherent limitations of any non-agricultural sites, just as they would for specific types of agricultural cropland.

9.1 Critical Control Points / Operational Controls

Biosolids used in non-agricultural settings (e. g., soil reclamation) are valuable for both the slow-release nitrogen they provide and their soil enhancement properties (specifically organic matter, which is often lacking on such sites). To achieve these benefits, application rates considerably higher than those designed for agricultural crop production are common when biosolids are used for reclamation. Generally, this rate is a one-tine application in order to rejuvenate barren soil and provide a basis for a stable ecosystem. Application rates for agronomic purposes typically range from 5 to 20 dry metric tons per hectare applied repetitively (every 1-5 years) while initial reclamation rates typically range from 50 to 150 dry metric tons per hectare. Silvicultural application rates usually fall somewhere between agronomic and reclamation and biosolids are applied only once or very infrequently for those slow growing and long life-cycle crops. Because reclamation, silvicultural, and other non-agricultural uses for biosolids are different from agricultural uses in several ways, they may entail different regulatory requirements and management practices, as well as specific community participation efforts to be successful.

These considerations, or controls, that should be considered in developing non-agricultural land application include:

- Effect of organic material on soil properties
- Nutrient addition
- Soil pH
- Access and application

9.1.1 Effects of Organic Matter from Biosolids on Soil Properties

Applying organic matter in the form of biosolids can benefit plant establishment, especially on sites whose physical, chemical and biological properties do not favor growth of vegetation. In general, organic matter (the non-living mixture of organic components from the microbial and chemical transformations of organic debris) has long been recognized as contributing greatly to soils' productive capacity (Sopper, W.E., 1993). When incorporated into the soil, organic matter can favorably affect its structure (porosity, aggregation and bulk density) as well as improve the content and transmission

of water, air and heat and soil strength. Nutrients such as nitrogen are mineralized during decomposition of organic matter; this results in an increase in carbon, nitrogen and cation exchange capacity following biosolids additions. Since the organic matter represents new energy sources for organisms, changes in biological populations will also occur, in turn influencing synthesis and decomposition of humic substances produced by those microbial populations, nutrient availability and interactions with soil inorganic constituents.

Unlike fresh animal or plant residues incorporated into the soil, most biosolids have been subjected to a biological treatment where partial decomposition has occurred. Thus, biosolids decomposition rates in soils may be slower than most fresh organic residues, resulting in longer-lasting effects on soil organic matter levels and changes in the composition of the organic fraction of soils. Adding biosolids to soil decreases resistance to root penetration and results in improved root:shoot ratios as compared to inorganic fertilizer additions. Increased plant growth from biosolids application has been well documented in numerous research studies. However, a more interesting effect of biosolids is not the direct short-term fertilizer effect, but the longer-term effect of soil organic matter (i.e., an increase in soil productivity that cannot be explained by the mineral nutrients alone). This improved productivity relates to such factors as increased soil moisture, higher organic matter levels, and very importantly, an accelerated decay cycle with more rapid microbial action as well as the slow release of N and P from biosolids.

Using biosolids for reclamation provides the most dramatic evidence of the benefits of using biosolids to enrich soils and enhance plant growth. The organic matter content, which is valuable in agriculture, is especially important in disturbed sites where topsoil is inadequate or on sites where topsoil does not exist. While organic matter is an important factor in the improvement of soil physical properties which are achieved using biosolids, the fertilizer elements and neutralizing compounds that improve soil fertility and pH are also of great value for reclamation purposes. The increasing number of successful reclamation projects using biosolids across the U.S. is a further demonstration of the value of biosolids as a recyclable resource rather than a waste product.

The use of biosolids for reclamation purposes has been most prevalent in the Midwest, Northeast and mid-Atlantic areas of the U.S. These projects resulted in excellent growth of forage and cover crops in a variety of research, demonstration and full-scale operations. Many sites are seeded with a mixture of grasses (to provide quick vegetative cover) and legumes (which eventually predominate as permanent vegetative cover). The application of biosolids has also helped in the establishment of tree seedlings on reclaimed areas, by improving growth rates, particularly for the hardwood species when they are seeded simultaneously with the grass-legume mixtures.

Extensive research has been carried out in the United States and elsewhere on the practice of reclaiming disturbed land with biosolids. This research, along with large-scale projects, has demonstrated that biosolids provide an excellent soil amendment and chemical fertilizer substitute for reclamation purposes.

9.2 Reclamation Sites

Mineland reclamation: Land that has been disturbed by surface or underground mining is generally unsightly, unproductive, and a potential source of significant water quality problems. Surface mining in the U. S. has disturbed more than 1.5 million hectares, much of which has been caused by coal mining. Some type of surface mining area is found in all fifty states, and 20 states each contain more than 25,000 hectares of disturbed land (Sopper, W.E., 1993). The potential for disturbed/mined sites to receive biosolids is enormous, both on sites which have been abandoned and are not subject to the reclamation law requirements ("orphaned lands") and on active mine sites, on which reclamation is required as the mining operation proceeds.

9.2.1 Regulatory Considerations

In addition to Part 503 Rule requirements, non agricultural land application of biosolids may be subject to other federal and state requirements that biosolids managers must include in their project design and management.

Many state regulations and guidelines include provisions for application rates higher than those established for agronomic crops in order to establish growth on these infertile sites. Such application may not exceed cumulative loading limits under federal (and most state) regulations and still qualify as land application. If reclamation with biosolids is conducted on a site that is designated as a "Superfund" site, the regulations governing such sites may also be applicable.

When using biosolids to reclaim sites, it is important to consider federal and state mining regulations concerning revegetation. These include 30 CFR Parts 816 and 817 and the federal Surface Mining Control and Reclamation Act (Public Law 95-87, Section 515, (U.S. Department of Interior, 1979; Federal Register 1982) and its amendments (54 FR 230. Regulations established under this Act require the establishment of a diverse, effective and permanent vegetative cover of the same type of plants native to the affected area. The requirements of the Act are often difficult to meet using conventional reclamation techniques and the use of biosolids represents a very effective option for meeting the regulatory requirements.

Prior to mining operations, the reclamation methods and post-mining land use must be submitted to the appropriate agency, and must adhere to the following:

- Permanent vegetative cover must at least equal the area's natural vegetation in extent of cover, and must achieve productivity levels comparable to unmined land for post-mining use. Native and/or introduced species may be planted.
- The period of extended responsibility (after revegetation success is insured) is not less than 5 years for areas with more than 26 inches of average annual rainfall; 10 years for areas with 25 inches or less.
- Normal husbandry practices to assure plant establishment are allowed during the period of responsibility if they can reasonably be expected to continue after bond release
- Success standards are required for 2 years for pasture, grazing and cropland (specified with respect to precipitation); for ground cover, productivity, or tree

stocking, these standards are based on a 90% statistical confidence of 90% success.

Potential post-mining land use must equal or exceed the pre-mining use. Typical land uses include:

- Wilderness
- Limited agricultural or recreation use with little or no development
- Developed agricultural or recreation
- Suburban dwellings or light commercial/industry
- Urban dwelling or heavy commercial/industry

Many of the above land uses are compatible with the use of biosolids. Since reclamation sites that are managed as land application projects are subject to the same federal regulatory requirements as are agricultural sites, applying biosolids at reclamation rates will not adversely affect their potential to support agricultural production or any other land use that is appropriate to the site. The research results from such sites have paralleled the results found for agricultural crop production and have demonstrated clearly that the usability of the site has been significantly improved by the application of biosolids. Most research results have shown that trace element concentrations in biosolids-reclaimed mined areas are within the range considered normal for such metals in unpolluted and unamended soils.

9.2.2 Environmental Considerations

The immediate goal of reclamation is to establish a vegetative cover to prevent soil erosion; in the longer term, a stable soil ecosystem is the goal. Since such areas lack microbial activity and organic matter, the normal soil microbial processes and N-cycling are also a measure of the degree to which these reclaimed areas resemble undisturbed soil. Application of biosolids has uniformly resulted in increased microbial populations and activity—bacteria, fungi, and actinomycetes. The use of biosolids as reclamation material has been shown to eliminate the initial lag period of several years that is characteristic of conventionally reclaimed areas during which microbial activity and plant growth are minimal. For such conventionally reclaimed areas to eventually acquire “soil” characteristics, intensive reclamation and management techniques, along with annual fertilizer additions, are usually necessary. By contrast, superior results in the form of normal soil populations and processes in the surface soil on biosolids reclamation sites can be achieved within two years.

The beneficial effects of biosolids application on the whole ecosystem of reclamation sites have been demonstrated in a variety of settings (USEPA, 1995). Except for a brief temporary elevation of nitrate-nitrogen (NO_3-N) in soil percolate water resulting from a higher-than-agronomic application rate, no negative effects on water quality have been demonstrated, and in many cases significant improvement in overall groundwater quality has been observed at reclamation sites where biosolids have been used. The temporary elevation of nitrates represents a minimum ecological impact that is clearly offset by the positive environmental benefits achieved by reclaiming these sites with biosolids. It is particularly important to not remove the vegetation established on reclamation sites in

order to enhance the development of healthy, sustained vegetative growth on these sites--the primary objective of reclamation, unlike the crop production goals that determine agricultural production methods.

A number of wildlife studies conducted on reclamation sites have found no adverse effects on the health of domestic or wild animals and birds living on such sites. Research and practice have clearly shown that biosolids, if applied properly under present regulations and guidelines, can be successfully used to revegetate mined or other disturbed lands in an environmentally safe manner. Revegetation of a variety of otherwise devastated sites has been demonstrated in many studies using various types and application rates of biosolids. All of the results validate the present regulatory framework which protects the environment, as well as animal and human health, when using biosolids to reclaim drastically disturbed land.

9.2.3 Design and Operational Considerations

The potential for biosolids use in reclamation is significant, and combining the use of such sites with agricultural land application can allow application during periods of the year when agricultural or other cropland is not available. The following design considerations will impact overall good management of nonagricultural use of biosolids:

Active Mine Sites: Site evaluation should include an assessment of existing vegetation, if any; cause of site disturbance (e.g., strip mining or coal); previous attempts at reclamation, if any; need for grading; existence of approved reclamation plan, if any, for site.

Land Application Equipment: In some cases, the same types of equipment used for land application (see chapter 8, Vol. 1 of this Manual) are also appropriate for reclamation and other uses, especially if such equipment is relatively heavy-duty. Typically, biosolids cake application is the better choice for reclamation projects due to the amount of material that has to be applied, and the often-rough terrain of non-agricultural sites, which could damage injectors on liquid applicators. For some applications, other types of industrial equipment may be available or currently in use (e. g., forestry equipment) and can be used/adapted for biosolids use. In general, biosolids managers should think creatively when selecting application equipment and methods in non-agricultural settings.

For active mine sites, the reclamation requirements are generally part of the mining permit and must become part of the overall project design and operation. Site evaluation should include an assessment of:

1. existing vegetation, if any
2. cause of site disturbance (e.g., strip mining or coal)
3. previous attempts at reclamation, if any
4. need for grading
5. existence of approved reclamation plan, if any, for site
6. type of parent material

Application Equipment: In some cases, the same types of equipment used for land

application (Chapter 8) are also appropriate for reclamation and other uses, especially if such equipment is relatively heavy-duty. Typically, biosolids cake application is the better choice for reclamation projects due to the amount of material that has to be applied, and the often-rough terrain of non-agricultural sites, which could damage injectors on liquid applicators. For some applications, other types of industrial equipment may be available or currently in use (e. g., forestry equipment) and can be used/adapted for biosolids use. *Biosolids managers should think creatively when selecting application equipment and methods in non-agricultural settings.*

9.2.4 Factors Affecting Success

Nutrient Status: Depending on the treatment process, much of the nitrogen in biosolids is in the organic form, and therefore becomes available (through mineralization) over a period of several years following application. This slow-release nitrogen offers a significant advantage over the immediately soluble forms usually supplied by inorganic (chemical) fertilizers.

To establish appropriate reclamation and other non-agricultural rates, the amount and type of nutrients in the biosolids should be taken into account, along with the requirements of the vegetation to be established.

If the site has topsoil, annual agronomic applications may be sufficient; sites with little or no topsoil will require a much larger application rate to establish vegetation, restore soil fertility and improve soil physical properties. The phosphorus and micronutrients present in biosolids will also improve plant growth.

Soil pH. Non-agricultural sites may exhibit very low pH levels, and require adjustment to the optimum plant growth range of 5.5 to 7.5. Lime or other recommended pH-adjusting materials may be used, and when biosolids are processed using an alkaline material, the biosolids themselves will increase pH levels.

Vegetation. Many species can be successfully established, but each site should be considered individually, and careful attention paid to plant species or seed mixtures selected.

Application methods. Site preparation (e. g., debris removal, erosion and runoff control, and scarification) is often necessary for non-agricultural sites and mulching may also be required following planting.

Community relations. Relationships with nearby local communities are often especially sensitive at reclamation sites. Resentment and opposition have often accompanied the activities that led to the site needing to be reclaimed (e. g., ongoing mining operations). Neighbors are frequently concerned about quality-of-life issues. ***Biosolids managers should be especially sensitive to local community members and strive to convey the positive aspects of this final stage of the mining or other process.*** The recommendations contained in chapter 1 (Public Acceptance) of this manual should be included in the development as well as the ongoing management of non-agricultural land application

projects.
Detailed descriptions of reclamation research, methods and operations are contained in the references for this chapter.

9.3 Silviculture (Forestry) Application

In general, the chemical, biological and physical interactions of biosolids and soil in forest applications are similar to those in agricultural operations. Trees have been shown to respond positively to nutrient additions, particularly when forest soils are low in nitrogen and the surface litter layers have comparatively high N storage (immobilization) capacity. Some advantages of forest application include the great flexibility in scheduling because forests are perennial (which may also translate to reduced storage requirement) and the extensive acreage of forest land in many regions which provide large areas for application.

9.3.1 Application to Forested Sites

The amount of biosolids applied to particular forested areas will depend to a large degree on the growth state of the forest. When the stand is developing high nutrient content tissues (early development), nutrient demand will be significantly higher than occurs in near-mature or climax forests, which maintain biomass rather than synthesizing new growth.

Biosolids managers applying biosolids on forestland must be prepared to address any special operational challenges.

Forestland is frequently rugged, steeply sloped and relatively inaccessible. In addition, the tree stand itself may present obstacles to biosolids distribution methods. Such factors must be taken into account in developing and managing forestland application. Forestland application can be conducted on commercial timber and fiber production lands, federal and state forests as well as privately owned forest areas. Biosolids may also be used in nurseries, green belt management and Christmas tree production as appropriate in specific situations.

The three common scenarios for forest application include:

- Recently cleared land that has not yet been planted,
- young plantations, and
- established stands.

Each of these must be considered separately when designing a forest land application program.

9.3.2 Physical Features to be Evaluated

Proximity to public access (e.g., recreational areas, dwellings, public roads and hiking trails). The application sites should be as removed from these public access areas as practical. Many states will also impose the minimum setbacks or buffer zones that have been developed for agricultural biosolids application.

Proximity to surface waters. The application site should be located and managed to avoid contamination of surface waters, including setbacks (which most states require). For steep slopes and/or relatively impervious soil, greater runoff is likely to occur and increased setback distances should be considered.

Proximity to drinking water supplies: Where forest application is to occur in water supply sensitive areas, provisions should be made for biosolids quality control, minimization of biosolids movement and possibly monitoring of surface and/or groundwater quality in the area.

Distance to groundwater: Guidelines suggest that forest application sites have an average groundwater table distance of one meter (0.7 meters minimum) below the soil surface. This recommendation is to prevent seasonal surface flooding and boggy conditions, which might cause biosolids migration.

Forest soils are often infertile by agricultural standards—deficient in organic nutrients and low in available nitrogen. Added organic N from biosolids may make up this deficit without adverse impacts on groundwater. Tree species differ significantly in their uptake of available nitrogen; there is also a large difference in N uptake by seedlings, rapidly growing young trees and mature trees as noted previously. The average annual N uptake of fully established and vigorously growing forest ecosystems varies from 100 to 400 kilograms per hectare per year depending upon species, age and other factors. These estimates include the overstory and understory vegetation or gross N uptake by the forest ecosystem.

For specific projects it is recommended that state or regional forestry management or research agencies be contacted in designing forest utilization projects.
While information on forest uses of biosolids is not as extensive as that relating to agricultural production or reclamation, there has been a growing interest in such application in the last decade, particularly in the Pacific Northwest. Research conducted at the University of Washington, College of Forest Resources, coupled with a number of operating projects, has provided information and relevant experience for implementing forest application projects. Technical data are available from these efforts in a variety of silvicultural settings.

9.3.3 Application to Cleared Sites

Application of biosolids to recently cleared forest sites has the advantage of providing better access for application equipment and the possible option of incorporating the biosolids into the soil if the site is sufficiently cleared. It may also be easier to control public access to a cleared forest site (which is generally less attractive than wooded areas for forest recreational activities).

There may also be an option to select species that are superior in growth and survival characteristics on biosolids amended sites.

Some disadvantages of applying biosolids to recently cleared areas include the potential

for salt or ammonia damage to new seedlings for some species (this can be overcome by allowing the biosolids to age for six months or more). Seedlings also have a low nitrogen uptake rate and biosolids application may be inappropriate if there is an underlying potable aquifer that could potentially be impacted by excess N. Extensive weed control is also necessary to prevent competition with tree seedlings for up to three or four years and browsing by deer and other pest species may also require control measures since animals may selectively feed on biosolids amended sites due to their higher food value.

9.3.4 Application to Young Forests

Applying biosolids to young forest plantations (over two years old) provides a greater tolerance of fresh biosolids application, less concern for weed control than with cleared sites, more rapid nitrogen uptake, reasonably good access and rapid growth response from many tree species. However, biosolids application by spraying over the canopy may be restricted to certain times of the year, some weed control will probably be necessary and plant nitrogen uptake is less than that of a well-established forest cover.
Further details regarding application of biosolids to forestland are contained in reference 3 of this chapter.

9.4 Other Non-Agricultural Uses of Biosolids

Biosolids are used on a range of nonagricultural sites, each exhibiting specific needs and characteristics. Biosolids managers should become familiar with site characteristics and needs of their individual situations, and design projects to accommodate them. While the majority of regulatory and technical experience in land reclamation relates to such efforts on land that has been surface mined for coal or sand and gravel, the principles involved in such uses, as well as many of the agricultural considerations discussed in chapter 8 may be modified to apply to other types of marginal or disturbed sites.

Nonagricultural sites being reclaimed with biosolids include:

Sites affected by human activity: Roadway and other construction, deposits of dredge materials and ash, as well as forestry- related activities often result in large areas that are frequently difficult to reclaim conventionally with inorganic fertilizers and other soil amendments. Application of biosolids on the above types of sites, as well as areas disturbed by mining or other activities that disturb soil (e.g., copper mines, oil shale mine areas, zinc and lead smelters, landfills), offers an opportunity for using biosolids to stabilize and revegetate eroded, unproductive soils. The environmental benefits achieved by providing a medium for the re-creation of a soil/vegetation system are significant, and often translate into economic benefits, as well.

Biological Deserts: Areas that are a biological desert due to high metal contamination (e.g., zinc, lead and copper) have been successfully reclaimed using biosolids when virtually no other reclamation effort could succeed on such a site.

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