Twenty-Five Years of Mine Reclamation with Biosolids in Pennsylvania

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Abstract

Pennsylvania has been a leader in the use of biosolids for reclamation of mine lands. In the 1970s, Federal mining laws established standards for reclamation, and marine protection legislation banned the practice of ocean disposal of biosolids. In a beneficial confluence of needs, biosolids from Philadelphia were made part of early developmental approaches in Pennsylvania for compliance with mine reclamation requirements.

This paper is a retrospective of lessons learned from the Pennsylvania program. Over a twenty-five year period, the field experience with biosolids use continues to demonstrate clear environmental benefits and negligible adverse effects. Re-inspection of sites, even two decades after completion, shows vigorous ground cover, signs of active animal populations, minimal surface erosion, and clear flowing waters in nearby watercourses. But even against this positive feature has arrayed opposition in some communities and a loss of political support, a situation that needs to be addressed.

This paper summarizes the aspects of this program that have allowed it to be a successful biosolids recycling and a model for programs in other states and regions. It will present priorities for additional study to address areas of technical and public concern.

Background

History of Mining Reclamation

Practices of modern mine reclamation and biosolids recycling emerged coterminously in the mid 1970s. The federal Surface Mine Reclamation Act of 1977 required mine reclamation. And under the Marine Protection, Research and Sanctuaries Act of 1972, the US EPA had compelled the City of Philadelphia to abandon its ocean dumping of solids in favor of land application. These two programs came together in the late 1970s as experiments in mine reclamation with biosolids.

Pennsylvania has been a leader in the use of biosolids for reclamation of mine lands since the 1970s. Research by Penn State professor William Sopper, undertaken in the 1970s and early 1980s, remains preeminent for its documentation of the environmental effects of biosolids use in land reclamation. Yet reclamation work did not end with the research, and Philadelphia has been since joined by other municipalities in the employment of biosolids at mine closure sites in Pennsylvania. Philadelphia's program for reclamation has now completed twenty-five years, amassing a track record of about 4,000 acres reclaimed and the utilization of 1,000,000 tons of biosolids products.

Federal mining laws were an impetus to this program. Reclamation of mine sites, and the posting of bonding by coal mine companies to guarantee reclamation, had been always required. But the size of the bonds and the details of their release to the coal companies increased after 1977. The release of bonds became a three-stage process. Stage 1, the rough grade of the site with backfill, allowed release of 60% of the bond; Stage 2, planting of ground cover, released another 25% of the bond; and, Stage 3, the remaining 15% of the bond, required 5 years for full performance. Coal companies frequently experienced difficulty meeting the Stage 3 standards,

and remedial plantings were frequently necessary. The immediate payback of reclamation work at mine sites using biosolids was in the near certainty that Stage 3 bonds would be released on schedule.

Pennsylvania, like many other states with coal mining activity, confronts an overwhelming challenge in stewardship of lands affected by extraction activities. An estimated 133,000 acres of mine lands pre-dating the 1977 law remain inadequately stabilized and could benefit from regrading and revegetation. Each year, an average of 12,000 acres of lands is disturbed by new mining activities. Although nearly 50,000 tons of biosolids applied annually, on average, to mine lands in Pennsylvania between 1988 and 2002 is a substantial volume, this quantity nevertheless has treated a scant 2 percent of lands disturbed by mining. In reflecting on the loss of soil and habitat resources as a consequence of mining, a principal environmental issue is how to make the best possible use of recyclable organic material, particularly biosolids, for mine land restoration, as municipalities across the Commonwealth are already employing public funds in their disposal or use. Harnessing these funds for land restoration is sound public polilcy.

Techniques of Bituminous Coal Mining

To appreciate the scope of reclamation work and the role of biosolids, a description is useful of the process of bituminous coal mining, where the vast majority of biosolids to date has been employed.

Operators first remove the top stratum, called topsoil, but in reality a very shallow layer of unconsolidated rubble and soil particles. Then the operators remove the overburden, which is the rock layers overlying the coal. The rule is that as much as 20 feet of overburden can be economically removed for each one (1) foot of coal seam sought. The overburden is blasted with the sadly infamous ammonium nitrate/fuel oil (ANFO) mix. Operators pile the overburden off to the side of the excavation, keeping it handy for replacement. After the coal seam or seams are extracted, the overburden is replaced, shaping the surface of the overburden to approximately the original contour.

Runoff control is a part of the mining work. Sediment ditches and ponds are used to collect sediments from storm runoff prior to discharge of runoff to surface waters. These structures are kept intact until the end of stage 2.

Biosolids is part of achieving stage 2 bond release. After the overburden is put back in place, the "topsoil" is placed over the top of the overburden and smoothed out. Biosolids is spread over the topsoil, using farm type equipment. If anaerobic digested biosolids is employed (as in the case of Philadelphia's biosolids), pulverized agricultural lime is applied at a rate based on a calcium carbonate equivalency calculation. Lime stabilized biosolids may not need supplemental lime amendment. The goal is to achieve a lasting soil pH of greater than 6.0. A common lime application rate may be as high as 6 tons per acre.

Techniques of Biosolids Applications

Biosolids Delivery and Staging

Biosolids are trucked to the mine site in triaxle dump trucks, which is a vehicle type commonly and economically available to the coal industry. Biosolids are emptied into a staging area, a bermed area made of overburden type material. If the biosolids are scheduled to be held for more than 30 days, a situation regarded as long-term storage, the staging area is equipped with a leachate collection system, commonly a tarp-lined sump.

Biosolids Application and Incorporation

Any farm tractor and spreader equipment may be used to apply biosolids to the mine surface, but for many projects large, heavy-duty equipment is used. The application rate in Pennsylvania has been typically 60 dry tons per acre. Whereas the solids concentration of Philadelphia biosolids product (a dewatered material called "cake") is about 25%, this translates to an application rate of

approximately 240 tons per acre. This is a layer of biosolids about 2.5 inches deep. Biosolids may be applied in flat areas in one pass, but on hillsides several passes may be required. Biosolids are incorporated with chisel plow or very large disc plow, with at least three passes, occasionally more, and with the last pass of the plow pulled along the contour. In some settings, the operator applies a layer of cellulose-based hydromulch, a step that can help with odor control and surface stabilization.

Vegetation Establishment

Good vegetative cover establishment is the key objective of the reclamation work. A drill seeder is used to sow typically a blend of legumes and grasses. When hydromulch is used in the final cover, seed may be incorporated with the mulch and applied in the same pass as the hydromulch. The landowner, who is generally not the coal mine operator, is involved in choosing the final vegetative land cover. The most common final use for the site is for wildlife habitat. Over the past several years, the variety of choices in vegetative cover has expanded, and warm season grasses, oats and buckwheat have been tried for their desirability for target game species.

If the revegetation plan calls for forest cover, the reclamation operator may cover 40 inches of the seeder drill to eliminate seeding in a strip left for planting seedlings. Trees are planted in early spring the year following the planting of grasses. Tree seedlings grow vigorously, although they have difficulty competing with grasses and surviving deer browsing.

Post Reclamation Requirements

Soil pH

Soil pH is checked annually in the fall season to ensure compliance with the pH 6.0 standard for at least two consecutive years following reclamation. Use of biosolids on reclamation sites, in conjunction with a liberal lime application, most often results in compliance with the standard. At conventional mine reclamation sites (sites in which chemical fertilizers and lime are used for soil preparation), re-liming in spring frequently proves necessary, and monitoring often continues for four years after reclamation before the standard is met on some sites.

Water Monitoring

Quarterly water monitoring continues for two years beyond completion of the soil pH goal (two years over pH 6). A state hydrogeologist selects monitoring points that are hydrologically connected to the mine. These points may be seeps, springs, streams or wells (even private wells). The mine operator is responsible for arranging the analysis of the samples and reporting the results to the mining officials.

Surface Vegetation

Surface vegetation must achieve coverage of 70% of the soil surface. The standard for Stage 2 bond release is 70% vegetative coverage. Stage 3 is accomplished when after 5 years the site still has 70% vegetative cover or better. The success of biosolids in reclamation is most marked in contrast to conventional techniques in the number of mines successfully meeting Stage 3 vegetative cover standards at the fifth year.

Surface Stability

Reclamation sites must exhibit surface stability, as defined by absence of gullies and by good vegetative cover, for Stage 2 and 3 bond release. Gullies are a common occurrence at reclamation sites treated with conventional reclamation techniques. Biosolids sites are typically free of gullies and usually exhibit no significant runoff during even very intense storm events.

Overview of the Biosolids Sites in Pennsylvania

The current state program for administering mining and reclamation activities was put into place in 1989. Since that time, 3,000 acres of mine lands have been reclaimed with 730,000 tons of biosolids products. Most of the mine reclamation sites employing biosolids have been within the bituminous coal mining region of northcentral Pennsylvania, a region whose mining activities are administered by the Hawk Run District Mining Office of the Pennsylvania Department of Environmental Protection (PaDEP). Starting in 2002, a project site in Schuylkill County, within the anthracite coal mining region has been operated on behalf of Philadelphia. This is administered through the Pottsville District Mining Office. While Philadelphia has been the longest standing source of biosolids for reclamation work, two other sources from other Pennsylvania utilities are currently employed, and several sources have been from out-of-state. Virtually all sites are privately owned and most are designated for wildlife habitat, although farming occurs on a few.

Permitting and Regulation

Biosolids are authorized for recycling under Pennsylvania's Municipal Waste Management Act. Biosolids regulations had been administered primarily by PaDEP's Bureau of Land Recycling and Waste Management. In January 1997, amendments to waste management regulations established a general permit program for biosolids recycling, and recent changes within the PaDEP have reassigned administration of biosolids regulations to its Bureau of Water Management.

But biosolids applications at mine sites are administered in a fashion different from other biosolids recycling activities. The new general permit program has granted to PaDEP's Bureau of Mining and Reclamation the authority to issue approvals for mine sites. Projects are reviewed and approved by that bureau's District Mining Operations, under an MOU with the Bureau of Land Recycling and Waste Management and the Bureau of Water Management. Biosolids used in mine reclamation is construed as a revision to the Surface Mine Permit issued by the District Mining Office. As part of that revision, public notice is required, and, when requested, the mining office will hold a public hearing and consider the input of the community in the stipulations put into the permit modification.

Biosolids Impacts

Vegetative Establishment

Obtaining stage 2 and stage 3 bond release has been successful for coal mine operators in all cases in which biosolids have been used. Vegetation growth is vigorous at biosolids sites compared to conventional (chemically-fertilized) sites. The remaining, benign problem is that plant growth is so dense as to make difficult inspecting the sites in mid summer. The soil has substantial water holding capacity, a factor that helps enable plants withstand drought. Tomato seeds that come in with biosolids result in the added bonus of a tomato crop attractive to wildlife in the same year as application is complete.

This is the “normal” soil condition at reclamation site many years after unsuccessful fertilization and planting.

This is the same mine site as the picture above, but from a portion that received biosolids in 1984, showing the good topsoil and the vigorous vegetative growth.

These are locust saplings planted by hand two years ago into a biosolids amended overburden (picture taken in May 2002)

The locust trees in this picture are 6 years after planting. The fir in the foreground had to be replanted, as the original planting was out-competed by the grasses.

Wildlife Establishment

The bituminous coal mining area of northcentral Pennsylvania is a strong hunting region. The establishment of permanently improved wildlife habitat has helped develop public support for the program. This has been one of the very significant benefits of biosolids recycling. The choice of seeding and cover has been evolving over the past several years in response to game enthusiasts. For example, buckwheat generates wildlife that generates enthusiasm among the hunters.

Wildlife has responded enormously to the vegetative cover at the biosolids sites. A Pennsylvania District Forester was excited by the hold over of hawks at the edge of one reclamation site. The hawks are drawn to the mice and voles residing in the dense matting. A bald eagle was seen at one site and has been nesting for several years. Turkey flocks have grown large, as they are attracted to the fields due to dense grasshopper populations, and the turkey can readily retreat to nearby woods to roost. In 1998, reclamation sites were sown to sorghum, using seed donated by the Wild Turkey Federation. Also, doves have flocked to these sites, attracted to the wheat, rye and oats that are a cover crop during the first year of reclamation.

Large-mammal populations have also increased. Deer frequent biosolids-amended reclamation sites. Deer are primarily woodland browser, but they come into the fields for buckwheat, and the fields appear to help offset variations in annual mast production within the forests. Nutrients in the browse on reclaimed mine sites seem to help build good racks. One exciting program developed by the Pennsylvania Game Commission is reintroduction of elk. An elk herd is being relocated to some large field reclaimed with biosolids and planted to warm weather grasses. The elk graze on the grass, and hence are not in competition with the deer. Anecdotal reports of bobcat sightings add to reported sightings of bear and fox at biosolids sites.

The benefits of biosolids for upgrading game habitat has led to several projects on game lands owned by the Pennsylvania Game Commission. One notable project in Tioga County involved a site known as the Rattler Mountain Reclamation Project. In late 2001 and in summer 2002, about 14,000 tons of biosolids cake were used on a seventy acre area of strip mined land that was also subject to acid mine drainage. Using a multi-prong approach and innovative technologies, the Game Commission, in collaboration with the Babb Creek Watershed Association, is working to restore stream quality and the vegetative cover in order to achieve maximum potential for environmental recovery of the watershed. The Game Commission is targeting plantings to encourage habitat for grouse.

Erosion Control

Biosolids virtually eliminates erosion at reclamation sites. One factor is the deep chisel plowing undertaken during biosolids incorporation. The second factor is the root mass that develops under the grasses and legumes. Furrows created during biosolids act as small diversions. Even two-inch rainfalls have not shown surface runoff. Moisture retention is an added benefit of the control of surface runoff and erosion.

Low erosion at biosolids-amended sites is in strong contrast to conventional reclamation treatment that does not employ chisel plowing. Rills and gullies typically arise in conventional sites, and these become a continual maintenance problem. Bonds will not be released if rills exceed 9 inches in depth.

Water Quality Benefits

Acid Mine Drainage Control

No comprehensive study has been yet made of the changes to acid mine drainage (AMD) that result from biosolids use in reclamation. Quarterly monitoring data collected over the past decade yield a strong suggestion that AMD is significantly reduced from sites at which biosolids has been used. At one site, for example, seep discharges went from 0 units of alkalinity and 219

units of acidity to a remarkable net balance of acidity and alkalinity. A long time trend has not been closely examined, nor has the data been reviewed for all sites. A study of this phenomenon, complete with control sites, is warranted.

Nitrogen

Release of nitrogen from mine reclamation sites may occur due to the large dosage. Total nitrogen in a 60 dry tons per acre rate is about 2,500 pounds per acre, of which about 5% is in the nitrate form, 15% is in the ammonium form, and the balance is organic nitrogen. Over the years of groundwater monitoring, some release of nitrate nitrogen has been observed. This is seen particularly in samples taken below the surface soil after heavy rainfall soon after biosolids applications. Nitrate levels fall quickly to background. Eighty percent of nitrogen is in the organic form, but this can be converted to soluble nitrate during the growing season. The location of the reclamation sites tend to be in watersheds that are nutrient deficient, thereby the impact of the nitrogen release may be, on balance, positive to the watershed. Dr. Richard Stehouwer at Penn State University has been examining the fate of nitrogen from application sites in the Tangascootack Creek Watershed.

Phosphorus

No water monitoring samples have yielded phosphorus concentrations above background. This is a notable finding, as the application rate of total phosphorus is in the 3,000 to 5,000 pounds per acre range. As the biosolids industry begins to confront regulation of phosphorus, water quality data from reclamation sites deserve to be closely examined.

Metals Contamination and Movement

Metals are present both in the overburden and in the biosolids. Philadelphia's biosolids have been consistently lower in metals than standards set for biosolids used in reclamation. The table below compares Philadelphia's biosolids quality to federal and state standards, and for a point of comparison, to other organic amendments Metal loadings to the mine sites from biosolids are calculated by the applier, verified by DEP staff, and kept well within requirements set for total allowable cumulative quantities. What is more, metals are not released in significant quantities from the completed reclamation site. This is based on research work performed in the 1980s as well as ongoing monitoring. In water monitoring data reviewed over the past several years, a pattern is seen of elevated metals in the initial samples after application, with concentrations quickly falling to background.

Comparison of Soil Amendment Metal Concentrations (mg/dry kg)

Metal	Dairy Cattle Manure[1]	Beef Cattle Manure[1]	Swine Manure[2]	Poultry Manure[3]	NPK for Phosphorus[4]	Biosolids[5]	EPA/DEP Standard
Arsenic	NA	NA	3.7	13	13	15	75
Cadmium	0.25	NA	2.5	2.4	31	4	85
Copper	38	36	109-501	465	31	596	4,300
Lead	NA	NA	7.6	46	217	142	840
Mercury	NA	NA	ND	NA	0.07	1.5	57
Molybdenum	6.2	4.94	2.6	19	NA	25	75
Nickel	23	NA	29	16	29	38	420
Zinc	150	129	455-656	602	234	1,391	7,500

ND = not detected; NA = not available

Manure and fertilizer data taken from LH Moss, et. al.,"*Comparing the Characteristics, Risk and Benefits of Soil Amendments and Fertilizers Used in Agriculture,*" Proceedings of Water Environment Federation, 16th Annual Residuals and Biosolids Management Conference, March 3-6, 2002

ND = not detected; NA = not available

(1)Adapted fromASAE, 2000

(2)Compiled from ASAE, 2000 and Epstein, 1999

(3)Compiled from ASAE, 2000 and Texas Agricultural Extension Service (2001)

(4)Data from USEPA, 1999, *"Estimating Risk from Contaminants Contained in Agricultural Fertilizers."*

(5)Average of monthly samples of Philadelphia's Southwest biosolids cake, 2002

Public Awareness Issues

Early Program Mistakes

Use of biosolids in mine reclamation faced serious public and political opposition in the early years. One debacle arose from reclamation done in secret without involvement of the community. Operational issues contributed to early controversies, such as unconfined storage of biosolids close to streams and excessive application rates. Poor application practices were observed, for example inconsistent rates over a field and inadequate incorporation. A large political controversy ensued that resulted in banning of biosolids from counties and townships hosting the original application sites. Biosolids are still excluded from some these localities.

Sproul Forest Debacle

Sproul Forest, a forest within the Pennsylvania state forest system, suffered an intense fire in 1991. To assist with remediation of this project, an experimental biosolids project was undertaken. Philadelphia delivered to Sproul Forest a biosolids material that was mixed with common fill as part of a clean up project at its facility. This mixed material was viewed later by the public as evidence of waste contamination of the biosolids. The community had not been notified prior to the project start up, because some regulatory procedures had been bypassed. Although results within the forest were good, significant public controversy was engendered by this project in the local press that has had long-term adverse effects on public acceptance.

The Tony Behun and Daniel Pennock Stories

In 1999, a story began to circulate in the local press, and then circulated in even national publications, asserting that a boy had died in 1994 after exposure to a biosolids reclamation site while riding a vehicle through the property. While initial details were sketchy and the charge was provocative of community fears, investigations by state environmental and public health officials completely exonerated biosolids. In fact, the material originated with the Philadelphia Water Department, and the department kept records of stabilization processes involving the mine mix product used on the site of alleged exposure. Moreover, the product was tested for fecal coliform organisms as an indicator of human pathogen, and all samples measured below detection. Though the possibility that an illness was associated with biosolids in this case is vanishingly small, the story developed a life of its own and is frequently repeated at public meetings, both in Pennsylvania and across the country, largely due to the ability of the Internet to distribute unfiltered allegations for downloading and reproduction.

More recently, a young man's death in Berks County has been associated with biosolids use. Based on newspaper reports, Daniel Pennock of Robesonia acquired a fatal Staph infection while he was hospitalization for pneumonia. This kind of infection is sadly not a rare complication. But, several years after Pennock's death, his parents became convinced that the infection had been connected with use of biosolids in his community at the time of his original illness. While the belief of the parents that biosolids has caused them to be active opponents to biosolids use, none of the charges has withstood professional scrutiny.

Odor Nuisance Regulations

When opposition to biosolids recycling arises, frequently odor nuisances in the surrounding community are a primary cause. In Pennsylvania, air quality regulations set a high standard for odor nuisance control. A malodor detected beyond the property boundary may be cited as a violation of state air quality laws. This standard may be included as a condition of permit modification approval by the District Mining Office. With the large application rates and large volumes of biosolids handled at reclamation sites, odor management to this standard can be very difficult for conventionally-stabilized biosolids. The experience of Philadelphia and its contractors is that odors will be released from even the most diligently managed application site. This is in part because some portion of biosolids products remains on the ground surface even after repeated plowing. The odorous organic sulfur and nitrogen compounds that are generated and released within the cake have a very low threshold for detection by the human nose, and are also highly offensive. A very high priority for research in the biosolids industry is the modification of odor generation processes in biosolids products.

Legislative Relations

An ongoing challenge to the mine reclamation program is engendering political support and managing political opposition to biosolids use. The state legislator representing the bituminuous mining district frequently introduces legislation hostile to biosolids recycling. While his proposals would seriously affect biosolids program across the entire state, he has not typically sought to interfere with reclamation projects within his district. Very recently, with the introduction of biosolids to the anthracite coal region, and without the benefit of a thoughtful public outreach program, political opposition has developed in Schuylkill County, engendering opposition from a

number of state senator and several representatives. Also, local townships are adopting restrictive ordinances. The power of townships to regulate biosolids locally is being challenged in both federal and state courts.

Watershed Management

As the national regulatory focus on water management has shifted to watersheds, the link between biosolids and water quality is beginning to be forged in Pennsylvania's mining region. Between 1995 and 2001, biosolids applications from Philadelphia focused on comprehensive improvements to the Tangascootack Creek Watershed, a watershed affected by acid mine drainage (AMD). Biosolids applications within this watershed seem to have served as a passive treatment system alternative for AMD control. Multiple years of program activity within this watershed is demonstrating on a field trial scale that metals, sulfate and pH in seeps draining to the Tangascootack Creek have significantly improved following biosolids utilization.

This program demonstrating watershed benefits of biosolids use has evolved to include a wide number of groups. The watershed improvement program is connected to the Clinton County Conservation District, Pennsylvania Game Commission, the Pennsylvania Fish & Boating Commission, and the Pennsylvania Department of Natural Resources and Conservation's Bureau of Forestry.

Recommendations to Biosolids Managers

Form Partnerships

Utilities and applicators need to form partnership with their regulators and with the industry associations representing the landowners. A strong regulatory presence is important. A regular refrain with the public is "who is watching this thing?" The public must know that someone with regulatory responsibility is monitoring the work. In programs where regulatory officials are involved, timely decisions are made and programs are completed. The Pennsylvania mine reclamation program has enjoyed success in large part because of the commitment of mining officials and mine associations to support biosolids use and to ensure its proper implementation. Another group that has partnered in reclamation work has been County Conservation Districts. The districts have advocated biosolids for its genuine value as an ingredient in land reclamation and habitat restoration. Also helpful for outreach to the community is groups such as watershed associations and those concerned with acid mine, for instance the Eastern Pennsylvania Coalition for Abandoned Mine Reclamation. These groups can support the delivery to the local media and citizens information on the benefits of habitats and watersheds treated with biosolids.

Send the Message of the Benefits of Biosolids

The biosolids industry has not been successful in demonstrating the payback of biosolids use on mine lands. Because of a history of landscape abuse and a long legacy of short dumping on old mine sites, the public naturally presumes that biosolids use is an example of further environmental abuse. The industry needs to describe the benefits of recycling in terms of habitats, visual aesthetics and acid mine drainage. The message is that biosolids are not being "dumped" but are instead a resource for reclamation. The message needs to include the compelling results of biosolids use -- the verdant landscapes that replace the barren, gray landscapes. A recent dedication of the Rattler Mountain Reclamation Project, and coverage by news media, helped to bring this story out.

Education in the schools is an opportunity to convey the benefits of restoration. David Strong, of Sweet Soils in Brockway, has used connections to local schools and science programs with great success at Bark Camp and his own property, and he advocates a program for youth involvement in every restoration project.

This is the Rattler Mountain landscape in Spring 2003, after work was completed in summer 2002.

Use Demonstration Sites

Biosolids can be introduced to a reclamation program through small demonstration sites. This helps to develop believability within the community. If complemented with monitoring, the demonstration program can help characterize the performance of different biosolids (lime stabilized vs. digested vs. raw), varying application rates, and alternative seeding mixes. This is being done in several projects involving "non-biosolids" residuals, such as dredged materials. Two well-known projects in Pennsylvania are Bark Camp and Tamaqua Borough. Philadelphia is supporting the development of other demonstrations that have side-by-side treatment types with varieties of residuals and biosolids.

Keep Public Informed

All agents of the project, from utilities, to service companies, to mining officials, must not fail to keep the public informed. While not always a pleasant chore, public meetings need to be set up by officials when requested by the public. Biosolids professionals need to view such meetings as opportunities to explain to the public the environmental benefits of biosolids use for reclamation and to help answer their concerns. Philadelphia has played host to several groups of public officials, media and citizens at its wastewater and biosolids treatment facilities. Also, the Internet is a convenient way of posting regular information about projects and product quality.

Build a Constituency

A great opportunity presents itself in reclamation work with biosolids to build a constituency in favor of biosolids recycling. Governmental agencies responsible for game and forestry management and private organizations managing wildlife and hunting programs are natural allies, once the value of good reclamation has been demonstrated. In recent years, groups such as the

National Wild Turkey Federation have provided support to land treatments post- biosolids application.

Employ Sound Site Management Practices

Biosolids applicators need to use good management practices in reclamation work. In addition to doing a good job of application and seeding, biosolids applicators need to be especially aware of off-site nuisances. They need to select truck routes that minimize intrusion in residential area, and they need to select their staging and temporary storage areas with an eye toward minimizing odor complaints.

Temporary stockpiling is often helpful to make reclamation practicable. Reclamation sites require a substantial mass of biosolids to sustain a meaningful project. While large utilities are capable of providing this mass, small utilities have to stockpile biosolids to have enough to handle economically. The measure of sound stockpiling practice is containment on the reclamation site of all potential pollutants, whether in surface runoff, groundwater infiltration, or air emissions.

Some Remaining Issues

Odor Management

A major challenge to the reclamation program in Pennsylvania is finding effective means of avoiding odor nuisance complaints. One appropriate strategy for this is site selection. The more remote the site, the less likely that odors will cause offense. A second strategy is timely handling of the biosolids, such that it is as “fresh” as can be accomplished, as there is evidence that odor emission potential increases over a matter of a week or two following its production. A third strategy, as mentioned above, is good incorporation, followed by mulching. In one application site to which Philadelphia has delivered biosolids recently, an odor counteractant has been sprayed in the direction of the spreading work with the goal of capturing a meaningful quantity of odor-causing chemicals. Philadelphia is aggressively searching for other effective, in-plant and field-site odor treatments, including a search for coal ashes that can adsorb odors.

One aspect of odor management goes beyond control technologies. Psychologists who work

with human response to odors recommend a pre-impact public information campaign. This is based on the finding that a human being's physical and emotional response to odors is colored strongly by his fore-knowledge of the odor. This is particularly important for odors that, like fecal odors, that are associated in the human psyche with the potential for disease. Biosolids odors are mixes of organic nitrogen and sulfur compounds that have been shown to invoke "fear and flight" at a deep emotional level. But this reaction can be lessened by information explaining that the odors are not harmful and are transient.

Application Rates

Pennsylvania officials long ago adopted a policy of permitting 60 dry tons of biosolids per acre for one-time application. But now that "agronomic rate" is part of the regulatory framework, this long-held guideline is subject to change. Experience in Pennsylvania suggests that while even high biosolids application rates do not result in environmentally-significant release of nitrogen. But if lower rates of application are shown effective in reclamation, then the potential for release of nitrogen would be further reduced. Research into the fate of nitrogen at reclamation sites is warranted

Vegetation Selection

The type of vegetative cover planted at the sites is being reconsidered. The traditional grass-legume seed mix does not invite plant succession past open field habitat, and some experts have noted that efforts to restore forest habitat have not been successful. Alternative covers need to be tracked over long-term trials. Selection of plant types attractive to target game species is an avenue for further experimentation.

Acid Mine Drainage (AMD)

Some researchers in the past had expressed a concern that biosolids may aggravate AMD. They point to the lack of data on the field results of biosolids-based reclamation on acid mine drainage, and have hypothesized that high fertility may exacerbate acid formation. Field experience indicates that AMD is reduced with biosolids application. But the mechanisms by which this occurs are not known. For this reason, this area of inquiry deserves additional field-based research.

Temporary Stockpiling

Successful reclamation typically requires delivery of such substantial quantities of biosolids to an individual site as to warrant temporary winter-time stockpiling of biosolids. But state regulators are left with little national guidance as to how to control such activity. Evaluation of temporary stockpiling practices needs to be made to help provide background information for public officials responsible for developing standards and guidance. One concern with stockpiling is that the potential for odor nuisances can increase during winter storage. To offset this potential impact, the biosolids may need to be amended or further treated, leading to additional steps within the regulatory framework for biosolids management.

Public Support

Even after a long and positive track record, Philadelphia's reclamation program remains a target of community and political opposition. Philadelphia is a participant in a project of the Water Environment Research Foundation titled "Biosolids Public Acceptance." This project explored ways to develop public relationships and to explore areas of mutual gains. For Philadelphia's reclamation program, the implementation of this research project might be to focus on demonstrating the benefits of biosolids for wildlife habitat restoration and environmental improvements in ways that respond to community interests and needs. The strategy might also embrace an intent to listen to the concerns of the community and to identify meaningful responses. Responses might include, for instance, research or demonstration projects that are able to address concerns in the area of public health from air emission or groundwater supply contamination.