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POWELL RIVER PROJECT

# On-Site Treatment and Disposal of Residential Wastewaters on Mined Lands

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The development of Southwest Virginia's coal mining region is limited by a lack of building sites. Much of the land in this region consists of steep slopes with shallow soils that are poorly suited to residential development. In recent years, widespread surface coal mining has created landforms that are favorably located and configured to support residential housing. However, because such sites are commonly located beyond the extent of public sewers, developing them requires a means for on-site wastewater treatment and dispersal. This publication is written for homeowners, homebuilders, land developers, public officials, and others who may have an interest in building residential housing or other types of development on mined lands that are not accessible to public sewers.

Current Virginia Department of Health regulations (VDH 2014) do not allow conventional on-site wastewater systems (OWS) on most reclaimed mine sites, and the lack of on-site wastewater treatment options is often an obstacle to residential development on reclaimed coal mines. In response to this problem, Virginia Tech personnel have been investigating the potential for alternative OWS to operate successfully on reclaimed mines. The conventional OWS — a septic tank and gravity-fed drainfield commonly used by rural housing on natural soil sites — is not an available option on most mine sites. However, experience indicates that it is possible to effectively treat residential wastewater on mine sites by applying alternative technologies in a management regime that takes full responsibility for adequate operation and performance of the treatment systems on a permanent basis. This publication contains guidelines and recommendations for establishing and operating alternative OWS on reclaimed coal mines.

Readers are encouraged to become familiar with background information on technologies for use in establishing on-site wastewater treatment and disposal systems on soils that have some limitations, as described in detail in "On-Site Sewage Treatment Alternatives," Virginia Cooperative Extension publication CSES-116P (448-407; Galbraith, Zipper, and Reneau 2015). The definitions of terms and concepts in VCE publication BSE-77P, which replaces VCE 448-405, are helpful to comprehending this publication. Both publications are available online through the VCE website (pubs.ext.vt.edu).

## Wastewater Treatment

Establishing effective sewage treatment is an essential element of any residential construction project. People produce sewage, and the effective management of pollutants present in sewage is vital to the protection of environmental quality. Untreated or inadequately treated human sewage can spread disease when discharged to the environment in a manner that allows human exposure. If conventional OWS are placed in soil or on sites that are inadequate to render effective treatment, fecal bacteria can spread to other environmental media and can potentially spread disease.

Contamination of groundwater with sewage wastes can expose other humans to fecal bacteria if the





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contaminated groundwater is accessed by wells used for drinking water. Contaminated groundwater may also emerge at the surface, contaminating the waters of receiving streams and lakes and making them unfit for recreation that involves skin contact, such as swimming and boating. Emergence of contaminated groundwater to the surface can also spread disease even if such water is not subject to direct human contact. Animals, such as rodents, flies, and mosquitoes that contact the surface-discharged sewage, can act as vectors, transporting pathogens and spreading them to other animals and humans.

## Government Regulation of On-Site Systems in Virginia

In Virginia, the Virginia Department of Health is the primary regulatory agency for on-site wastewater systems. Anyone intending to construct and operate OWS must apply for and receive appropriate permits from VDH. Readers are encouraged to contact their local health department early in the process of developing OWS on a reclaimed mine.

The vast majority of OWS in Virginia are composed of conventional septic tanks that remove solids from the sewage wastes and discharge wastewater known as "primary effluent" to a gravity-fed absorption field that disperses the primary effluent into the soil environment. Such systems must be located in soil with properties suitable to render effective treatment of the primary effluent, thus assuring that disease-causing pathogens and other fecal bacteria do not spread. The soil must have sufficiently moderate conductivity to allow satisfactory residence time for microbes to complete the decontamination process. Conventional OWS also remove nonbacterial contaminants from the primary effluent.

When appropriate soil and site conditions are present on a building site, VDH or licensed professionals can approve conventional OWS for the site. Developers of such systems must apply for and receive a construction permit prior to starting construction. After construction is complete and approved by VDH, the system developer receives an operating permit. Once that permit is received, the developer may begin system operation.

Under VDH regulations, "fill" is defined as "soil transported and deposited by man as well as soil recently transported and deposited by natural erosion forces." In most cases, a conventional, septic-tank OWS on a reclaimed mine site will not qualify for a VDH construction permit because VDH regulations consider mine spoils to be fill. The regulations state, "Placement of subsurface soil absorption systems in fill materials is generally prohibited except in three specific situations." Those situations include two specialized systems: the Wisconsin mound and sand-on-sand systems.

Both of the specialized systems utilize soil fill as construction materials. The third specific situation is for systems constructed in "fill material consisting of colluvial soil derived from sandstone (noncarbonaceous) in the mountainous area." Colluvial soils are those that form at the base of mountain slopes from soil materials that originated higher on the slope but were transported downward by sheet erosion and gravity. Noncarbonaceous sandstones are ones that do not contain calcium carbonate, the mineral calcite that is soluble when exposed to soil solution. Under VDH regulations, sandstone colluvial soils may be considered for conventional OWS on a case-by-case basis. Some conventional OWS have been constructed on mine spoils under the colluvial soil regulations. However, most mine sites will not qualify for conventional OWS.

VDH regulations also allow for construction of systems that are not eligible for a general permit. VDH procedures for issuing experimental permits are described in part II, article 2 of the regulations (VDH 2014). The intent of the experimental permitting is "to encourage the development of any new methods, processes, and equipment which appear to have application for the treatment and disposal of sewage." At the time this publication was written, applications for OWS on reclaimed mines are being handled by VDH as experimental permits; however, as VDH gains experience with mined-land OWS, this policy may change.

Under VDH regulations, OWS approved with experimental permits will most likely be considered an alternative on-site system and must be designed and installed under the supervision of qualified personnel, such as a professional engineer or other qualified environmental professional. The system's operation must be monitored by a licensed individual for a period of 18 to 36 months under the experimental status, and thereafter if considered an alternative on-site system. Monitoring personnel must submit regular reports on system operations to VDH. Once the experimental system has demonstrated "satisfactory performance and operational competence," the experimental permit may be converted to a non-experimental general permit. In order to receive an experimental permit, the applicant must propose an approved alternative mechanism for wastewater treatment and disposal so as to assure that access to adequate wastewater treatment is available if the experimental system failed to perform adequately. Such treatment alternatives might include installation of piping to convey the sewage to a distant, but accessible, public sewer; installation of an aerobic treatment unit approved to discharge to a surface-water stream; or some other mechanism approved by VDH.

If the OWS is designed, installed, and managed as needed to achieve satisfactory performance over the monitoring period, the experimental permit is changed to a general permit and the system owner will not be required to utilize the treatment alternative. If the experimental system fails to perform as expected and endangers public health, VDH may require that the treatment alternative be utilized. Experience shows that appropriately installed and managed OWS, designed using the principles described in this publication, have operated effectively on reclaimed mine sites.

As time passes, if additional OWS with experimental permits are installed on reclaimed mines and found by the VDH to operate effectively, the agency will consider altering its permitting policies to enable construction of these systems as general permits.

## Research Review

Virginia Tech personnel have been investigating the capacity of mine soils capacity to renovate sewage wastewaters since the late 1980s.

Skousen et al. (1998) did a field test on two mine soils and reported that they were unsuitable for wastewater disposal based on the application methods and rates they tested. However, most other early activities were laboratory studies (Peterson, Reneau, and Hagedorn 1994, 1998), and those investigators found different results than Skousen et al.

Peterson and others applied septic-tank effluent and effluent from a sand-filter treatment system ("secondary effluent") to leaching columns containing both natural soils and mine spoils. In this research, the characteristics of liquids emerging from the leaching columns were compared to the original effluent in order to determine the soil treatment's effectiveness. The passage of the effluents through both the natural soil and the mine soil reduced fecal bacterial counts due to the activity of nonpathogenic bacterial populations living within the soil columns. However, both the ability of both soils to render effective treatment was dependent on effluent characteristics and effluent application rates. The soil column bacteria were able to renovate the secondary effluent more effectively than the primary effluent (defined in VCE 448-007); this result was expected because the secondary effluent contains fewer bacteria than the primary effluent, and it contains reduced amounts of other contaminants, such as organic materials, that have the potential to interfere with effective bacterial treatment.

The research also found that effluent application rates affect the ability of the soil bacteria to render effective treatment; treatment was most effective at the lower application rates. This result was also expected, as atmospheric oxygen is essential to the soil bacteria's capability to render effective wastewater treatment. At higher application rates, access by soil bacteria to atmospheric oxygen is hindered.

Based on these results, Harrison, Reneau, and Hagedorn (1999) installed and operated several experimental-scale OWS on a reclaimed mine at the Powell River Project Research and Education Center in Wise County, Virginia. These included a low-pressure distribution system that dispersed primary effluent at controlled application rates on a mine spoil fill. However, the fill material used was composed of topsoil and subsoil removed by the mining operation and placed at the experimental site for the specific purpose of accommodating the effluent dispersal. This low-pressure distribution system was operated to apply effluent at a rate of 0.24 to 0.48 gallons per square foot per day (0.4 to 0.8 liters per square meter per hour) over a seven-year period. The researchers found that about 2.5 feet (0.76 meters) of mine soil fill was effective in reducing fecal coliform bacteria to background levels.

Harrison, Reneau, and Hagedorn (1999) also operated a constructed, experimental-scale wetland at this location. Primary effluent was applied to the wetland system; this was effective in reducing contaminants, but not to levels where the wetland outflow was suitable for human contact or environmental discharge. The secondary effluent from the wetland system was disinfected using chlorination and applied to vegetated mine spoils via slow-rate spray irrigation. The spray irrigation system adequately reduced the biological and chemical contaminants in the wastewater to levels less than environmental backgrounds after passage of about 2 feet (0.6 meters) of mine soil.

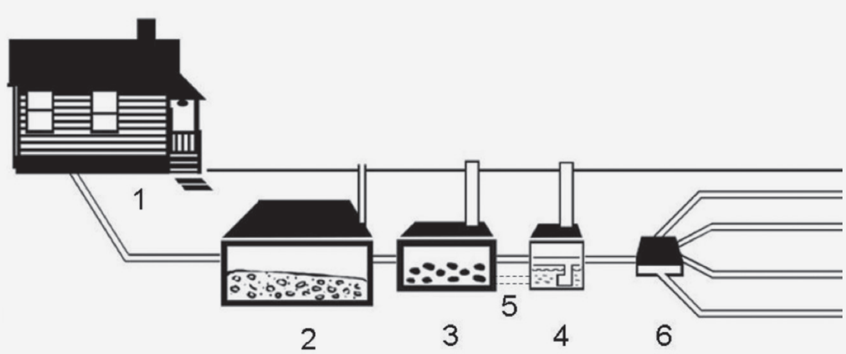
These experimental applications were followed by an operational-scale installation on a mine site in Wise County that began operation in late 2002 (Zipper, Reneau, and Saluta 2005). Sewage wastewaters received primary treatment by passing through a conventional septic tank. The primary effluent was treated with a media filter (a secondary treatment system), and the media-filter effluent was applied to the reclaimed mine soil using a gravel-lined trench. However, in contrast to conventional OWS installations, the secondary effluent was dispersed to the drainfield on a controlled dosing schedule. This was achieved by installing a holding tank to receive the secondary effluent and applying effluent from the holding tank to the drainfield in controlled doses. A pump in the holding tank applied roughly one-seventh of the total daily volume to the drainfield at 3.5-hour intervals. This system operated successfully over a two-year monitoring period and was converted from an experimental to a general permit that did not require continued monitoring. The mine soils rendered effective treatment; the presence of fecal bacteria was not detected in groundwater samples withdrawn from locations within 18 inches of the drainfield ditches.

The system's greatest limitation was hydraulic (i.e., in some portions of the drainfield, wastewater percolation rates were very slow due to soil compaction by mining equipment that had occurred prior to the drainfield installation). This problem was addressed by adjusting the distribution box to apply larger effluent volumes to those ditches where percolation was not limited. The average hydraulic loading was about 0.4 gallon per day per square foot (15 liters per day per square meter) of trench bottom over the entire drainfield. Considering that the majority of effluent was being directed to two of the four ditches, it appears that these ditches were receiving on the order of 0.7 gallon per day per square foot of trench bottom. No other recent studies in this area have been published.

## Recommended System on Existing Mine Soils

On-site wastewater systems for existing reclaimed mines should be designed in a manner similar to the Wise County systems described by Zipper, Reneau, and Saluta (2005) and represented by figure 1.

In figure 1, the sewage source (1) is a home or other facility that produces human sewage and associated wastewaters. These materials are conveyed to a septic tank (2) using gravity flow. The septic tank should be




**Legend:**
1. Sewage source
2. Septic tank
3. Secondary treatment device
4. Holding tank with pump
5. Recirculation loop (optional)
6. Soil dispersal system (a conventional drainfield is represented, but an alternative system, such as drip irrigation or low-pressure distribution, may be required)

Figure 1. The sewage source (1) is a home or other facility that produces human sewage and associated wastewaters. These materials are conveyed to a septic tank (2) using gravity flow. The septic tank should be outfitted with an effluent filter. Filtered effluent from the tank is conveyed to a secondary treatment device (3), such as a media filter that is capable of reducing the bacterial and organic constituents to levels well below those of the primary effluent. Secondary treatment effluent is conveyed to a holding tank (4) that doubles as a pump chamber. Depending on the effectiveness of the secondary treatment device and whether or not effluent nitrogen reductions are necessary, recirculation of the effluent (5) may or may not be required. Effluent from the holding tank is pumped to a soil dispersal system (6) that may or may not include a separate holding tank and pump, depending on system design. Note: Figure is conceptual; it is not to scale.

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The most effective soil dispersal system for reclaimed mines would be one that distributes wastewater in controlled dosages, such as a low-pressure distribution, drip irrigation, or spray irrigation that has been disinfected. VDH will consider conventional gravity-fed, gravel-lined trenches for use on mine sites on a case-by-case basis. Experience indicates that systems using conventional trenches should have the capability to apply effluent in controlled dosages and to manually adjust effluent amounts being directed to each of the soil dispersal lines.

## System Placement and Operation

On mine sites that are not constructed to accommodate on-site wastewater systems, primary consideration must be given to the spatial variability of soil properties. Because the major factor influencing variability is mining equipment operations, that variability is not predictable based on factors — such as landscape position — that typically are used to evaluate the spatial variability of natural soil properties. Subsurface mine soils can be highly variable within short distances, even when no expression of that variability is detectable at the surface. Mine soils can range from quite porous to heavily compacted, with limited capacity to absorb and move treated wastewater. Although not common, some mine soils contain subsurface voids (Haering, Daniels, and Galbraith 2004) that might allow rapid subsurface liquid movement. Because contact of treated wastewater with soil surfaces is essential to further renovation, the presence of subsurface voids can be expected to severely limit the soil's wastewater renovation effectiveness. Because of mine soil variability and the hazards of human exposure to untreated primary effluent, OWS for reclaimed areas should be designed to apply secondary effluent at controlled dosing rates. The following principles should be applied to the design and construction of OWS on reclaimed mine sites.

### Layout and Design

- Apply basic principles of drainfield layout and design for natural soil areas (e.g., avoid placement where surface water is present, where subsurface gray or mottled conditions indicate a high water table, or where soils have been compacted by high traffic or equipment operation).

- Lay out effluent dispersal lines parallel to site contours so as to limit the potential for effluent to emerge from the surface. Lines placed on the contour are also necessary to encourage movement of effluent through the soil system so as to avoid "short circuiting" the soil purification process.

- On existing mine sites, expect greater lateral variability of soil conditions over the area occupied by the drainfield than would be typical in a similarly sized area of natural soil. Dig some exploratory pits prior to construction as would be done on natural soil. If compacted soil areas are identified, lay out the effluent dispersal field so as to avoid these areas. Similarly, avoid excessively rocky spoil materials that contain insufficient soil-sized fragments to fill the spaces between larger rock fragments.

### Installation

- A person who is knowledgeable about the system design should be on-site with the contractor at all times during drainfield installation to ensure that installation conforms with layout and to assist in dealing with any unanticipated conditions found during excavation.

- Use a distribution box that will allow the user to adjust the relative volumes being directed to each dispersal line.

- If conventional gravel trenches are used, consider installing a PVC standpipe with a removable top in each drainfield ditch to allow monitoring of water levels.

- If the drainfield operates as expected, these pipes can be cut and capped below groundlevel to eliminate their aesthetic impact (the standpipes should not be pulled from the gravel trenches).

- Grade the site after construction using light equipment to (1) avoid causing soil compaction, (2) create a surface configuration that will aid rainwater runoff, and (3) discourage infiltration.
- Plant turfgrass or similar vegetation that will transpire moisture and can be maintained in a manner that will not interfere with the drainfield.

## Operation

- Use a highly treated effluent because some mine soils can be quite porous (Haering, Daniels, and Galbraith 2004).
- Time pump cycles so that the average daily effluent production is applied over a 24-hour application cycle.
- Start by dispersing effluent evenly over the drainfield area. If standing water levels are observed consistently in any part of the effluent dispersal field, redistribute the effluent so that larger volumes are applied in those areas where effluent infiltrates rapidly. Make sure the contractor inspects the system operation periodically as a routine maintenance activity and is prepared to adjust dosing rates and/or effluent distribution if necessary to maintain satisfactory operations.

The best dispersal methods for highly treated effluent on mine-fill sites are technologies such as low-pressure distribution or subsurface drip irrigation that allow effluent to be dispersed more uniformly over the soil area used for treatment and disposal. This will result in more unsaturated soil conditions and, thus, a reduced potential for contaminants reaching groundwater and surface water. Because these systems are placed underground at shallow depths and are vulnerable to damage, such systems should only be placed in locations where surface activities can be limited.

## Maintenance

Installed secondary treatment systems will require maintenance on a regular basis. System developers are encouraged to obtain the services of a qualified contractor to perform regular maintenance services as required by VDH.

## Constructing Mine Sites for Housing

- Where a mine site is being constructed for the purpose of supporting housing that will be served by OWS, surface soils from the mining site should be collected and concentrated to construct an effluent dispersal area. These soils should be placed with enough depth to extend at least 3 to 4 feet below the point of effluent release.
- If foot traffic is expected over the soil dispersal system, the system should be placed beneath 12 inches or more of overlying soil (vehicle traffic should not be allowed over the soil dispersal system).
- If surface soils are not available, overburden materials that contain sufficient soil-sized particles to fill the voids between larger rock fragments and/or that break down readily should be used for this purpose.
- It is essential that soil compaction be avoided within the area intended for effluent dispersal.
- Soils should be placed in piles in the effluent dispersal area and graded with a backhoe or a small dozer while in a dry condition.
- Once the soils have been graded, all mining equipment should be excluded from the area.
- If natural soils with suitable properties and in sufficient quantities for effective wastewater renovation are used to construct the effluent dispersal site, the OWS should be designed to apply primary effluent using a controlled dosage system, such as low-pressure distribution or drip irrigation.
- It is essential that soils used for such installations be free of large rocks, woody debris, and subsurface voids and be sufficiently permeable to allow wastewater treatment. Because such a system would not include a secondary treatment, it will be less costly to construct and operate than systems previously recommended for existing mine sites.

Movement of excess water into mine-spoil fills that are used to support structures can have the effect of accelerating spoil settlement. Therefore, effluent dispersal systems should be located away from any buildings that are supported by the mine-spoil fills so as to avoid movement of treated effluent waters into the fill materials supporting buildings. See “Foundations for Housing on Reclaimed Mined Lands,” VCE publication 460-115 (Krebs and Zipper 2009), and “Stabilizing Reclaimed Mines to Support Buildings and Development,” VCE publication 460-130 (Zipper and Winter 2009) for more information.

## Summary and Conclusions

Experience indicates that most mine soils that lack subsurface voids, are not excessively compacted, and contain at least 50 percent soil-sized particles by volume are capable of renovating secondary-treatment effluent and septic-tank effluent effectively. Because of mine soil variability and the hazards of human exposure to untreated primary effluent, on-site OWS for existing reclaimed areas should be designed to apply secondary effluent at controlled dosing rates for properties of each absorption trench. Such installations will require the homeowner to bear higher installation costs than required by conventional OWS (septic tank and gravity-fed drainfield) and more frequent maintenance. However, these technologies provide a means for developing mined-land sites that are not accessible to public sewers, and the increased costs for OWS will be modest relative to the total cost of residential construction. When mining operations are constructing reclaimed land for use as housing sites that will require OWS, surface soils should be collected and concentrated in the area intended for effluent dispersal at a 4- to 5-foot (or more) depth.

VDH personnel should be contacted early in the process of developing OWS on a reclaimed mine. In order for the system to operate, it must receive a permit from VDH. At the present time, VDH anticipates that such systems will be considered for approval as experimental permits. If experience continues to demonstrate that OWS can operate routinely and effectively on reclaimed mines, VDH will consider an alternative mechanism for permitting such systems, such as issuing general permits.

Experience illustrates a basic principle of technology application: Even the best technology must be operated and managed properly in order to achieve the desired results. Problems encountered with experimental installations have been primarily due to human error. These problems occurred despite the fact that treatment technology was performing satisfactorily. The managers of such systems must monitor their operations — especially during the initial days — and be prepared to make operational adjustments, if necessary, to ensure a successful operation.

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