CCPC BULLETIN

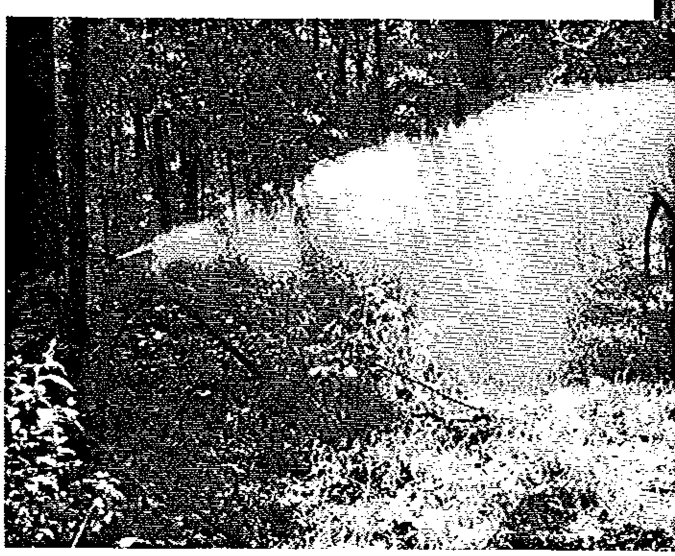
PLANNING BULLETIN #40

CHESTER COUNTY PLANNING COMMISSION

NOVEMBER 1990

# UTILIZATION OF

# SPRAY IRRIGATION



# IN WASTEWATER TREATMENT

BOARD OF COUNTY COMMISSIONERS

D. T. Marrone, Chairman
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## EXECUTIVE SUMMARY

The purpose of this Bulletin is to help municipal officials and interested citizens become more familiar with an unconventional approach to wastewater treatment - spray irrigation. In spray irrigation treated effluent is applied to the land surface rather than discharged to a nearby stream. Chester County is somewhat unique in that we have more spray irrigation facilities which have been operating for a longer period of time than just about any other county in the Commonwealth. The Kendal at Longwood facility, for example, has been functioning for nearly 20 years. The case studies described in this Bulletin offer information useful in our considerations of future spray irrigation applications.

We present information in this Bulletin on existing spray irrigation sites within Chester County, providing as much descriptive and technical information about the facility as has been made available to us. Some spray irrigation facilities, especially the larger ones, have much more information readily available than others. Because our emphasis here has been on case study experiences, descriptions of proposed facilities or facilities actually under construction typically have not been included. Information is also presented on spray irrigation facilities in neighboring counties and the State of Delaware, although our investigations necessarily were more abbreviated as we moved away from Chester County municipalities.

Summary information on the nature of spray irrigation, its problems and opportunities, is also provided in the background section. Interested readers are directed to various other technical references, such as EPA's 1981 Design Manual, for a more complete description of the spray irrigation technology and its essential engineering aspects.

## ACKNOWLEDGEMENTS

We appreciate the generous assistance of a variety of people in the preparation of this Planning Bulletin. Staff at Tatman and Lee, Inc., including principals Russ Tatman and Preston Lee, Tom Kelso, and Craig Kologie, have been especially helpful, as were Jerred Golden, operator of the Hershey's Mill facility, and its engineer, Satterthwaite and Associates. Support has been provided by the Brandywine Valley Association and Brandywine Conservancy. Special thanks go to Jack Shaeffer of Shaeffer and Roland, Inc., Wheaton, IL, who has provided substantial information on spray irrigation technology.

# UTILIZATION OF SPRAY IRRIGATION IN WASTEWATER TREATMENT

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# CHESTER COUNTY PLANNING COMMISSION
# INVENTORY OF EXISTING COUNTY WASTEWATER TREATMENT FACILITIES WITH SPRAY IRRIGATION

## I. INTRODUCTION

This Planning Bulletin has been compiled by Chester County Planning Commission as part of an ongoing effort to provide information on alternative and innovative wastewater treatment approaches, specifically spray irrigation of wastewater effluent. Although spray irrigation is viewed by some as a new and experimental technique, the technique is not all that new and/or experimental. There are a surprising number of sites within Chester County where spray irrigation has been developed and has been functioning for some period of time. The purpose of this Bulletin is to help make those involved with wastewater planning and development in Chester County aware of these projects. As new projects are planned, these experiences can be of considerable value.

This Planning Bulletin is part of a larger effort by the CCPC to collect and distribute information to both the public and private sectors relating to different aspects of environmental planning and other planning issues. Ultimately, the Commission anticipates providing information on other innovative approaches to wastewater treatment which have been or could be implemented in the County. In general, planning bulletins are developed on an as needed basis by the Planning Commission. A listing of other available planning bulletins appears at the end of this document.

Although some explanatory discussion on spray technology is presented here, interested readers are urged to go to the US Environmental Protection Agency's Process Design Manual or some of the other technical references listed here for specific engineering consideration. This Bulletin in no way purports to be a technical manual for the spray irrigation approach.

We also want to stress that this inventory is evolving. We would be happy to receive additional information either about the systems presented here or about other systems which we may have overlooked. Call 344-6285 and we will include your information in future updates of this Planning Bulletin.

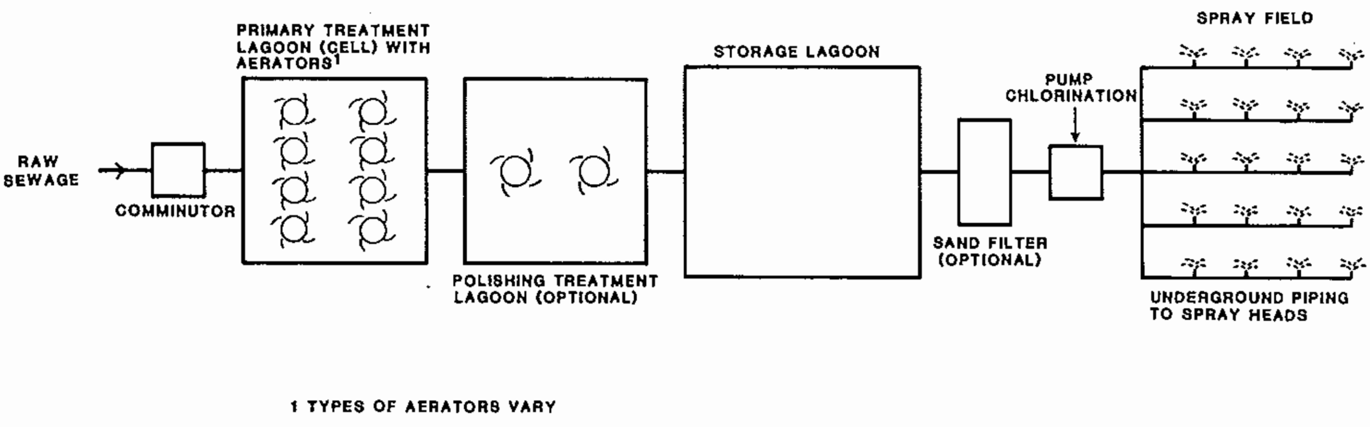
Finally, we want to stress that spray irrigation is not the perfect wastewater treatment solution for all contexts. This Bulletin is intended to communicate and inform so that this innovative approach to wastewater management is considered as an alternative and not necessarily advocated as a solution. Our overall objective is to provide wastewater treatment in the most cost effective and environmentally sensitive manner possible.

## II. BACKGROUND INFORMATION ON SPRAY IRRIGATION

What exactly is spray irrigation? A summary description of the nature of spray irrigation is provided in this section. Spray irrigation, technically speaking, pertains only to the manner in which wastewater effluent is dealt with after treatment. Most modern sewage treatment plants put wastewater through a mechanical treatment process, usually providing what is known as a secondary level of treatment. These plants usually discharge this secondary treated effluent into a nearby stream. Spray irrigation simply means that this treated effluent is applied--or sprayed--onto the land rather than released into a stream or waterbody.

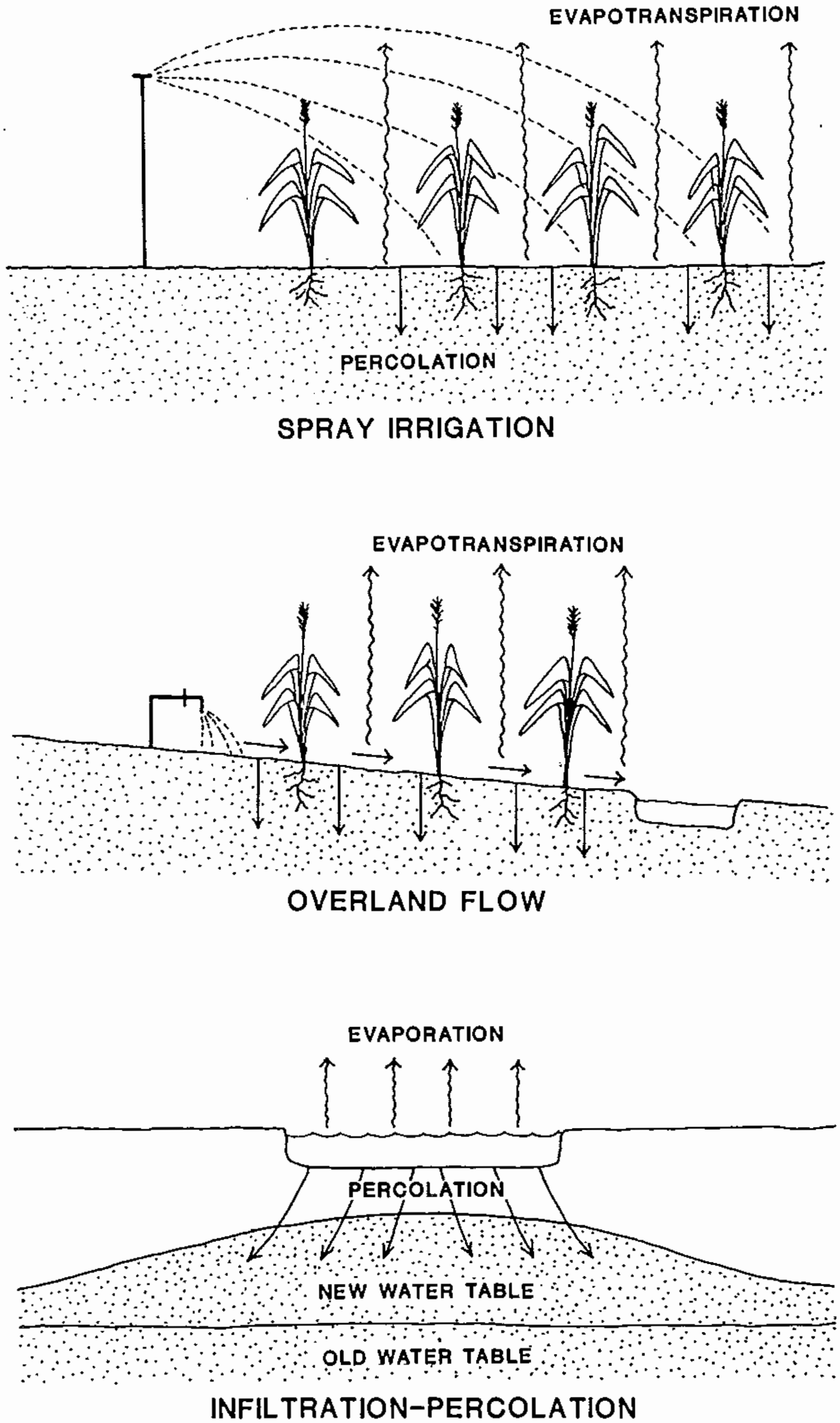
Spray irrigation of effluent always is preceded by treatment of the wastewater before it is land applied. The actual wastewater treatment process can take one of several different forms, ranging from the traditional mechanical treatment plant to a system of aerated ponds or lagoons which has been successfully used in recent years and offers several advantages above and beyond a conventional mechanical plant. We should also point out that spray irrigation is but one of several different approaches to the application of wastewater effluent onto the land. In addition to spray irrigation, other slow rate techniques include ridge and furrow irrigation and border strip flooding, as well as overland flow. Rapid rate infiltration-percolation systems also have been developed. Treatment plants of different sorts can also be constructed with subsurface seepage or disposal beds which return the treated effluent back into the ground. From a groundwater recharge perspective, subsurface seepage alternatives require considerably less land and return more water back into the ground than spray alternatives, although the question of nutrient accumulation in the groundwater over the longer term must be addressed.

Figure 1: Hypothetical Spray Irrigation Wastewater Treament System




Source: CCPC 1990 adapted from USEPA, 1981.

Figure 2: Different Approaches to Land Application of Wastewater Effluent

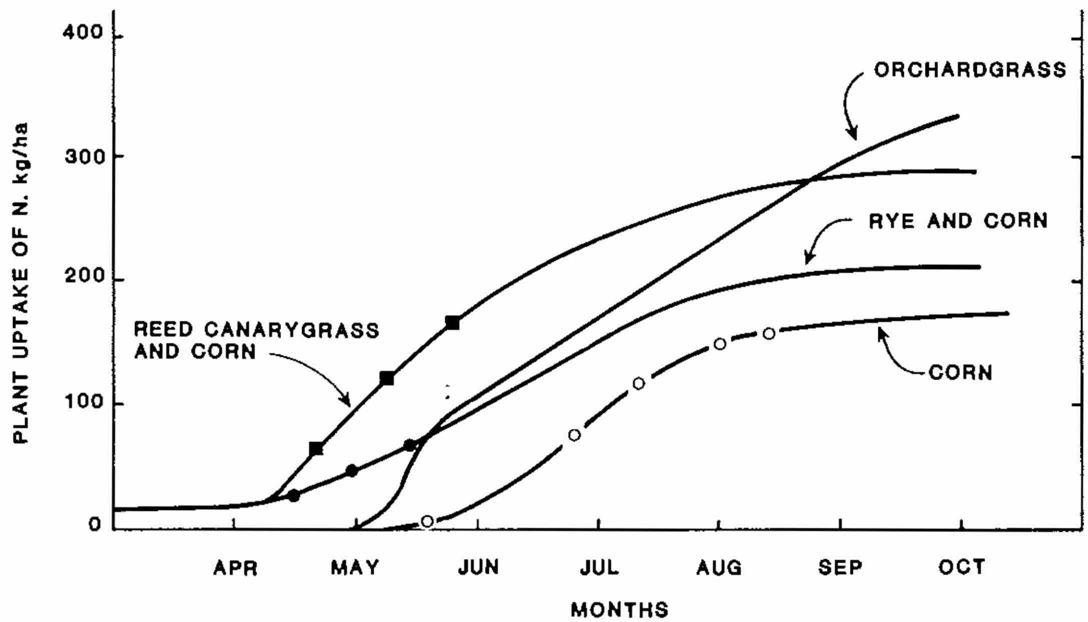



Source: Sopper, 1979.

BENEFITS OF SPRAY IRRIGATION

The inherent logic behind spray irrigation touches on both environmental and economic concerns. In most secondary treated effluent, the vast bulk of pollutants of concern have been removed. Nevertheless, significant amounts of both phosphorus and nitrogen typically remain in the effluent, in some cases even after expensive advanced treatment processes are put in place. These nutrients must be viewed not so much as pollutants, but as resources out of place. When these nutrients are discharged into our streams and lakes, serious imbalances--and ecological damage--can result. On the other hand, if this same effluent is applied to areas of cultivated crops or grasslands or forested areas, the nutrients are taken up, consumed, and translated into economic value in the form of improved crop growth. This natural uptake of nutrients has given rise to the use of the term "living filter" by researchers at Penn State University and elsewhere, where uptake rates of different crops and other vegetation types in removing different potential pollutants have been established. Applying the effluent to the ground also makes efficient use of natural purification processes accomplished as the sprayed effluent moves its way gradually down through the soil and rock layers.

Figure 3: Differential Rates of Nitrogen Uptake for Annual and Perennial Crops




Source: Adapted from USEPA, 1981.

Another important benefit to spray irrigation is that water is returned to the ground, often times in a more decentralized pattern throughout a watershed and further upstream than would be the case if typical stream discharge facilities were constructed. There are a variety of related benefits that result from returning this water back into the groundwater, not the least of which is maintenance of stream baseflow. Use of spray does result in considerable water loss through evaporation and through uptake and ultimate evapotranspiration by plants. Rates of this loss are extremely variable during the course of a year. During summer months, water so "consumed" may be virtually 100 percent. On average, water recharge probably doesn't amount to more than about half of what is applied during the course of the year. In many cases, water loss may approach 75 percent of the total amount land applied (i.e., if a maximum of 2 inches are applied per week, only about 25 inches could be credited as an annual net gain to groundwater).

Some rapidly developing municipalities, such as Buckingham Township in Bucks County, are using spray irrigation of wastewater effluent as a mechanism to preserve open space and manage development pressures. Spray irrigation is land-intensive. Typically, spray fields themselves, together with required buffer areas, become part of the development proposal. These wastewater-linked areas are added to zones of otherwise required open space, further reducing the amount of land which can be developed. For example, Buckingham Township in Bucks County now has eight different spray irrigation sites in some phase of development which require nearly 400 acres to remain open for land application. This wastewater management approach is similar to a "carrying capacity" approach, in that new development takes care of its own needs on a site by site basis. Furthermore, the system requires that developers fund their own facilities, removing significant cost burden from the remainder of the municipality.

## SOILS CONSIDERATIONS

Spray irrigation feasibility is very much linked to site soils and vegetation. Soils must have reasonable permeability. Rock and fine-particle clays which prevent infiltration make spray irrigation impossible. On the other hand, excessively permeable or rapidly draining sands must be avoided so that effluent does not rapidly percolate into the groundwater without biological uptake and chemical and physical filtration. Spray is normally done on several different areas on a rotating basis where a measured amount of effluent is applied to an area of vegetation and then allowed to "dry out" for several days to prevent anaerobic conditions from developing. Application rates are tailored to type and density of vegetative cover, slope, and other factors to make sure that effluent sprayed does not run off, but fully infiltrates. The objective is to make sure that nutrient loadings are taken up by the existing vegetation. During the pre-spray treatment process, effluent is often run through a sand filter and then chlorinated as an added safeguard. Spraying is curtailed during rainfall or when the soil is saturated. Spraying usually doesn't occur when winds are excessive. Spraying may occur in winter months, even during sub-freezing temperatures in forested or densely vegetated settings.

## CCPC POLICIES

Although spray irrigation of wastewater effluent is not an appropriate solution for all Chester County contexts, spray irrigation does help to implement several critical environmental policies adopted by the Chester County Planning Commission:

- **To promote sound environmental practices,**
  - **Protect in-stream uses (aquatic life and recreational uses),**
  - **Protect flow of perennial streams,**
  - **Protect or enhance water quality,**
  - **Protect priority water resource areas as identified by the Chester County Water Resources Authority;**
- **To encourage the return of treated wastewater to the groundwater system;**
- **To discourage the inter-basin transfer of wastewater for treatment;**
- **To discourage the construction of new stream discharge package plants.**

## QUESTIONS ABOUT SPRAY IRRIGATION

As with any nonconventional technology, not all applications of spray irrigation have been problem-free. Critics of spray irrigation point to the possibility of aerosol-borne viral contamination in adjacent areas. Spray proponents claim that virtually all viruses and other pathogens are eliminated during the extended treatment process (if lagoon systems are used). The limited studies which have explored this issue have not been able to demonstrate that such problems exist. Another potential problem involves the contamination of spray fields by heavy metals, especially if industrial users are connected to the wastewater system. Required industrial pretreatment programs effectively eliminate this heavy metals contamination problem.

Probably the most frequently asked question relates to potential odor problems in nearby areas, in part related to the mistaken assumption that wastewater itself is being sprayed onto the land. If the treatment system is operating properly, effluent does not produce an unpleasant odor. As a matter of fact, even the primary wastewater treatment lagoons which receive the raw sewage are not offensive, when engineered and operated correctly. US Environmental Protection Agency-funded studies have concluded that dwellings adjacent to spray sites did not suffer reduced market value as the result of any negative effects from spray. In many cases values have increased, apparently due to the adjacency of permanently committed open space. Emphasis must be placed on both the correctness of the design and ongoing operating practices, if odor and other problems are to be avoided.

## OPERATING AND MAINTENANCE

Operating and maintenance features of spray irrigation also can be positive attributes, especially if combined with the aerated lagoon treatment concept. The spray irrigation system is simpler and easier to operate than the mechanical treatment plant with stream discharge. Energy requirements are minimal, considerably less than those associated with mechanical plants. Possibly most important is that the aerated lagoon treatment system produces virtually no sludge, which is generated in substantial quantities in the typical mechanical plant. Sludge disposal has become incredibly expensive for sewage treatment plant operators and is increasingly difficult to arrange at any price.

Institutionally, spray irrigation, as with other land application of effluent systems, can be managed and operated in a variety of different management and institutional configurations. Large regional or area-wide authorities need not require construction of large regional wastewater plant facilities, although historically our treatment plants and management agencies have grown ever larger together. In fact, spray irrigation systems can be developed and operated privately or publicly on a large or small scale. For example, small treatment facilities with highly decentralized spray sites can be developed and operated by much larger authorities. An interesting municipal model might be to have private developers or groups of developers arrange to develop needed wastewater treatment and spray irrigation facilities in the particular neighborhood which they are developing. After completion, the facilities could then be conveyed to the municipality or municipal authority. In such an arrangement, comprehensive and rigorous specifications should be set in place by the municipality. These specifications guarantee that all elements of the systems are constructed according to best engineering standards, which can meet and even exceed existing State and Federal standards and guidelines. Sites must be properly inspected during the process. Necessary safeguards and redundancy should be incorporated into the process. Alternatively, private systems may be owned and operated by homeowners' associations, with essential operating responsibility contracted over to experienced professional operators.

## ADDITIONAL READING

In addition to site-specific references listed below, general references for spray irrigation include:


ASCE. Pound, Charles E., et al. Series on Water Pollution Control No. 7 Land Treatment: Present Status, Future Prospects. Civil Engineering June 1978.

Pennsylvania Department of Environmental Resources, Bureau of Water Quality Management. Spray Irrigation Manual: A Guide to Site Selection and System Design, Including Preparation of Plans and Reports. Publication No. 31. 1972 Edition.

Pennsylvania State University, College of Agriculture Extension Service. Spray-Irrigation Disposal of Wastewater: Special Circular 185. University Park, PA. Undated.

Pennsylvania State University and USDA Cooperative Extension Service. Epp, Donald J. Applying Municipal Wastewater to Farmland and Forests. Farm Economics, January 1981.

USEPA, Ground Water Research Branch, Robert S. Kerr Environmental Research Laboratory. Preliminary Survey of Toxic Pollutants at the Muskegon Wastewater Management System. Ada, OK, May 1977.

USEPA. Health Effects of Land Treatment--Is It Really Safe? Pamphlet, March 1980.

USEPA, National Small Flows Clearinghouse. Walters, Daniel H. Case Study No. 9 Craigsville, VA, Slow Rate Land Treatment, October 22, 1986.

USEPA, Region III. The Effects of Wastewater Spray Irrigation Systems on Adjacent Residential Property Values. October 1981.

USEPA Technology Transfer/Center for Environmental Research Information. Process Design Manual: Land Treatment of Municipal Wastewater. Also USACE, USDOI, USDA.

# III. SPRAY IRRIGATION SITES IN CHESTER COUNTY

The descriptions of the existing spray irrigation systems vary a great deal, depending upon our ability to locate sources of information. Several new systems are about to come on-line in the County. The Marsh Harbour (Upper Uwchlan Township) facility has just been completed and is operational. Spray systems have been proposed at Rouse and Associates' large Churchill development (the 1,500-acre Church Farm School site in East and West Whiteland, Uwchlan, and Charlestown Townships), also at Waldengate (Upper Uwchlan Township), at Penn's Preserve (Willistown Township), at Village of Glenmoore and Devereux School (Wallace Township) and at other sites in the County, but are not discussed here in any detail. Hopefully, for those existing systems with only minimal information provided here, we will be able to expand our files as this inventory effort continues. At the end of each description, we list any available citations and references, where such references have been obtained for our files. This material is available for review at the Planning Commission's office (235 West Market Street, West Chester 19382; 215-344-6285). A basic reference on spray irrigation also is reprinted at the end of this Bulletin (see Appendix).

Greatest emphasis has been placed on describing those spray systems which are actually functioning within the County. Local engineering consultants (Tatman and Lee Associates, Inc., at 302-791-0700 and Satterthwaite and Associates, Inc., at 692-5770) have also designed systems in adjacent Montgomery and Bucks Counties, as well as in neighboring states, such as Delaware and Maryland. Information on some of these systems is provided here. Other engineering firms, such as Shaeffer and Roland, Inc., in the Chicago area (708-462-898) have engineered and designed a large number of spray irrigation facilities around the country (Shaeffer and Roland have designed the system which is being proposed by Rouse and Associates for the Churchill development, as well as new systems in Mercersburg, PA, and Sussex County, DE). This material is available at the Commission's offices.

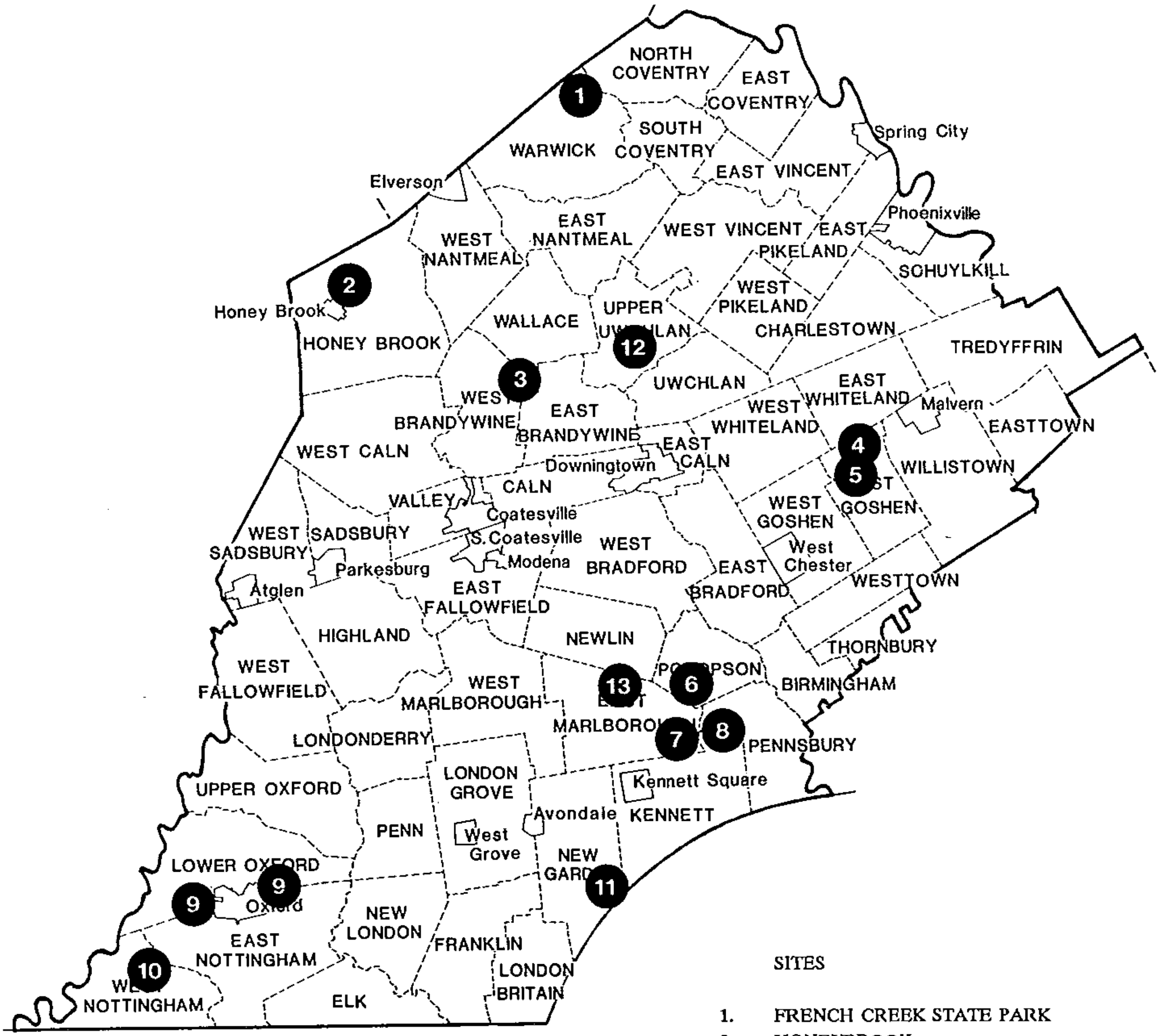
We want to emphasize that not all spray irrigation systems are alike. Systems differ considerably in their engineering, in the nature of wastes received and waste treatment provided. Some systems appear to be much better engineered than others for one reason or another. Also, more recent system design appears to have evolved substantially from that of the first systems put in place.

The general locations of most of the sites discussed on the following pages are shown on Figure 4. Smaller sites and private industrial facilities typically have not been shown. In many cases, these industrial facilities spray industrial process wastewater effluent after treatment, which can be quite different in nature and chemical composition than traditional domestic sewage effluent and, therefore, must be viewed as somewhat exceptional in their operating characteristics. Examples would include Foote Mineral (West Whiteland Township), Hudson Farms (London Grove Township), Nottingham Canning (West Nottingham Township), Hyponex Industries (Lower Oxford Township), and Sunny Slope Dairy (East Vincent Township).

### EAST VINCENT TOWNSHIP INDIVIDUAL SYSTEM

Robert Basca of Spring City developed this individual spray system located on Buckwalter Road.

Figure 4: Selected Spray Irrigation Wastewater Treatment Sites in Chester County 1990




SITES

1. FRENCH CREEK STATE PARK
2. HONEYBROOK
3. KIMBERWICK
4. LOCKWOOD CHASE
5. HERSHEY'S MILL
6. POCOPOSON HOME
7. LONGWOOD GARDENS
8. KENDAL/CROSSLANDS
9. OXFORD BOROUGH
10. NOTTINGHAM MANOR
11. SOMERSET LAKE
12. MARSH HARBOUR
13. UNIONVILLE/CHADDS FORD SCHOOL DISTRICT

Source: CCPC, 1990.

FRENCH CREEK STATE PARK, WARWICK TOWNSHIP, CHESTER COUNTY

This system has 16-foot deep aerated lagoons with another four feet of freeboard provided. According to Warren Doaty (582-1514), who operates the system at the State park, this system has been operating since 1983. The system includes an extended aeration lagoon, where raw sewage enters with a rapid air mix. The system was called a "Lasaire" system and was designed by Allen Myers, Milwaukee, WI. The lagoons are actually in Berks County with the spray fields in Chester County.

The spray fields involve 14 acres of woodland on Mount Pleasure; lagoons are fenced, whereas the spray fields are not fenced. The lagoons are located about 75 yards from the dam breast at Hopewell Lake. A system of 100 spray heads distributes effluent over five zones. Spray rates translate into about 50,000-60,000 gpd during one 24-hour period, usually over just one of the spray zones. The Park opens on April 15 each year and only has to spray about three times each season, given the extremely small flows generated. The plant process itself takes about seven days. Effluent is applied at very low dosages. There is no stream discharge here; nor is there any need for wintertime spraying.

Doaty indicated that the system is sound and has not produced complaints from users or neighbors. One problem is that due to the seasonality of the Park, wastewater flows vary tremendously, which makes this system somewhat atypical. Two quarterly water quality monitoring wells provide data for the spray field area; no water quality problems have resulted based on these sample analyses. Lab results are conducted in PaDER's Harrisburg laboratory. Doaty believes that the Warwick facility is the only State park in the State to have such a facility.

The land requirements of such a site were considerable. However, because this land had to be acquired by the State in any case, this approach worked out well. Algae blooms do occur in the lagoons, but can be controlled. Effluent is chlorinated prior to spraying. There are no perceptible turnover problems in the lagoons during periods of temperature change/transition. Doaty has been amazed at the nature and extent of the aquatic species (frogs, turtles, etc.) which now can be found in and around the lagoons.

HERSHEY'S MILL, EAST GOSHEN TOWNSHIP, CHESTER COUNTY

The Hershey's Mill facility, by most accounts, is a very successful system. The Hershey's Mill system started operating in 1980. It consists of a system of three aerated facultative lagoons (rubber-lined) which provide secondary treatment, followed by spraying of effluent on the golf course (60 acres) in warm weather or on a 7.5 acre forest and a 12 acre field of reed canary grass during the winter. Average retention time for wastewater in the lagoon treatment system is 12 days. Spraying usually occurs at night. Effluent also is stored in a 40 million gallon (MG) holding pond with a floating aerator which is surrounded by a well-used jogging/hiking path. Air is diffused throughout the treatment lagoons to enhance biological treatment, using a system of submerged bubblers arranged in a web on the lagoon floor. The system must be periodically flushed with hydrochloric acid to prevent the bubblers from clogging. Although sludge removal occurs infrequently, removal is made more difficult by these aerators on the lagoon bottom. This system is known as the "Lasaire" system and is similar to the system used at French Creek State Park. System manager Jerred Golden, a professional agronomist, indicated that if he were to construct the system again, he would use a system of floating aerators to eliminate the sludge removal and clogging problems. This Satterthwaite Associates project is operated by West Chestnut Realty (PaDER file # 49805).

The system produces only about one-fifth of the solid sludge waste that a regular wastewater treatment plant produces. Solids settle to the bottom of the lagoons where they are further decomposed by anaerobic bacteria, thereby reducing sludge mass. The treatment system also reduces nitrogen levels to 3-4 ppm, which is considerably lower than had been expected. Lagoons can handle 325,000 GPD and have a holding capacity of 3.3 MG, potentially serving about 3,000 dwelling units. According to Jerred Golden (692-2648), build-out may be reduced to about 1,800 dwelling units, down from the originally anticipated 2,300. The Hershey's Mill development encompasses 752 acres. About 1,000 dwelling units are currently completed with a total average daily wastewater flow of 150,000 gpd. Yearly operating costs average about $200,000 for the entire system, or about $16 per residential unit per month.

*Treated effluent storage lagoon at Hershey's Mill with adjacent exercise path.*

Considerable soils analysis was undertaken at the site to determine feasibility of the spray technology. Over 100 soil borings were taken during the planning of the system to make sure that the soils at the site could accept and renovate the effluent. Throughout much of the site, groundwater is 15 to 30 feet below the ground surface. Soils are deep and well-drained (Glenelg and Chester series) with permeabilities of from 0.6 to 2.0 inches per hour. There are some areas with a seasonally (wintertime) high water table where spray is restricted during wet periods.

Spraying rates are carefully managed so that the potentially polluting nutrients and other loadings in the effluent can be fully taken up and adequately consumed by the vegetation and soil mantle microbes. Effluent is sprayed according to a schedule which permits proper aeration of the soils, prevents surface ponding, and optimizes evapotranspiration. Chemical and hydraulic overloading is avoided. The wooded area spray field on the typical summer day receives four 1-hour spray periods per week, allowing a three day rest period. Depending upon the nature of the vegetation on the site, the spray schedule may be varied. Winter spray applications occur twice weekly for 2-hour periods in order to avoid ice formation and pipeline freezing. Spraying is terminated when wind speed exceeds 10 mph. The spray schedule is designed for specific design pressures and application rates. The irrigation system is shut down during periods of rainfall and high soil moisture content. Spraying schedules also relate to soil moisture conditions.

*Spray irrigation in forest at Hershey's Mill. Arrow show's stream of spray from spray head during winter operation.*

An extensive system of 18 upgradient and downgradient monitoring wells (at 30 and 60 foot depths) together with a comprehensive water quality sampling program are maintained to guarantee that groundwater contamination is not occurring. Quarterly sampling of parameters of interest (pH, Kjeldahl-N, ammonia, nitrate, nitrite, and phosphate, along with static water level measurement) is performed. Lysimeter measurements also are taken and analyzed by an independent laboratory. Overall, sampling results indicate no significant overloading of nutrients or any other constituent at the site during the last 10 years. Based on sampling results, nitrogen, for example, does not appear to make its way beyond the turf grass level and is taken up by the vegetation. Nitrogen levels have not increased during the 10 years of sampling performed thus far.

*One of Hershey's Mill spray fields is located in the forest to the left; dwellings are located about 100 ft. away from the spray, to the right of this access road.*

Golden has stated that the system in total is quite cost-effective. In fact, careful recycling of nutrients in the wastewater effluent sprayed onto the golf course has cut the cost of golf course fertilization in half (although the State permit allows nitrogen application at 4 lbs/1,000 sq. ft., only 2 lbs/1,000 sq. ft. is applied, with any extra nitrogen need for the turf being supplied via fertilization). During dry periods, Golden maintains that the golf course remains in better condition than other comparable courses as the result of effluent application. The ground is kept reasonably moist and allows for more infiltration to occur during summer thunderstorms.

The effluent spray areas surround the upscale golf club and restaurant facility. Residential lots adjacent to the spray-irrigated golf course command a lot premium.

*Wastewater effluent is sprayed on this highly-rated golf course at Hershey's Mill.*

Golden, who has given over 200 tours of the land application system in recent years, has indicated that the system usually generates little odor and, therefore, few complaints. Occasionally, during periods of rapid temperature change or spring/fall "turnover" in the lagoons, some odor is detectable, though has not been a problem. Golden characterizes the system as extremely simple to operate and far less prone to breakdown than the traditional sewage treatment plant. The Hershey's Mill facility has been evaluated in greater detail in the attached EPA Case Study from the National Small Flows Clearinghouse (see Appendix A).

References:

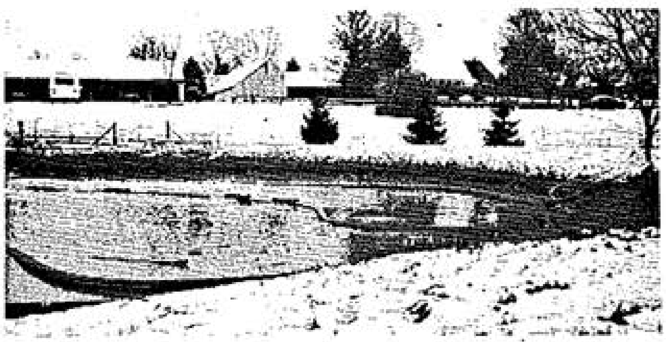
Satterthwaite, Walter B. and Gerald W. Longenecker, "Water Management Program Involving Waste Treatment and Spray Irrigation." Water Pollution Control Association of Pennsylvania Magazine, September-October 1984.

Longenecker, Gerald W. and David F. Lakatos. "A Case Study in Water Management Using Spray Irrigation (Paper 82-2084)." American Society of Agricultural Engineers 1982 Summer Meetings, University of Wisconsin-Madison.

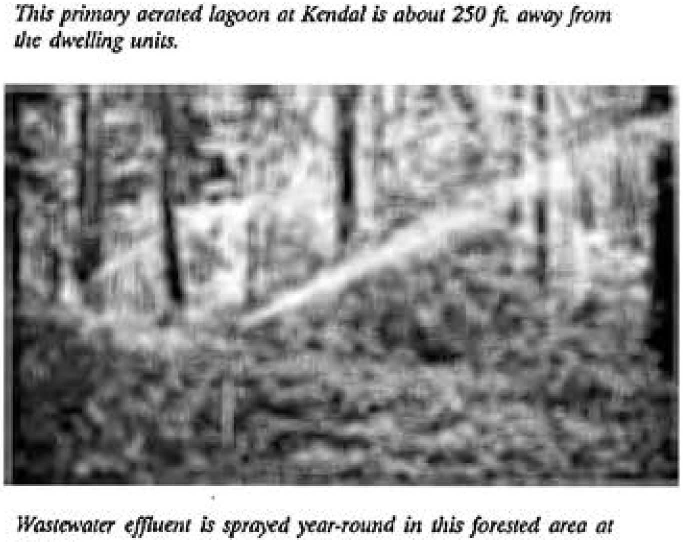
## HONEY BROOK SYSTEM, CHESTER COUNTY

This small facility, built in 1983, was the first spray system in the County to be developed for a single private residence. The system consists of four tank chambers which first treat the raw sewage. The system includes six spray heads which spray treated and chlorinated effluent onto the back yard of this 2-acre parcel year-round, according to Maria Goman of the County Health Department. Guy Hadden is the owner of the system. Debbie Hadden, wife, indicated that they have received no odor or other complaints from the neighbors next door. The system appears to be operating satisfactorily.

## KENDAL-CROSSLANDS, KENNETT TOWNSHIP, CHESTER COUNTY



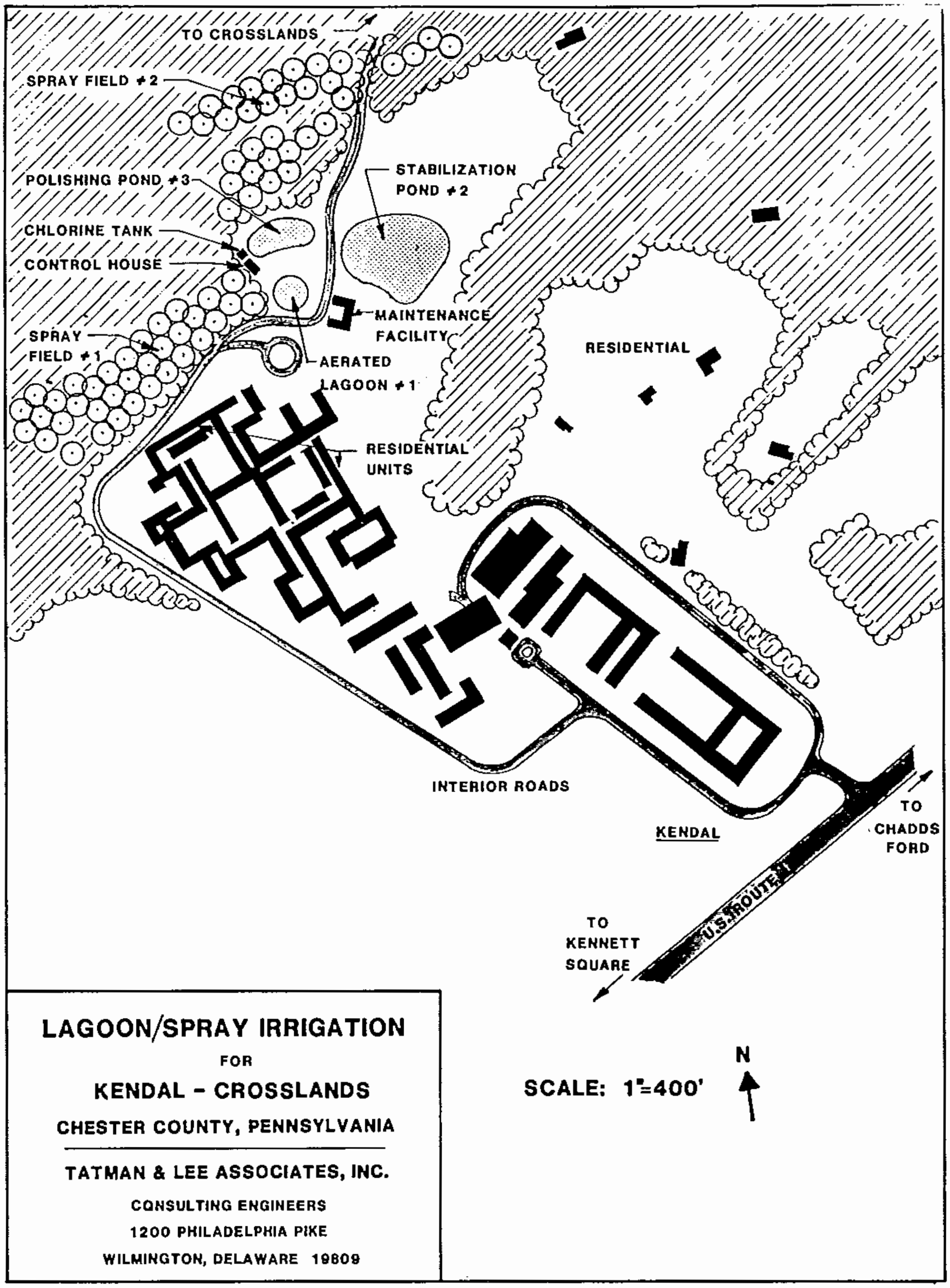
*This primary aerated lagoon at Kendal is about 250 ft. away from the dwelling units.*



*Wastewater effluent is sprayed year-round in this forested area at Kendal.*

This system was the first local project designed by the principals of Tatman and Lee and now has been expanded and modified due to the tremendous increase in the size of facilities. At Kendal, the system includes an aerated lagoon with two polishing/storage lagoons, effluent chlorination, and year-round spraying (Figure 5). A special study is being conducted to monitor groundwater quality, as well as lagoon performance. The Kendal system, operating since 1972, is currently rated at 70,000 GPD and serves a 500-unit retirement complex. The system's aerated lagoon receives the raw sewage after it has been passed through a comminutor. The lagoon and spray fields are located adjacent to residential units. Thirty days of lagoon storage is provided for adverse weather periods. Spray occurs on 14 acres of established mature forest at a rate of two inches per week and is year-round. Spraying is reduced only a few days during each winter season due to very low temperatures. Spraying can occur in sub-freezing temperatures due to the fact that as the ice build-up increases, the ice itself acts as an insulator and allows ice to melt at the soil interface.

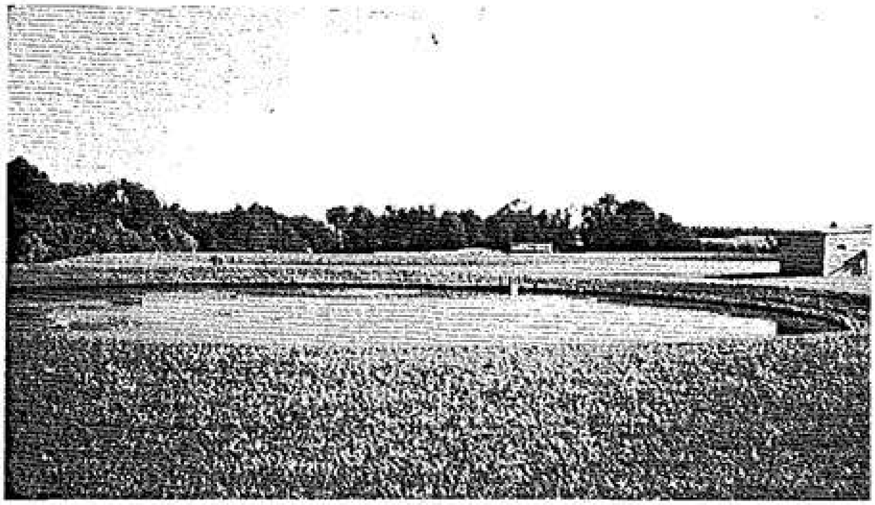
Figure 5: Kendal at Longwood Spray Irrigation Wastewater Treatment Plant Diagram




Source: Adapted from USEPA, 1981.

KIMBERWICK, WEST BRANDYWINE TOWNSHIP, CHESTER COUNTY

This system is located near Little Washington just off US 322 west of Guthriesville past Springton Road on right side (heading west). This system includes an aerated lagoon, a polishing/storage pond, and effluent chlorination before spraying. The several-year old system currently serves 55 dwellings in the Kimberwick development. The system was sized for expansion to include a nearby community of older homes suffering from malfunctioning septic systems. Ultimate system design is for 150 homes total, or 58,000 gpd. The lagoon is fenced with attractive wood/wire fencing, but spray fields remain open; homes are close (minimum of 100 feet) to the spray field. Spraying occurs on 10 acres of perennial rye grasses, harvested as hay, using fixed spray heads about three feet in height. Sixty days of lagoon storage is provided; winter spraying is conducted. Spraying occurs at night.



*Lagoons at Kimberwick are enclosed with ristic wood fencing and serve to provide large areas of attractive open space around the single-family residential development.*

County Health Department (CCHD) records indicate no problems with this system, and Maria Goman, CCHD, believes it is operating well. Sue Dissinger, PaDER Inspector at the Norristown Regional Office, confirmed that she has received no public complaints about this system (270-1975; telephone conversation 1/17/90). She has not visited the site. In reviewing data from four monitoring wells which must be submitted to PaDER quarterly, Dissinger indicated that there did not appear to be any degradation of groundwater quality. These monitoring well results are also passed on to staff geohydrologists at PaDER for more detailed scrutiny.

Planning Commission staff also have visited the Kimberwick site and detected no odor, nor any water quality or other types of problems. The treatment lagoons give the appearance of farm ponds and waterfowl breeding is evident. Staff spoke with the owner of the home closest to the spray area (his new pool and patio installation extend to about 100 feet from the spray field), who offered no criticism of this system. In the several years since his house was built, he has not experienced odor or other problems associated with the system and had heard no complaints from others in the development. His home looks out over the fields and lagoons which he considers to be an amenity. A private firm is hired to operate the facility. The homeowner interviewed felt that the facility was well operated and maintained. In fact, he indicated that he and other owners would like to be able to apply some of the effluent to their lawns during drier periods,given the lush green growth which characterize the spray fields.

*Sprayfields at Kimberwick abut backyards. This homeowner indicated his satisfaction with the spray irrigation concept to the CCPC staff.*

LOCKWOOD CHASE, EAST GOSHEN TOWNSHIP, CHESTER COUNTY

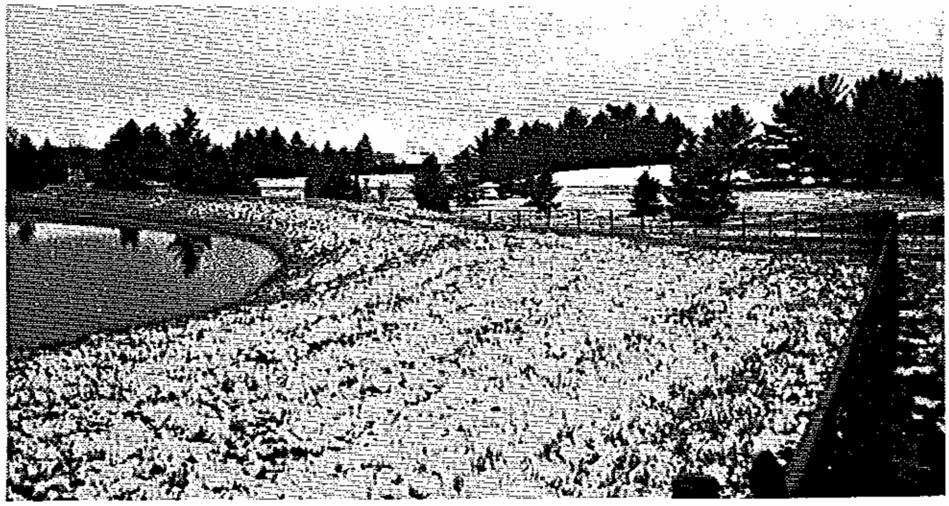
This residential development is near the intersection of PA 352 and Township Line Road (old Malvern Golf Course) and has fenced lagoons with five acres of open space (fields and forest) where spraying occurs. This system has a comminutor and aerated lagoon plus a second polishing/storage pond, providing 60 days storage volume, where effluent is chlorinated before spraying. The system was originally constructed by Ferguson and Flynn, but now is owned by the East Goshen Municipal Authority (EGMA). Mr. Czop at C.E. Moore said they operated the facility for Ferguson and Flynn about two years ago; he recalled that the facility functioned well, though it did trigger some odor complaints during dry summers. According to Suzanne Fish, Secretary for EGMA, the facility is operating well. They have had no complaints in the last two years. Her first file report is from 1983. One hundred three single-family residential units ($250,000-$325,000) are connected, 80 of which are in East Goshen and 23 in East Whiteland. Since EGMA took over, Environmental Operating Services of West Chester, Inc. operates the plant (contact Tom Horrex or Tom Hauser at 380-8680 for additional information). Flow limit is listed at 26,000 gpd, but the October 1989 flow is given as 30,545 gpd. This system sprays effluent during winter months; there is no stream discharge.

*The aerated lagoons at Lockwood Chase give the appearance of farm ponds. Aerators promote aerobic digestion of waste which, in turn, prevents odor from occuring.*

*Homes in the $300,000 and up price range back up to the treatment lagoons and spray fields at Lockwood Chase.*

During an April 1990 field visit (lagoons were operating, but spraying was not observed), Planning Commission staff noted soap suds on the surface of the primary lagoon as well as a faint soap odor along the perimeter of the primary lagoon. The spray field appeared to be in good shape with no evidence of erosion or runoff. Large homes abut the facility. The homes themselves, as well as elaborate patio areas, are located about 200 feet from the treatment lagoons and spray fields. There is no evidence of conflict or incompatibility here. From the vantage point of adjacent homes, the lagoons give the appearance of ponds surrounded by open space. Joanne Dolchak, of the Norristown office (270-1975), is PaDER's facility inspector.

LONGWOOD GARDENS, EAST MARLBOROUGH TOWNSHIP, CHESTER COUNTY



*Longwood Gardens recently converted its stream-discharge wastewater treatment system to spray irrigation. Treated effluent is stored in this lagoon prior to being sprayed on an area of meadow and young trees.*

Tatman and Lee recently worked on this somewhat controversial project where homeowners on nearby properties were resistant to the spray concept. This system retains use of an existing mechanical (activated sludge) treatment plant built in 1958 which has been operating satisfactorily. The new system land applies effluent from this existing mechanical treatment plant in an effort by Longwood Gardens administration to improve the overall environmental performance of their operation and eliminate the stream discharge. The facility began irrigation on the 40-acre field this past fall. Maximum flows are rated at 100,000 gpd. A 9 million gallon kidney-shaped lagoon, which provides over 90 days of storage, is included in the system. The lagoon is six feet deep and has only one aerator. Spray occurs on sparsely vegetated countryside which is not open to the public. Eleven different spray zones allow for rotation of spraying so that each area can fully dry after spray application. Because of differences in vegetation and soils characteristics, these different spray zones have different assigned spray rates in the State permit. Spraying occurs at night. Spraying is permitted until December of each year and is resumed in the spring. Annual operating cost is projected to be about $18,000 for the irrigation portion of the system.

This system uses five monitoring wells, four of which are downgradient, for surveillance of groundwater quality. It should be noted that Longwood's primary drinking water well lies near these spray fields. Jim Cogill, Assistant Director of Maintenance, indicated that in earlier studies, estimates had been made that up to 60 percent of the effluent applied to the land would ultimately makes its way into the groundwater each year.

MARSH HARBOUR, UPPER UWCHLAN TOWNSHIP, CHESTER COUNTY

The Marsh Harbour facility, designed by Tatman and Lee, consists of a sequencing batch reactor treatment plant and one lagoon providing 60 days of storage volume. The plant capacity is 80,000 gpd. Effluent is sprayed year-round on a 14-acre spray field (open land), adjacent to Marsh Creek State Park. The facility has just been completed and is now operational. Source of sewage is primarily residential.

NOTTINGHAM MANOR MOBILE HOME PARK, WEST NOTTINGHAM TOWNSHIP, CHESTER COUNTY

This is a lagoon and spray system rated at 50,000 gpd for the mobile home community. The system is located east of Cemetery Road, south of PA 272, and west of US 1.

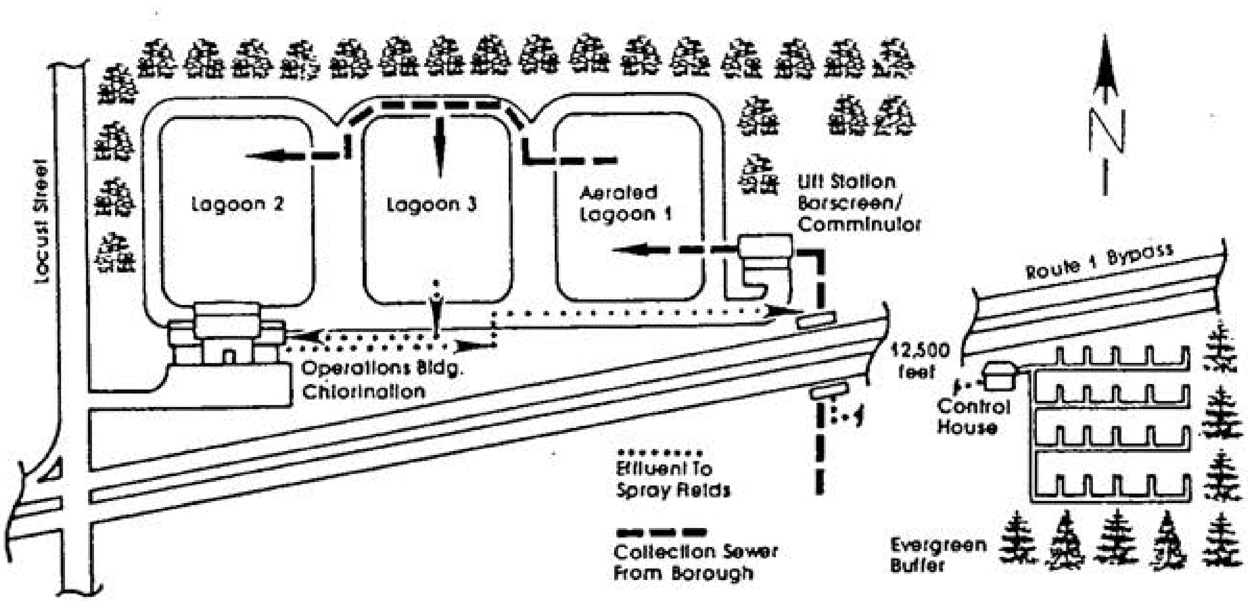
OXFORD BOROUGH MUNICIPAL WASTEWATER TREATMENT FACILITY, OXFORD, PA

The planning for this EPA-funded facility was started in 1972. As an "innovative system," EPA underwrote 85 percent ($3,602,000) of the total cost of the project, with the Borough paying $676,300. The system is simple and considerably cheaper to operate than a conventional mechanical treatment plant. The facility was dedicated in 1985.

The Oxford facility is Tatman and Lee's largest aerated lagoon and spray system with 600,000 gpd capacity, serving 4,000 persons. This system includes three 20-ft. deep treatment/storage lagoons, providing 60 days of storage volume, before chlorinated effluent is sprayed onto 100 acres of hayfields year-round (Figure 6). Hay harvesting is leased, providing an additional source of income. The upper layers of the lagoons are aerated to provide oxygen for wastewater treatment, but the lower levels are anaerobic for complete degradation of solids to carbon dioxide, water and inert "ash." The primary treatment lagoon stores 15.4 million gallons with the other two lagoons holding 35 million gallons. According to D. Preston Lee, Jr., P.E., wastewater is pumped from the treatment site on the west side of the Borough, adjacent to US 1, in a 12,500 feet long 12-inch force main and sprayed onto fields close to residential and shopping areas on the east side of the Borough. The spray fields were designed to provide a 200 foot buffer, initially, with the capability to reduce the buffer to 100 foot in the future. The State accepted this reduction in buffer size. Spraying occurs both during the day and at night. Winter spray rates are about half the summer rates. The system is staffed by two operators.

*Aerators in Oxford's primary treatment lagoon add oxygen to the wastewater. Quantity of oxygen added (i.e., amount of aeration) varies directly with how much waste must be treated or "digested."*

Figure 6: Oxford PA Spray Irrigation Wastewater Treatment Plant Diagram




Source: Borough of Oxford Pamphlet, undated.

The Borough's water supply wells are located directly beneath the spray fields. Careful monitoring of the water quality in these wells has indicated no groundwater pollution from the wastewater effluent.
According to Sue Dissinger, facility inspector at PaDER Norristown (270-1975), there are no significant problems here relating to system functioning. She explained that without informing PaDER, Oxford sold a portion of the spray field area. Since the area sold was part of the State's permit package, Oxford was placed and remains in technical permit violation. The Borough is currently working to resolve this situation and has authorized Tatman and Lee to design additional irrigation facilities for a nearby farm. Dissinger explained that she had received no public complaints about the operation of this system. There were no problems with the results of the required monitoring wells which have been submitted to date. Apparently these results are submitted quarterly to both Dissinger and staff geohydrologists. Dissinger has not conducted a site inspection of this facility per se. Ideally, if staff time allows, the inspectors try to get out to each site at least annually.

During a recent tour of this facility (4/90), Commission staff detected no odors at the treatment plant site itself. One small spray field observed appeared to be suffering from over-application of effluent.

## POCOPSON HOME AND CHESTER COUNTY PRISON, POCOPSON TOWNSHIP, CHESTER COUNTY

This facility includes an aging trickling filter plant. The County Planning Commission inventory lists this facility as a lagoon system with spray field. The facility receives wastes from both the Pocopson Home and County Prison. County Health Department staff have indicated that the lagoon/spray part of the facility is relatively new. The Pocopson system sprays onto row crops and has resulted in some runoff problems, probably due to inadequate conservation management practices.

Tony Riccardi, the County's PaDER-licensed operator of the facility, has explained that the existing mechanical treatment plant with stream discharge was developed around 1950 to serve the County Home (793-1212; telephone conversation, 1/24/90). In 1960, when the Prison was added to the complex, flows increased. Because of pollutant loadings to the stream, PaDER required a facility upgrade. In 1985, Phase I was undertaken, including construction of an effluent polishing pond with 14 acres of ground around the Prison for spraying of effluent. Adequate storage of effluent is provided for a maximum of three months, presumably occurring during the winter when spraying is not undertaken due to weather. The plant is rated at 105,000 gpd and is currently flowing at about 95,000 gpd. All effluent sprayed is chlorinated. Spraying, which is done in compliance with permit requirements, occurs on a maximum of two acres per day. Neighboring residences are within about 150 yards. All lagoons and spray areas are fenced (within Prison grounds). Riccardi indicated that they have received odor complaints from adjacent residents, typically when the pond "turns over" in spring and fall. When this happens (it does not happen every year), sodium nitrate is applied to the pond which eliminates the odor problem.

Phase II, designed by Delaware consultant Richardson/TetraTech, is being installed during 1990. Phase II involves creation of aerated lagoons for sewage treatment, replacing the mechanical treatment plant. If the Prison facility is expanded, future sewage treatment needs possibly could be handled by reactivation of the old mechanical plant, although it's not clear how effluent disposal would be handled.

SOMERSET LAKE (SHANGRI LA), NEW GARDEN TOWNSHIP, CHESTER COUNTY

This 130,000 lagoon/spray system was constructed some years ago by local farmer and State Representative Benjamin Reynolds. The system has been upgraded by Tatman and Lee and has been approved for single-family residential treatment use for 500 single and multi-family residential units. The system includes two lagoons, with the first lagoon being partially baffled and aerated. Effluent is sprayed on a 24 acre open field.

UNIONVILLE CHADDS FORD SCHOOL SYSTEM, EAST MARLBOROUGH TOWNSHIP, CHESTER COUNTY

According to Tom Marinelli, Administrative Assistant for School Plant Operations (388-0632; also Ron Kennel, licensed engineer and operator, at 347-0413), this system has been operating since 1980. The system, which receives wastes from the middle and high schools, consists of several open tank lagoons where aeration, settling, and chlorination take place. Spraying occurs in the rear of the school grounds beyond the playing fields in a wooded area, which has been made into a conservation area with nature trails. Ten spray heads operate year-round on a cyclical schedule. Spraying usually occurs during the school week, unless special weekend events occur and generate additional effluent volumes which must be sprayed before the opening of school on Monday. Spray volume appears to total around 15,000 gpd, although flows can be quite variable. According to Ron Kennel, the District's licensed operator of the facility, there have been no problems with this system. The District has no record of odor or other complaints relating to spray system operation.

## IV. SPRAY IRRIGATION SITES IN NEIGHBORING AREAS

ANGOLA ESTATES, HERRING CREEK, SUSSEX COUNTY, DE

Tatman and Lee designed a lagoon/spray system which includes an aerated lagoon with two polishing/storage ponds, providing 60 days of storage volume. Effluent is chlorinated prior to spraying onto eight acres of lightly wooded area year-round. The system serves a 450-unit mobile home park (vacation community), where flows range from 32,000 to 116,000 gpd.

BUCKINGHAM TOWNSHIP; PEDDLERS VILLAGE/LAHASKA, BUCKS COUNTY

This system includes a mechanical treatment plant (activated sludge sequencing batch reactor) with storage lagoons and spraying of effluent for six months of the year (May through October). About 20 days of storage is provided. During the period of November through April, the effluent is filtered and stream discharged. Service is provided to 228 homes and 49 commercial and institutional properties, with an average flow of 236,000 gpd (about 50 percent of which is commercial). Land acquisition of spray fields was quite difficult here, according to Tom Kelso of Tatman and Lee, Project Manager (telephone conversation, 1/9/90). In the final project, the provision of spray fields worked to help the municipality provide much-desired open space. Spraying occurs on a 73-acre nursery, where the local nurseryman retains the right to grow products as he chooses. Another 46.6 acre spray field was acquired through an agreement with a developer who is planning to cluster homes around open spray fields in return for sewer service. Spray fields are both wooded and open farmland; hay crops will be grown in the open fields.

George Collie, long-time supervisor of Buckingham Township, indicated recently at a Brandywine Valley Association meeting that the Township has decided to embrace this concept of spray irrigation as its primary wastewater treatment philosophy. Eight different spray systems are either currently operating or under construction in the Township, providing 861,000 gpd treatment capacity and creating 385 acres of permanently dedicated spray field area--open space--in addition to open space otherwise required by the Township. Buckingham has decided to accept long-term operating responsibility for all of these facilities. Buckingham makes sure that design and construction of each spray facility are carefully monitored to ensure that problems do not emerge in later years.

## COUNTY CLUB ESTATES, WHITEMARSH TOWNSHIP, MONTGOMERY COUNTY

*Sprayfields at Country Club Estates are a combination of meadow and young hardwood forest. These sprayfields provide an additional open space buffer between the residential lots and the adjacent Wiss. Val. Wisd. Assoc.*

*Sprayfields at Country Club Estates abut new homes in the $750,000 bracket.*

This system includes a small 1-acre facultative lagoon with center wooden baffle, providing 60 days storage with irrigation on three acres of field/forest mix. Wastewater effluent is chlorinated before spraying. The spray field has limited 50-foot buffers and adjoins a railroad, Fort Washington State Park, and the Wissahickon Valley Park. Application rates are reduced significantly during the winter to 0.38 inches from the summer rate of 1.0 inches per week due to presence of seasonal high water table and other factors. Country Club Estates includes 31 large-lot (1.5 acre) single-family homes ($750,000+) with a design flow of 8,200 gpd; Tom Kelso of Tatman and Lee(telephone conversation with Wesley R. Horner, CCPC, 1/9/90) explained that this system is on-line and operating successfully, although the development is only partially completed. Property owners include Bud Hansen of Hansen Properties, as well as the developer, Sal Paone. The system was developed to maximize the number of lots, avoid use of sand mounds, and satisfy the local watershed association.

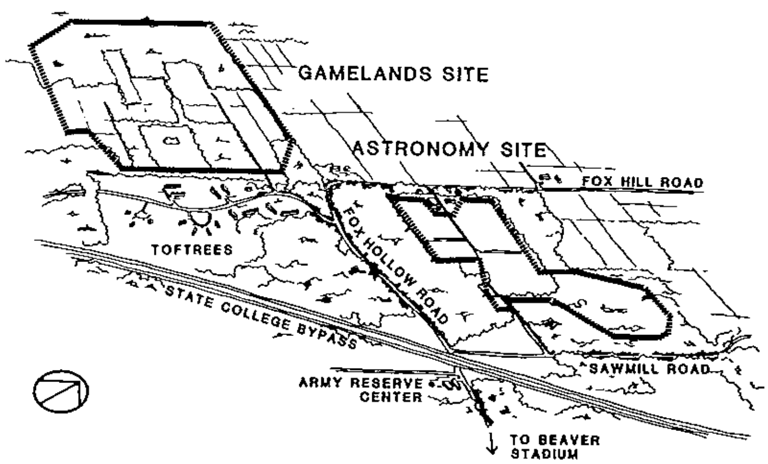
The Country Club Estates system uses a spray field consisting of both meadow and forested areas which provide additional open space and natural area buffering between the dwelling and the Wissahickon Valley Park, owned by Montgomery County.

## DEL AGRA, BRIDGEVILLE, DELAWARE

This lagoon system provides waste treatment for 600,000 gpd of food processing waste; effluent is sprayed on farmland.

This system has been operating for many years. Dr. William Sopper, at 814-863-0291, explained (telephone conversation, 1/9/90) that the Penn State system can treat up to 4 MGD (it currently treats over 3 MGD) and is the largest spray effluent application in the northeastern states. The spray field system includes 516 acres on two parcels north of the Penn State campus in State Gamelands and near the University Park airport (Figure 7). On the one site, known as the Astronomy site (156 acres; bounded by Fox Hollow Road on west and Sawmill Road on the south), effluent has been applied since 1962. The 360-acre Gamelands site, north of the Toftrees development, is more recent in its application. The total system includes over 3,000 individual spray heads with 60 miles of pipe. At full capacity, a maximum of two inches per week of effluent is sprayed onto these sites with maximum rate of application being 1/6 inch per hour. Only 7 percent of the total spray field area receives spray at any one point in time.

Figure 7: Spray Irrigation Sites at the Penn State University Wastewater Treatment Facility




Source: Penn State Pamphlet, The Living Filter, undated.

Penn State's extensive monitoring and testing of this site has indicated no degradation in adjacent well water quality. No negative effects on fauna in the area have been detected; in fact, both flora and fauna appear to be enriched as the result of the spraying. There have been no public health problems arise here. The system continues to meet all PaDER established treatment standards and criteria. In a recent presentation to the Downingtown Area Regional Authority Phase III Committee, Dr. Earl Myers, colleague of Dr. Sopper, indicated concern over long-term accumulation of nutrients in the sprayfields if vegetative growth (biomass) were not harvested or otherwise removed from the system. Dr. Myers is currently studying this question.

*Winter spraying occurs at the Penn State facility; ice at the ground surface gradually melts and infiltrates even in sub-freezing temperatures.*

According to Dr. Sopper, this "living filter' concept, as they call it, effectively removes about 90 percent of the phosphorus and 50 percent of the nitrogen in the effluent, all in the top four feet of the soil mantle. These nutrients are used by native vegetation and cultivated crops which increase in size and abundance as a result. Dr. Sopper has provided several studies investigating different aspects of their project. Several books compiling all of Penn State's research on the facility also are available.

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THE PLANTATIONS, PRD, LEWES/REHOBOTH, SUSSEX COUNTY, DE

This Tatman and Lee system includes an aerated lagoon and two polishing/storage ponds, providing 60 days of storage volume before chlorinated effluent is sprayed year-round on 10 acres of grass. Spray irrigation occurs on golf course and driving range areas, similar to the Hershey's Mill system. The system serves 611 vacation homes with seasonal flows ranging from 40,000 to 140,000 gpd.

TOWNSEND'S INC., MILLSBORO, SUSSEX COUNTY, DE

This system treats and then spray irrigates chicken processing wastewater onto corn fields, increasing yields from 30-45 bushels per acre to 150-180 bushels per acre. This system uses center pivot irrigation on 1,100 acres.

WHITE RESIDENCE, BUCKINGHAM TOWNSHIP, BUCKS COUNTY

This 400 gpd system, designed by Tatman and Lee, was the first individual single-family spray system in the State.

# APPENDIX A

CASE STUDY NUMBER 10

HERSHEY'S MILLS, PENNSYLVANIA
YEAR ROUND SLOW RATE LAND TREATMENT

Daniel H. Walters
EPA National Small Flows Clearinghouse
Research Assistant Professor

October 22, 1986

Hershey's Mill is an adult community located in southeastern Pennsylvania. The village encompasses 752 acres of land; half of this acreage is devoted to open space and is composed of a golf course, woodlands, and open fields. Currently, over 900 people reside in the community; final plans envision a total of 2300 housing units.

As in any development, one of the major considerations is the proper treatment and disposal of the wastewater generated by the community. At Hershey's Mill, public wastewater treatment facilities were not close enough to be considered as an option in meeting the sanitation needs of the village. Homes and small developments surrounding the area utilize onsite soil absorption systems. However, the size of the proposed Hershey's Mill development warranted consideration of a centralized collection and treatment system with stream discharge as a means of wastewater treatment and disposal. The system was never built because local officials and organizations were concerned about the potential environmental effects of the plant's direct discharge into surface water.

A consulting firm was retained to propose alternative plans addressing the sanitation needs of Hershey's Mill. After a detailed and intensive study, the consultants conceptualized an innovative program which integrated wastewater treatment and disposal, and stormwater management into a spray irrigation program. Therefore, the plan would not only solve the wastewater disposal problem, but would also chart a complimentary strategy which satisfies Pennsylvania's regulatory requirements for stormwater management.

Aside from having the benefits of effective wastewater and stormwater management, the system achieves nutrient reuse, offers drought-proof golf course irrigation, provides groundwater recharge, and is cost-effective and energy-efficient. In addition, the combination of woodland, open field, and golf course fairway spray irrigation sites enables the benefits of the land treatment facility to be realized throughout the year.

Slow Rate Land Treatment

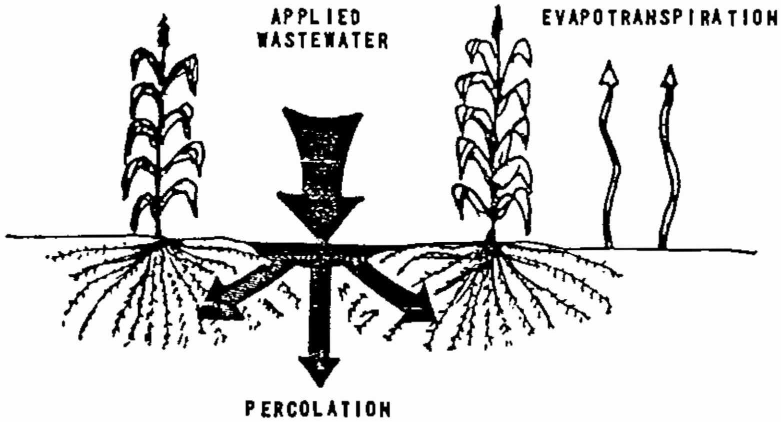
Land treatment is defined as the controlled application of wastewater onto the land surface to achieve a designated degree of treatment through natural physical, chemical, and biological processes within the plant-soil-water matrix. The three major types of land treatment are slow rate, rapid rate, and overland flow. The Hershey's Mill wastewater treatment facility utilizes the slow rate land treatment concept with spray irrigation type distribution.

Slow rate land treatment is the controlled application of liquid onto the land where the primary disposition of wastewater is through evapotranspiration, infiltration, and subsequent percolation. Figure 1 illustrates the various liquid pathways associated with slow rate land treatment.

A number of objectives can be achieved through slow rate land treatment. Generally, the primary objective is the treatment and disposal of the applied pretreated wastewater. Other goals may be attained in agricultural systems, turf farm enterprises, and forest systems. In these settings the goals include the reuse of water and nutrients to produce a marketable crop, and the conservation of water by replacing potable water with treated effluent for irrigation, and the preservation and enlargement of greenbelts and open space.

Generally, soils with moderately slow to moderately rapid permeability are best suited to slow rate land treatment. Slopes must be less than 20% on cultivated land and can approach 40% on noncultivated land. The recommended minimum depth to the groundwater table is 0.6 to 0.1 meters.

FIGURE 1: Liquid pathways associated with slow rate land treatment




Storage of pretreated wastewater may often be required in cold climates or during adverse weather, such as periods of excessive precipitation or high winds. Land treatment may occur throughout the year in forested settings, or in fields with selected perennial crop covers. The forest floor is well insulated by a cover of litter; generally the soil does not freeze, or the depth of penetration of frozen soil is minimal. Solar warming in open fields combined with an insulating cover makes wintertime applications in these areas feasible.

Application rates and schedules are dependent upon the site characteristics, climatic conditions and cropping practices. When the primary objective of slow rate land treatment is wastewater treatment, the hydraulic loading is usually limited by the hydraulic capacity of the soil or the nitrogen removal capacity of the soil and plant system. Other systems base the hydraulic loading rate on the minimum water needs of the crop, or the need for control of pathogenic organisms. Depending upon these factors, application rates can vary from 0.5 to 6.0 meters per year. Sprinkler and surface application techniques including ridge-and-furrow and border strip application are used, depending upon the type of system and the proposed vegetative cover.

Calculation of the hydraulic loading rate involves consideration of precipitation rates, evapotranspiration rates, percolation rates, crop uptake of nitrogen, and crop irrigation requirements. The parameters that receive primary concern will depend upon the goals of the system and the site characteristics. A close examination of crop types, dentrification and volatilization rates, soil permeability, and local climatic conditions is necessary. Generally speaking, if nitrogen contamination of the groundwater is not a concern, then precipitation plus wastewater must equal evapotranspiration plus percolation plus a factor of safety. Off-site runoff resulting from these systems is not permitted. The trend in land treatment systems is very conservative; in slow rate land treatment, a factor of safety is incorporated by using only a percentage of the minimum soil percolation rate.
Additional design considerations include land area calculations, pretreated wastewater storage requirements, and distribution methods. Methods for runoff control and stormwater management must also be addressed.

Of all the land treatment processes, slow rate land treatment is capable of producing the highest quality effluent. Table 1 summarizes the expected quality of treated wastewater at the 1.5m soil depth, as a result of slow rate land treatment of primary or secondary effluent applied at moderate to low hydraulic loading rates.

TABLE 1: Expected effluent quality

| constituent | average | upper range |
|---|---|---|
| | mg/l | |
| BOD | 2.0 | <5.0 |
| Suspended solids | 1.0 | <5.0 |
| Ammonia nitrogen as N | 0.5 | <2.0 |
| Total nitrogen as N | 3.0# | <8.0 |
| Total phosphorous as P | 0.1 | <8.0# |
| Fecal coliforms, No./100 mL | 0 | <10.0 |

# concentration depends upon loading rate and crops

Concentrations of BOD and suspended solids are reduced by bacterial action and filtration as the wastewater percolates through the soil. At normally recommended application rates, these constituents are reduced below the levels given in Table 1 by percolation through 1.5 meters of soil. In most cases, BOD and suspended solids are not a concern in the design of slow rate land treatment systems.

Nitrogen can be a primary design consideration when thee proposed site is located above potable aquifers. The balance of the nitrogen removal rate and the nitrogen loading rate must be such that the groundwater can assimilate the nitrogen contained in the percolating wastewater, while meeting the drinking water nitrate standards.

The mechanisms for nitrogen removal include crop uptake, nitrification-dentrification, ammonia volatilization, and storage in the soil. Crop selection, soil analysis, and management are very important in maximizing these processes. Management of land treatment applications with regard to the growth stage of the crop and harvesting practices are special considerations, because uptake will vary with the time of the year. Much of the nitrogen removed is stored in the plant tissue, so the percent of the tissue removed from the site will greatly influence the quantity of nitrogen removed from the cycle. This is particularly important in forested operations where the leaves and small stems contain a large percentage of nitrogen. Generally speaking, 100% harvest is recommended. The understory and its relationship to nitrogen is also significant. The potential for phosphorus removal will depend upon the soil texture, aluminum content, iron content, calcium content and soil pH. In general, finer textured soils have the highest sorptive capacity. Phosphorus is removed by absorption on the surfaces of the soil's organic and mineral fraction, and by precipitation. Normally phosphorus is completely removed from the percolating wastewater within the first 1.5 meters of soil, and is not a concern in design. However, in areas where the soil textures are very coarse and the sorptive capacity may be low, phosphorus sorption tests should be conducted and the results used in determination of the design loading rates. The useful life of the proposed slow rate land treatment system can then be calculated with the use of empirical models.

In slow rate land treatment systems, removal of trace elements from solution is almost complete. As a result, trace element concentrations are not a major concern in the design of these systems.

Microorganism removals are also not a limiting factor in the design of slow rate land treatment systems. Bacteria, viruses, and parasitic protozoa and helminths are removed by many mechanisms including filtration, desiccation, adsorption, radiation, and predation. As with phosphorus, fecal coliforms are normally absent from percolating waters at a soil depth of 1.5 meters.

Pilot studies have indicated that slow rate systems are effective in removing trace organic compounds. However, if there is a large industrial input of these compounds into the system, pretreatment should be considered.

<u>Site Evaluation</u>

Over 100 soils and geologic borings were made to characterize the proposed site. Five soil series constitute the soil cover of the area. The two that dominate the landscape, however, are the Chester and Glenelg soil series. They are deep, well-drained soils with permeabilities ranging from 0.6 to 2.0 inches per hour. Tables 2 and 3 present the representative soil profile descriptions for the Chester and Glenelg soil series.

Ultimately, it was concluded that the overall wastewater renovation capacity of the site was excellent. 48 acres of golf course fairway, 7 1/2 acres of woodland, and 11 acres of open field were delineated for potential slow rate land treatment sites.

Table 2: CHESTER SOIL SERIES

The Chester series consists of very deep, well drained, moderately, permeable soils on uplands. They formed in materials weathered from micaceous schist. Slopes range from 0 to 65 percent. Mean annual temperature is 53 degrees F., and mean annual precipitation is about 40 inches.

TAXONOMIC CLASS: Fine-loamy, mixed, mesic Typic Hapudults.

TYPICAL PEDON: Chester silt loam - on a 3 percent convex slope in a hardwood forest of oak, hickory and tulip poplar at an elevation of 400 feet. (Colors are for moist soil unless otherwise stated.)

A--0 to 4 inches; dark grayish brown (10YR 4/2) silt loam; weak fine granular structure; friable, slightly sticky, many medium roots; very strongly acid; clear wavy boundary. (2 to 4 inches thick.)

E--4 to 8 inches; brown or dark brown (10YR 4/3) silt loam; moderate coarse granular and weak fine subangular blocky structure; friable, slightly sticky, slightly plastic; many medium roots; common very fine vesicular pores; few fine angular quartzite pebbles; very strongly acid; gradual smooth boundary. (4 to 6 inches thick.)

Bt1--8 to 15 inches, brown or dark brown (7.5YR 4/4) heavy silt loam, moderate medium subangular blocky structure; friable, sticky, slightly plastic; many fine roots; common very fine vesicular pores, few fine angular quartzite pebbles; very strongly acid; gradual smooth boundary.

Bt2--15 to 27 inches, brown or dark brown (7.5YR 4/4) silty clay loam, moderate medium blocky structure; firm, sticky, plastic; few fine roots; prominent continuous clay films on ped faces; few black manganese films; very strongly acid; gradual smooth boundary.

Bt--27 to 36 inches, yellowish red (5YR 4/6) silty clay loam; moderate and strong coarse blocky structure; firm, sticky, plastic; few fine roots; prominent continuous clay films on ped faces; few black manganese films; very strongly acid; gradual smooth boundary. (Combined thickness of the Bt horizon is 24 to 34 inches.)

BC--36 to 42 inches, yellowish red (5YR 4/8) loam; weak coarse blocky structure; friable, sticky, slightly plastic; many mica flakes; very strongly acid; clear irregular to broken boundary. (0 to 15 inches thick.)

C--42 to 62 inches, variegated yellowish red (5YR 4/6) and reddish yellow (7.5YR 6/8) loam, inherent laminar rock structure; friable; highly micaceous; very strongly acid.

TYPE LOCATION: Montgomery County, Maryland; on the north side of Fair Lane Road, one-half mile east of Beltsville Road.

RANGE IN CHARACTERISTICS: The solum ranges from 30 to 50 inches thick with the depth to the lower limit of the argillic horizon ranging from 30 to 40 inches. The solum contains additions of Eolian silts in some pedons. Depth to bedrock is 6 to 10 or more feet. Rock fragments range from 0 to 15 percent in the solum. Cobbles and stones range from 0 to 5 percent throughout the soil. Fragments are generally hard white quartzite or schist. Mica content increases sharply in the lower part of the solum and substratum. Unlimed reaction ranges from strongly acid to very strongly acid throughout.

Table 3: GLENELG SOIL SERIES

The Glenelg series consists of very deep, well drained, moderately permeable soils on uplands. They formed in materials weathered from micaceous schist. Slopes range from 0 to 50 percent. Mean annual temperature is 53 degrees F., and mean annual precipitation is about 40 inches.
TAXONOMIC CLASS: Fine-loamy, mixed, mesic Typic Hapludults.

TYPICAL PEDON: Glenelg channery loam--wooded. (Colors are for moist soil unless otherwise stated.)

A--0 to 2 inches, dark brown (10YR 3/3) channery loam; moderate fine granular structure; soft, very friable, slightly sticky, many roots; 20 percent schist fragments; fine mica evident; strongly acid; clear wavy boundary. (1 to 4 inches thick.)

E--2 to 6 inches, dark yellowish brown (10YR 4/4) channery loam; weak fine granular structure; slightly hard, very friable, slightly sticky, slightly plastic; many roots; 20 percent schist fragments; fine mica evident; strongly acid; clear wavy boundary. (3 to 7 inches thick.)

Bt1--6 to 13 inches, strong brown (7.5YR 5/6) channery silt loam; weak and moderate fine subangular blocky structure; hard, friable, sticky, plastic; common roots; thin clay films mostly in pores; 20 percent schist fragments; common fine mica flakes; strongly acid; diffuse boundary.

Bt2--13 to 24 inches, strong brown (7.5YR 5/6) channery light silty clay loam; moderate and strong medium subangular blocky structure; hard, firm, sticky, plastic; few roots; distinct dark yellowish brown (10YR 4/4) clay films; 20 percent schist fragments; many fine mica flakes; strongly acid; gradual irregular boundary. (Combined thickness of the Bt horizon is 14 to 21 inches.)

C--24 to 60 inches, yellowish red (5YR 5/6) loam; massive; friable, slightly sticky; highly micaceous; saprolite; strongly acid.

TYPE LOCATION: Frederick County, Maryland; on Emerson Road, one fourth mile north of Mapleville Road.

RANGE IN CHARACTERISTICS: The thickness of the solum ranges from 18 to 30 inches. Depth to bedrock is 6 to 10 or more feet. Rock fragments range from 0 to 35 percent throughout the solum and 5 to 35 percent in the C horizon. Fragments are mostly hard white quartzite or schist and range from pebbles to stones in size. Stone content ranges from 0 to 5 percent. Mica content increases sharply in the lower part of the solum and substratum. Unlimed reaction ranges from strongly acid to very strongly acid throughout.

The forested area consists of mixed hardwoods, and the fairways are planted with bentgrass. The open fields are characterized by vegetation indigenous to the area.

The depth to the groundwater surface is generally 15 to 30 feet below the land surface. However, a minor portion of the soil cover does experience a seasonal high water table within 12 to 14 inches during the wet times of the year. The spray irrigation schedules for these sites are adjusted accordingly to allow applications only during the dry seasons, when the seasonal high water table has receded.

## Design

The facilities at Hershey's Mill were based on an average daily wastewater flow of 325,000 gallons per day. A conventional gravity collection system conveys the sewage to the treatment area. Treatment includes secondary treatment in 3 rubber-lined, aerated lagoons with a total capacity of 3.3 million gallons. The lagoons can be operated in parallel or in series and provide a detention time of ten days. The lagoons extend 18" below the aerators providing a zone of anaerobic sludge digestion. Duckweed covers the lagoons during the summer months. Figure 2 shows the three lagoons at the Hershey's Mill development.

Figure 2: Aerated lagoons

Photographs by Walter B. Satterthwaite Assoc., Inc.

A 26 million gallon storage pond was also constructed. The pond serves two purposes: it stores pretreated wastewater when land treatment is suspended, and it also accepts stormwater during periods of high flow. The latter is accomplished by an intake pipe which, during storm events, can withdraw water in excess of the base stream flow from Ridley Creek.

Final treatment and disposal of the pretreated wastewater is attained by slow rate land treatment via spray irrigation. As recounted earlier, 3 areas were delimited for spray irrigation. Hydraulic loading rates were assigned to the spray sites in accordance to the soil permeability and the time of the year. The maximum hydraulic loading rates exercised in the summer range from 1.25"/week to 2.0"/week. In the winter, the maximum hydraulic loading rates vary from 0.5"/week to 1.0"/week.

The calculation of the loading rates for the respective areas were based on the nitrogen limitations rather than on the soil permeability, because it was determined that the nitrogen loading would be the most limiting factor. In marking the appropriate calculations, the concentrations of nitrogen in the pretreated wastewater was assumed to be 20 ppm.

During the winter months the application is limited to the wooded area and the open field. Warmer weather permits application to any of the application sites. However, the facility operator, an agronomist and licensed treatment plant operator, adjusts applications to the golf course in accordance with the conditions and needs of the fairway vegetative cover and soils, and in amounts conducive to normal golf play. The fairway hydraulic loading rates generally do not exceed 0.5"/week. An additional 30 acres of suitable land has been set aside for land treatment to permit the operator flexibility in handling additional wastewater flow. The application schedules for the woodlot and fields are maximized in regard to the amount of pretreated wastewater applied. The soil moisture content, the crop condition and climatic conditions are among the data considered when formulating the current hydraulic loading rate.

Spraying in the woodlots is suspended during the winter when the air temperature falls below 32 degrees Fahrenheit, and is suspended in the open fields when the air temperature falls below 28 degrees Fahrenheit. In 1985 spray applications were made during 50 of the 120 days of winter.

Three vertical turbine pumps are used to distribute the pretreated wastewater to the spray sites. A 500 gpm pump does most of the work, but a 200 gpm pump is available during peak demand. Full-time backup is supplied by a 700 gpm pump.

The spray system used in the fairways is a typical turfgrass irrigation system with pop-up sprinkler heads. The forested and open areas have a distribution system which features 3 foot risers equipped with impact spray nozzles spaced 65 feet apart. In the forested area, this close spacing is required to preclude short circuiting of proper distribution due to the influence of the understory and tree trunks. An operating pressure of 85 psi delivers pretreated wastewater to the fairway turfgrass irrigation system, while operating pressures of 45 to 55 psi are used in the wooded and field areas to lessen the chance of aerosol drift. Fairway spray applications are generally conducted during the night. All lines conveying effluent to the nozzles are buried below the frost line to protect them from freezing. Figures 3, 4, and 5 show effluent being applied to fairway, woodlot, and open field, respectively. Figure 6 also shows a fairway application site.

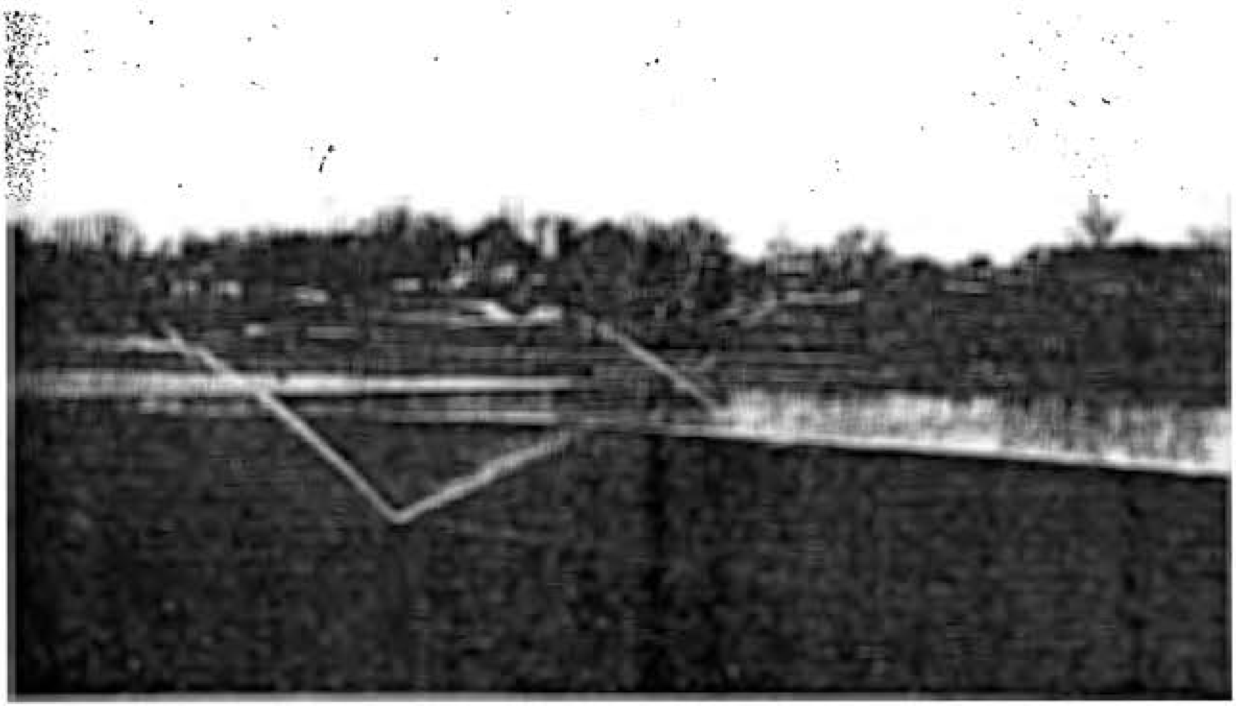
Figure 3: Fairway irrigation

Figure 4: Woodland irrigation

Photographs by Walter B. Satterthwaite., Inc.

Figure 5: Open field irrigation

Figure 6: Fairway Irrigation



Photographed by Walter B. Satterthwaite Assoc., Inc.

## Performance

The system began operating in the fall of 1980 and is currently treating a wastewater flow of 100,000 gallons per day. The BOD of the pretreated wastewater exiting from the lagoons has ranged from 1.0 ppm to 35 ppm since the facility was put into operation, while the suspended solids concentration has ranged from 4.0 ppm to 59.0 ppm. The average BOD and suspended solids for this period were 10.4 ppm and 33 ppm respectively.

Since 1980 groundwater samples have been collected from monitoring wells on a quarterly basis and analyzed for pH, total N, ammonia, nitrite, nitrate and total phosphorus. Water levels are also monitored to allow early detection of hydraulic loading problems.

Analyses completed through the first half of 1986 have shown no adverse environmental effects. All of the parameters have been below EPA drinking water standards, and there has been no evidence of hydraulic problems. In fact, when compared with analyses of the groundwater adjacent to the spray area, there has been a reduction in the concentration of many constituents. This phenomena is a result of the recharge of groundwater by fully renovated wastewater from the land treatment system.

Besides the treatment and disposal of wastewater, the slow rate land treatment system yields several other benefits to the Hershey's Mill community. The program provides a drought-proof irrigation supply which keeps the golf course green even through very dry periods and also supplies a continual source of plant nutrients, consisting largely of nitrogen, to the fairway vegetation. Furthermore, the nutrients are applied in low concentrations over the course of the growing season, thus providing the vegetation with a supplemental food source on a demand basis.

In addition, the system has proven to be an aesthetic success for the Hershey's Mill community. The storage pond and other water bodies are notable assets. The ponds are attractively landscaped, and along with the rolling, green golf course provides an appealing atmosphere as well as an attractive habitat for wildlife. The berm of the storage pond is planted with wildflowers and future plans include a jogging trail along its perimeter. Housing units near the storage pond with a water view will likely command a higher market price due to the aesthetic appeal of this location.

## Costs

The facility was built in stages over a period of several years. Table 4 lists the major construction costs for the Hershey's Mill wastewater facility. Being a multipurpose facility, it is impossible to specify the cost of constructing the wastewater treatment facility, or to precisely calculate the yearly maintenance and operational costs, exclusive of golf course management activities. Equally difficult is the task of putting dollar figures on the benefits derived from the system, such a golf course irrigation and fertilization, groundwater recharge, aesthetic value, and environmental reliability.

Table 4: Construction Costs

| item | cost |
| --- | --- |
| 3 lagoons, including the liners and fencing | $400,000 |
| 2 lift stations | $80,000 |
| pumping station, including aerators, building, 3 pumps, plumbing, and an emergency generator | $100,000 |
| winter storage pond | $575,000 |
| spray system, wooded area | $36,000 |
| turfgrass irrigation system | $260,000 |
| spray system, open fields, including 1 mile of 8" conveyance pipe | $47,000 |

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