ONSITE WASTEWATER TREATMENT AND DISPOSAL FOR COASTAL RESORT BUSINESSES

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ABSTRACT

Onshore commercial or institutional services for the New Jersey barrier island resorts frequently dispose of wastewater onsite, by percolating septic system effluent to the underlying aquifers. However, to protect the groundwater supplying potable water and brackish wetlands, larger onsite systems must now include advanced treatment to remove nitrates. Effluent produced by a mechanical treatment plant at a new nursing home was improved by percolation through a zoned sand mound disposal bed, but operation of the small but complex plant is expensive. Therefore, another system to remove organics and nitrogen was developed for a shopping center, which was expected to have severe seasonal variations in wastewater quality and quantity. Treatment in a series of in-ground and mounded aerobic and anoxic units provides operational economy and flexibility appropriate to resort area commercial establishments.

KEYWORDS

Groundwater; Wastewater Treatment; Nitrogen Removal; Nitrates; Onsite Disposal.

INTRODUCTION

En route to the barrier island resorts along the New Jersey Shore, vacationers from Mid-Atlantic cities drive through pine barrens and agricultural areas that recharge the series of aquifers underlying South Jersey. Groundwater is not only the primary source of potable water in the area, but its continuous discharge into the tidal marshes and estuaries maintains the brackish wetland environment. Land is limited and expensive on the islands. This forces housing and commercial development onto the mainland, concentrated at intersections of coastal highways and causeways to the islands. Where facilities for sewage collection and treatment exist, they are often overloaded. Regional authorities are improving the situation, but resources are necessarily concentrated on the densely populated islands and older communities. Consequently, new establishments in unsewered areas must often provide their own wastewater treatment and disposal through onsite septic systems.

In the Cape May area (Figure 1) there is a growing problem of excess nitrate in the groundwater due in part to agriculture, but primarily from conventional onsite wastewater disposal. Recent state regulations now require advanced treatment in the form of nitrification-
denitrification for large wastewater generators prior to effluent infiltration. Consequently, businesses in the resort area need flexible, reliable and economical treatment systems that improve effluent quality sufficient to provide the proper protection of groundwater quality.

Fig.1. Map of the Cape May area

This paper describes innovative onsite wastewater systems for a nursing home on the fringe of a community under a sewer connection moratorium and a regional shopping center in a rural, unsewered township. In the former, a 12,000 gallons/day (gpd) mechanically operated extended aeration-denitrification plant discharges to disposal fields designed to improve effluent quality during infiltration. The shopping center, with an 11,000 gpd design flow, has a more spacious site that allowed installation of a less mechanically complex system of in-ground treatment units. Two separate sets of treatment units in parallel provide capability for "rejuvenation" by alternate shutdowns in off-seasons. The solution used at each site represents a balance between meeting the effluent quality standards, the need for economical operation, and the local social-political conditions.

BACKGROUND

The sandy Cape May peninsula has few streams, such that infiltration is often the only feasible method for disposal of both stormwater and wastewater effluent at an individual tract. Such localized recharge of the water originally drawn from onsite wells maintains the historic subsurface flow regime, resisting salt-water intrusion. However, inadequate wastewater treatment before discharge is having measurable effects on groundwater and estuarine water quality, with nitrates being a particular concern.

Recently enacted regulations of the New Jersey Department of Environmental Protection (NJDEP) require a special state permit for onsite subsurface disposal of more than 2000 gallons per day (gpd). The application must include an analysis of the hydrologic impact of effluent infiltration. A permitted treatment system must produce effluent with maximums of 10.0 mg/l of NO₃ and 0.5 mg/l NH₄ at the point of discharge, with no consideration of subsurface dilution. Permit requirements also include monitoring of the effluent, the local groundwater, and any sludges generated by treatment for a wide array of substances, which may include volatile organic contaminants (VOC'S).

A number of problems are encountered in complying with such regulations:
- The combination of technologies required, including agronomy, geohydrology and environmental engineering have not been customarily applied to this scale of individual project.

\*1000 gallons = 3.8 m³
Several branches of the NJDEP and local agencies are involved in permit approval and review coordination procedures are not yet in place.

Few nitrogen removal systems are available, let alone economical for operation and maintenance by commercial owners. Proprietary systems for separately treating blackwater (sanitary wastes) and greywater (washwater) and then blending them in a denitrification step appear to suffice for residences and possibly, restaurants. However, the proper balance of nutrients and carbon sources to sustain growth of microorganisms is not always available in separated wastewater streams from commercial and institutional generators.

Seasonal and even weekly fluctuations in resort area wastewater flow and quality complicate advanced treatment, where the effectiveness of each stage depends upon the efficiency of the preceding one. For example, anoxic denitrification cannot occur without aerobic conversion of ammonia and organically bound nitrogen to nitrate.

**SITE "A" BACKGROUND**

A new 120-bed nursing home was planned at the edge of the community of Cape May Courthouse. Local utility services include deep wells in a confined aquifer about 300m from the site, and a municipal sewer district providing only primary treatment before discharge of effluent to a coastal stream. After nursing home construction commenced in early 1985, a moratorium on sewer hookups was imposed, invalidating the service allotment that the owners had obtained. Permanent resolution of the situation required repair of the collection system, abandonment of the local plant, and connection to a regional system. This was seen to take several years, such that temporary onsite wastewater treatment and disposal was necessary to allow the nursing home to open. A conventional septic system was designed and permits obtained again, but a community group brought suit to prevent operation due to severe nitrate pollution of the local groundwater from conventional septic systems upstream. The NJDEP then invoked the new regulations for nitrate removal, requiring the nursing home to obtain a NJPDES permit. The limited site area and local controversy dictated use of a package plant which had been previously approved for residential developments elsewhere in the state. The local stream cannot not handle direct discharge of disinfected effluent, such that onsite infiltration was required to force seepage of effluent into the stream after subsurface filtration (see Figure 2). Problems with simultaneous startup of the nursing home and treatment plant were anticipated, so that the disposal fields were designed to provide "polishing" of incompletely treated effluent if necessary.
Presumptive design flows for nursing homes based on historical records published in textbooks and design manuals (Metcalff & Eddy, 1960; U.S. EPA, 1980) vary from 50 to 150 gpd/bed. These do not account for more modern water conservation practices, and a survey of newer South Jersey nursing homes supported selection of a unit hydraulic loading of 67 gpd/bed. The net design flow rate of 8,000 gpd is only slightly below the actual average flow rate measured at the plant outfall since full occupancy was reached in Mid-1986. However, permit approval was contingent on demonstration that the facility could successfully treat a more dilute 12,000 gpd flow.

Published data on nursing home wastewater quality is limited. Consistency demanded that presumptive quality based on historical concentration records could not be used, as stronger wastewater would be expected with water conservation. Conservative use of domestic wastewater data was necessary, and each nursing home bed (unit) was assumed to produce a mass loading equivalent to 1.25 persons in a residential setting. The resulting wastewater quality (8,000 gpd basis) was predicted to be:

<table>
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<tr>
<th>Component</th>
<th>Concentration</th>
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<tr>
<td>Total Solids</td>
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<tr>
<td>Suspended Solids</td>
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<tr>
<td>Ammonia (asN)</td>
<td>50 mg/l</td>
</tr>
<tr>
<td>Nitrate N</td>
<td>0 mg/l</td>
</tr>
</tbody>
</table>

SYSTEM COMPONENTS

The layout of the onsite treatment and disposal system at Site "A" is shown in Figure 2. The package plant, fabricated by LYCO Systems, Williamsport, PA, has two major units:

- Extended aeration with activated sludge for oxidation of organics, organically bound nitrogen and ammonia. The aeration tank unit provides 24 hours of hydraulic detention at the 8,000 gpd rate, using a conventional air diffuser system and chemical feed pumps to maintain alkalinity. Waste sludge is retained in an aerated holding tank.

- Denitrification with a proprietary anoxic filter consisting of two downflow units containing quartz media to which bacterial growth can attach. Methanol blended in the filter influent provides a carbon source for growth of denitrifying bacteria and assures depletion of free nitrogenous material. When the percolate then enters the finer-grained substrate, the degree of saturation increases and an anoxic condition is generated to complete denitrification if necessary and filter or absorb bacteria and viruses.

RESULTS AND PERFORMANCE

The plant commenced operation in January, 1986. The wastewater quality has varied considerably, with the influent nitrogen frequently being as high as 75 mg/l. As the nursing home was being populated, an unusually large proportion of the wastewater originated in the laundry. This produced hotter water than expected, high disinfectant concentrations, and cleaning agents that interfered with sludge settling. The result was that it took many months to establish a stable biomass in the plant, and poor quality effluent with high suspended solids and up to 5mg/l NH₄ and 10-15 mg/l NO₃, was initially produced. The disposal field provided the aerobic/anoxic treatment as anticipated, such that ammonia was rarely detected in the monitoring wells, and nitrate readings were frequently less than 1.0 mg/l. In fact, the upstream monitoring well has frequently shown higher NO₃ levels than the three downstream wells, implying a dilution of the poor-quality background groundwater flow by the infiltrating effluent.

While now operating in a satisfactory manner, the complex package plant requires much more
ongoing attention than originally envisioned. The nursing home owners are involuntarily in the wastewater treatment business, and it has been a continual drain on both financial resources and management attention.

SITE B

Site B is a 91,000 ft² (8,430 m²) shopping center expansion which includes a large supermarket and assorted retail stores, and is in a lightly populated area for which there are no plans for public sewer or water services. The market served includes both seasonal and year-round residential areas. Groundwater from inland areas flows under the site to discharge in tidal marshes about 100m from the rear of the tract. There is a 70'(21m) deep cased well onsite, while neighboring homes have individual shallow wells. Recharge of both effluent and stormwater are desirable to prevent salt water intrusion.

Wastewater would be expected to be primarily sanitary and food service wastes, with very high solids and ammonia. Estimates of the anticipated flow depend upon the basis used: employment, patronage, square footage, etc. The NJDEP required design based on a flow of 0.125 gpd per square foot of occupied space, for a total of 11,970 gpd, and a high total nitrogen concentration of 80 mg/l. However the actual rate would vary radically between winter and summer. Such uncertainties about the quality and quantity favors use of a very flexible treatment system with flow equalization and long detention times. Conservative solids separation units, followed by aerobic, anoxic and facultative fixed-film biological processes appeared to be the best scheme, along with provision for selective unit shutdowns in low flow periods to allow drainage and lysis of excess biomass. A mechanically complex system was definitely to be avoided at this location.

The design chosen involves splitting the flow between two parallel sets of units, each of which contains the features shown in Fig. 3:

- Dual septic tanks, totalling 5000 gallons and providing 20 hour detention time, 2.5 x 10⁴ ft/sec longitudinal velocity and 38 gpd/sf overflow rate at the design flow. This assures flow equalization and high removal of settleable and floatable solids.

- Wetwell and pump to accumulate clarified liquid and apply it in high rate doses or batches of sufficient volume to flood the sand filter surfaces to a 1" depth up to six times per day.

- Dual aerobic sand filters, 5500 ft² (511 m²) each and 36" (0.91 m) deep, to oxidize organics in the upper portion and ammonia and organically bound nitrogen in the lower portion (Strand, 1986). The design application rate of 1.6 gpd/ft² (40.7 1/d/m²) results in an average downward seepage velocity of 0.75 ft/day (0.23 m/d), four days detention and an average saturation of about 50%. Nitrified effluent exiting the bottom of the filter is diverted by a lined, stone-filled drain to an underdrain pipe. Aeration is assisted by vents to the stone distribution bed, the underdrain, and also by the pore air exchange forced by the displacement of stagnant air with each application. Design of this unit was based on examples given in EPA (1981).

- Secondary wetwell and pump where methanol is added to the nitrified liquid in a 3:1 Carbon:
Nitrogen ratio, and injected into the anoxic tank in 450 gallon batches. The methanol feed controls are set to mix it with accumulating effluent between batch ejection.

- Anoxic, stone-filled upflow tank with denitrifying attached-growth. Each tank has sufficient void volume to provide at least four hours detention at the conservative design flow. Only 40% of the liquid is displaced at each dose injection, such that tank short-circuiting is minimized, but the high velocity scour the media to some extent.

- Final 5500 ft² (511 m²) infiltration bed on a silty sand mound of similar design as at Site "A". The temporary flooding at each dose produces a short-term anoxic/anaerobic condition in the distribution bed, followed by re-aeration as it drains. This cycling is intended to encourage facultative removal of excess methanol, biomass and residual nitrates.

Sludge removal in the form of septic tank pumping will be performed routinely. At low flow periods in late fall, winter and early spring, one of the parallel series can be valved off to allow drying and decomposition of excess biomass. Provisions to re-seed the sand filter and anoxic tank at re-start are included. The media in each unit must eventually be removed and replaced, but this is less expensive than continuous sludge handling. There are a number of monitoring points, including groundwater monitoring wells and lysimeters in the percolation beds, and the efficiency of clarification and nitrification can be monitored by sampling the two wetwells. Construction is underway now, with operation to commence in mid-1988.

CONCLUSION

Two solutions using the same basic processes in different arrangements were formulated to meet new standards for nitrogen removal in commercial wastewater. In each case, percolation to groundwater is the method of effluent disposal. One system based on a small but complex mechanical plant relied heavily on the redundancy provided in the effluent disposal portion, with a stress on its hydraulic performance. Another project had higher needs for flexibility due to uncertain and variable loading. The resulting design is a more diffuse or passive attached growth system that requires little ongoing attention, a critical feature for a commercial entity.

REFERENCES


