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Onsite Wastewater and Land Application Systems: Consumptive Use and Water Quality

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Background

Onsite wastewater management (septic) systems and wastewater land application systems (LAS) have been topics of discussion recently in regard to their effect on water quantity and quality. As the various technical advisory committees have been established in support of developing the state-wide water management plan, the question of consumptive use by onsite systems and LAS and their effect on water quality has arisen. In the report "Maximizing Water Returns to River Basins"[3], developed by the Carl Vinson Institute of Government (CVIOG), the authors state that "septic systems are a concern because they take water away from the system and do not return it to the waterways in measurable terms of quantity and time in the way a wastewater treatment system would". A Basin Advisory Committee Discussion Packet has also been prepared by EPD that suggests different policy and practices to maximize return flows. We address these issues in the following sections on Evaporation and Transpiration, Groundwater Hydrology, Water Quality, and Policy Alternatives.

Evaporation and Transpiration

Consumptive use is defined in the CVIOG report as "that part of a water withdrawal that is ultimately used and removed from the water source whether by evaporation, transpiration, or incorporation into products of crops or some other form of consumption"[3]. In a properly functioning onsite system or LAS, all of the water returns to the atmosphere or moves to ground water. Some fraction of the water that goes to ground water returns to local streams.

The first question is how much of the applied wastewater goes to the atmosphere and how much goes to groundwater. Water from onsite systems and LAS goes to the atmosphere because it is taken up by vegetation growing on the lawn or application site and is transpired or moves up to the soil surface and evaporates. Evaporation and plant transpiration represent true consumptive use of water that will not return to streams (except as rainfall). To evaluate evapotranspiration (ET) of water from an onsite system, we used a computer model to simulate wastewater additions and water losses. The simulated septic system was a typical design used in the Atlanta area with a trench installed at a depth of four feet below the soil surface. The simulation assumed that lawn grass roots penetrated to a depth of three feet, and the weather data used was from Athens, Georgia for 1995 which was a nearly "normal" year with 55 inches of rainfall. We assumed a typical three-bedroom home with a

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[3] Maximizing Water Returns to River Basins, A Report to the Georgia Environmental Protection Division, Carl Vinson Institute of Government, University of Georgia, Athens, GA, 2006, available at www.cviog.uga.edu/services/policy/environmental/policyreports/maximizingreturns.pdf

daily onsite system discharge of 450 gallons per day and 300 feet of septic trench line. We found that 91% of the water discharged into the soil by the onsite system went to groundwater. These results clearly indicate that only a small percentage of the water used by onsite systems is lost to evaporation and transpiration.

Groundwater Hydrology

The second question is what fraction of the water from onsite systems or LAS that goes to groundwater returns to local streams and what effect does this water have on seasonal stream flow. We are not aware of any research that shows what effect onsite systems have on stream flow. For LAS, however, two studies have reported measurements of annual discharge from streams containing LAS systems, and these studies provide an estimate of the portion of irrigation water that is recovered as stream flow. The 2,460 acre Huie Land Application System is located in the Piedmont near Atlanta, and the Headwaters of Pates Creek are located within this LAS. Cleveland[4] evaluated discharge records for Pates Creek prior to and following LAS system startup. He found that prior to startup of this forested land treatment system, average annual discharge was 24% lower than the average for streams in the region. After system startup, annual discharge was 69% greater than the regional average. Law Engineering[5] conducted a separate analysis of discharge from Pates Creek in 1998. Using a double mass analysis approach, they developed relationships between discharge from Pates Creek and discharge from nearby Walnut Creek before and after LAS system startup. They estimated that 70% of the LAS wastewater applied within the Pates Creek watershed was returned as stream flow.

Site factors and application rates may affect the portion of wastewater applied to the soil that is returned as stream flow. Groundwater recharge from onsite systems and LAS slowly moves toward nearby rivers and streams where it emerges as base flow throughout the year. While some of this flow is lost to evaporation and transpiration within the riparian zone, these constant discharges are likely to sustain important riparian and aquatic habitats year-round, and especially during hot, dry summers. Even with these losses of water in riparian areas and other buffer zones, however, the data suggest that 70% or more of wastewater applied through onsite systems and LAS should return to the stream. The percentage of wastewater returns to the stream from an onsite system may be greater than that from a LAS since the onsite system wastewater is discharged in the subsoil where root abundance is less than that near the soil surface. On the other hand, LAS typically apply more water than on-site systems and the soil profile is much wetter. This promotes downward movement of water throughout the year. In on-site systems where the profile is dryer during periods of low rainfall, the downward movement of water may be delayed.

Regional sewer systems have their drawbacks in that they require the construction of large networks of wastewater conveyance systems that are usually placed along streams, often disturbing aquatic and

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[4] Cleveland,W. G. 1990. The Effect of Wastewater Irrigation on Streamflow. MS Thesis, University of Georgia, Athens, GA. 62 p.

[5] Law Engineering. 1998. Edgar Blalock Reservoir Yield Study. Project 12000-7-0249. Law Engineering and Environmental Services, Inc., Kennesaw, GA.

riparian ecosystems during construction and routine maintenance. Two parallel flow systems are present in this case; the natural channel plus the sewer lines that serve as constructed channels for the wastewater. Wastewater treatment systems also typically discharge more flow during rainfall events due to intentional collection of stormwater runoff in combined systems or unintentional infiltration into the system. This inflow leads to higher peak flows and greater erosive energy than the stream would normally handle. When compared to streams functioning with wastewater treatment systems, we would expect streams with LAS or onsite systems to have a more consistent and uniform flow with lower peaks and less variability because of the storage provided in the shallow groundwater.

The fact that wastewater is bypassing the stream – by flowing through the constructed drainage system - means that base flows are likely to be lower, between the point where water is withdrawn and the point where it is returned to the stream, than if the wastewater was treated and released through onsite systems along the way. When the water is treated and released in a regional wastewater treatment facility, then the stream discharge at the point of wastewater return may cause a substantial change in the character of the receiving stream. Rather than a small increment in flows along the way, larger flow and water quality changes are often observed, especially during drought periods. While the effects of these changes are unknown, they are not characteristic of natural streams.

Water Quality

When properly sited, designed, installed, and maintained, LAS and onsite wastewater management systems effectively reduce or eliminate most human health or environmental threats posed by pollutants in wastewater. Because of expense and environmental degradation associated with central sewer systems, USEPA encourages communities to give equal consideration to decentralized wastewater management systems and central sewer systems during wastewater planning. This agency also considers onsite systems to be a permanent component of the Nation's wastewater infrastructure.

Onsite systems rely on physical, biological, and chemical processes in the septic tank and soil to sequester and/or attenuate potential contaminants in wastewater before it reaches ground or surface water. A typical onsite system consists of a septic tank, a drainfield, and the soil. The septic tank provides primary treatment by removing large solids and much of the fats, oils, and grease (FOG) from the wastewater. The tank has minimal effect on concentrations of nutrients, pathogenic organisms, or other potential contaminants in the wastewater. Because of its anaerobic environment, only 60 to 70% of the organic solids collected in the septic tank decompose, and the remainder accumulates at the bottom of the tank. Over time, the accumulation of solids and FOG will fill the tank which reduces residence time of the wastewater and may result in movement of solids into the drainfield where they will clog soil pores and cause hydraulic failure of the system. Thus, the septic tank must be periodically emptied (pumped) to remove solids and FOG as part of a regular maintenance program.

The wastewater flows from the septic tank into the drainfield which consists of underground trenches where the wastewater is distributed over a large enough area of soil to allow complete infiltration.

Little, if any, wastewater treatment occurs in the trench. Most wastewater treatment for both onsite systems and LAS occurs in the soil. Treatment efficiency varies with soil properties, hydrologic conditions, system design, and system management. Thus, reports in the literature that deal with soil removal of wastewater components vary widely.

Wastewater components that are potential contaminants of ground and surface water include organic matter, suspended solids, pathogenic organisms, nitrogen, phosphorus, toxic organic compounds, and metals. Though data are limited, most reports in the literature indicate that these materials are removed from the wastewater as it moves through two to three feet of unsaturated soil. This is the basis for the requirement in Georgia that the seasonal high water table and rock be at least two feet below the base of the onsite system drainfield trench. Similar separation distances between the soil surface and the seasonal water table are required for LAS sites.

Of the wastewater components listed above, the most problematic for maintenance of water quality is nitrogen. For LAS, the system design requires evaluation of the nitrogen balance, and for high nitrogen wastewaters, nitrogen assimilation by the soil and vegetation growing at the site is often the factor that determines allowable wastewater application rates. For onsite systems, a similar evaluation is not required. However, because the land area receiving wastewater is a small percentage of the total area of a subdivision, the process relied upon to maintain low ground water nitrate concentration is dilution of high-nitrate wastewater by low-nitrate precipitation and ground water. Thus, nitrate concentration in ground water is a function of the density of onsite systems. Most studies have found that ground water nitrate concentrations at the edge of a subdivision were less than the drinking water standard of 10 mg/l if the onsite system density was less than 1 to 2 systems per acre (0.5 to 1 acre lot size). Riparian buffers have been shown to reduce ground water nitrate concentrations in agricultural landscapes, but the effects of riparian buffers effects on ground water nitrate has not been evaluated in suburban landscapes. If low nitrate concentration is desired for ecological sustainability or other reasons, onsite system technologies are commercially available that remove most or all nitrogen from the wastewater before it is discharged into the soil.

The above discussions apply to properly functioning onsite systems or LAS. If an onsite system hydraulically fails and partially treated wastewater rises to the soil surface or if the LAS has surface runoff, there is the potential that the wastewater will flow to and contaminate surface water. Probability of onsite system failure or surface runoff from a LAS is low if the system is properly sited, installed, and maintained. Onsite systems do fail, however, as do central wastewater treatment facilities. When onsite systems fail, the homeowner is inconvenienced and a few hundred gallons of partially treated wastewater may move to surface water. In contrast, when central wastewater treatment facilities fail, thousands to millions of gallons of untreated wastewater are discharged into the stream or lake. The key for long-term performance of both types of systems is proper maintenance.