Article 31

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Microbes in Urban Watersheds: Implications for Watershed Managers

When it comes to bacteria, most watershed managers have more questions than answers. Can a beach, shellfish or drinking water use really be maintained in the face of watershed growth? Can water contact recreation uses ever be supported in an urban watershed, and under what flow conditions? What expectations are reasonable for future water uses? What kind of detective work is needed to discover existing bacteria sources? Which bacteria sources are the best targets for management? What watershed practices are most effective in preventing or treating new sources? Eliminating or treating existing sources? What kind of bacteria monitoring is needed to safeguard public health?

Some of the answers to these difficult questions depend on many complex watershed factors, such as the density of development, method of sewage disposal, bacteria sources, actual water uses and weather conditions. Given that watershed managers are increasingly asked to control microbes, this article seeks to present a more coherent framework for how bacteria can be managed in urban watersheds. It begins by describing a conceptual model for managing bacteria in urban watersheds, and then applies the general model to four specific watershed types. The implications for bacteria management in each watershed type are reviewed in detail, with a strong emphasis on the prevention and treatment of new bacteria sources. The last section presents a six-step process to detect existing urban bacteria sources, as well as a review of practices that can eliminate or treat these sources.

The Bacteria Management Model

Not much is out there to guide watershed managers on how to manage bacteria. To begin to fill this gap, we have developed general bacteria management "model." It is a simple framework that organizes what we know (or think we know) about managing bacteria in different kinds of urban watersheds. The model is a still work in progress, and many of its details need to be confirmed by more research data. It is best regarded as an initial hypothesis rather than a predictive model at this point. Still, it represents a starting point to guide debate on what we can expect to achieve in managing bacteria in urban watersheds (Figure 1).

The bacteria management model distinguishes two broad kinds of human uses: *consumption* as in drinking water and shellfish harvesting, and *contact* such as swimming and other forms of water contact recreation. The model also evaluates use impairments in four kinds of watersheds, based on their density and primary wastewater disposal technique. The watersheds include the following:

- *Very low density watersheds*. These watersheds are essentially undeveloped or rural in character and have less than 5% impervious cover. Septic systems are used for wastewater disposal, but occur at a relatively low density. As a result, livestock and wildlife constitute the primary bacteria sources.
- *Low density watersheds*. While portions of these watersheds remain undeveloped or in rural uses, they are primarily zoned for large lot residential development, which are serviced by individual septic systems. Lot sizes can range from one to five acres. Impervious cover typically ranges from five to 15%, and the density of septic systems frequently exceeds 100 per square mile. Septic systems and stormwater runoff are key sources.
- *Moderate density watersheds*. The land use in these watersheds is primarily suburban in nature. Residential and commercial developments are serviced by sanitary sewers. Impervious cover ranges from 15 to 30%. Stormwater runoff, pets and sanitary sewer overflows are key sources.
- *High density watersheds*. These watersheds are highly urban in character, and wastewater is disposed by a sewer system. Depending on its age and condition, the sanitary sewer system may be a bacteria source, either from combined sewer overflows, sanitary sewer overflows, illicit sewage flows or some combination thereof. Impervious cover in these highly urban watersheds exceeds 30%.

The model projects the frequency of use impairments under dry weather and wet weather flow conditions for each of the four kinds of watersheds, as defined by an exceedance of fecal coliform standards. The impairment curve is expressed as a band, to reflect the variability in watershed sources and the use of management practices which reduce bacteria.