DRAFT

Effects of Water Conservation on the Operation of Sewage Treatment Plants

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Executive Summary

The task of describing the effect of increased water conservation and its subsequent reduction of hydraulic loadings to sewage treatment plants is one of several being performed by the Interstate Commission on the Potomac River Basin (ICPRB) with funding support from Maryland Department of Natural Resources - Water Resources Administration under the general subject of freshwater inflows to the Chesapeake Bay. Most studies of reduced flows to sewage treatment plants concentrate on the relationship of flow to hydraulic capacity of the plant. The focus of this study is on the operational effects of both lower flow rates and the resultant higher pollutant concentrations. The findings described in this report will be useful in determining some of the secondary effects of water conservation, and of potential water quality as it affects the Chesapeake Bay.

The study was conducted primarily by personal communication with a sample of waste water treatment plant operators in the State of Maryland, the District of Columbia, and nearby Virginia. In particular, the larger plants in the Baltimore and Washington, D.C. area were considered.

A wide range of responses was obtained; however, the consensus of plant operators was that the effects of lower flows and resultant higher concentrations would likely affect each plant differently. In some cases beneficially, in others insignificantly or negatively. The type and capacity of individual unit processes would be the major determining factor. Plants which rely heavily on trickling filters would be worst affected by higher concentrations of pollutants, especially in winter when efficiencies normally decrease due to slower biological reaction rates at lower temperatures. Plants which incorporate activated sludge may realize positive benefits due to increased retention times in process tanks.

The conclusions to be drawn from this study are listed below.

1. For activated sludge treatment processes usually at larger plants, lower flows would generally produce beneficial effects by increasing the detention time in the aeration basins, and offset the higher concentrations of biochemical oxygen demand (BOD).

2. Most sewage treatment plants rely on pumping sewage into the plant and/or within the plant. Reductions in flow would diminish the operational cost required to lift the sewage.

3. In sewers where inflow and infiltration are significant, wide ranges of flexibility in the operation of treatment plants are necessary, and the variations in flows are likely to obscure any practicably obtainable reductions due to water conservation. Thus, there are potential instances where marginally lower flows would produce no significant operational effects at a sewage treatment plant.

4. Reduced influent flows are more likely to cause operational problems at smaller waste water treatment plants. The resultant longer detention times and higher pollutant concentrations might produce septicity in the primary sedimentation tanks. This would be undesirable due to the production of odor and subsequently more difficult treatment conditions.

5. Smaller plants are more likely to use trickling filters than activated sludge as the main treatment process. These filters are less flexible in their operational capacity, and thus would be more susceptible to adverse impact due to lower flows and higher pollutant concentrations. In particular, operational flexibility and treatment efficiency are least during cold weather periods when biological activity is naturally slowest.

6. At plants where the principal design parameter is pounds of BOD loading, a wide range of concentration can be accepted and treated without significant effects on the operation of such plants.

7. Occasionally, the biological processes at a plant are knocked out by high concentrations of industrial chemical pollutants. At plants where this condition may occur, a reduction in sanitary sewage may serve to aggravate the situation.

8. With regard to the sewers, it is possible that beyond some point, a reduction in flow would produce enough of an increase in the time-of-concentration that septic conditions would develop in the collection system. This negative impact would result in the production of hydrogen sulfide gas and difficult treatment conditions. Another potential draw-back of reduced flows might be the deposition of suspended material in the sewers, which during higher flows would be resuspended and delivered to the plant as a slug. Such an erratic regime of sediment delivery is difficult for most conventionally designed grit removal processes to accommodate.

9. If sewers are running nearly full or there are significant problems with excessive inflow and infiltration, a reduction in flow due to water conservation would be welcome.

It must be re-emphasized that the actual realization of benefits or added costs is dependent upon the treatment process configuration and degree of spare capacity at individual plants.

Introduction

The task of describing the effect of increased water conservation and its subsequent reduction of hydraulic loadings to sewage treatment plants is one of several being performed by the Interstate Commission on the Potomac River Basin (ICPRB) with funding support from Maryland Department of Natural Resources - Water Resources Administration under the general subject of freshwater inflows to the Chesapeake Bay. Most studies of reduced flows to sewage treatment plants concentrate on the relationship of flow to hydraulic capacity of the plant. The focus of this study is on the operational effects of both lower flow rates and the resultant higher pollutant concentrations. The findings described in this report will be useful in determining some of the secondary effects of water conservation, and of potential water quality as it affects the Chesapeake Bay.

Methodology

This task was accomplished by personal communication with waste water treatment plant operators in the State of Maryland, the District of Columbia, and nearby Virginia. Each offered a different perspective on the issue and gave their comments freely. This approach, via application and experience, is probably more practical for the purposes of this project than carrying out a literature search and developing a theoretical framework and numerical analysis. The breadth of material obtained in the responses of the plant operators justified this approach.

The selection of sewage treatment plants to be surveyed was based on the objective of covering a range of sizes and geographic locations in the area. Each of the plants was contacted directly, and discussions were held with the operators. A special effort was made to get information from the largest plants in the Baltimore and Washington, D.C. areas.

Findings

Although the focus of the study was to determine the impact of lower flows on the operation of sewage treatment plants, some interesting effects on sewage collection systems were offered. These merit mention prior to the discussion of the primary findings. Sewers are generally designed so as to meet several criteria which include: physical gradients such that a free atmospheric surface is maintained while at the same time sufficient depth and velocity are developed in order to mobilize and transport the silt and grit which finds its way into those sewers. Another, sometimes competing, constraint is the provision of the smallest (and therefore least cost) pipe which will accommodate the design flow.

It is possible that beyond some point, a reduction in flow would produce enough of an increase in the time-of-concentration that septic conditions would develop in the collection system. This negative impact would result in the production of hydrogen sulfide gas and difficult treatment conditions. Another potential draw-back of reduced flows might be the deposition of suspended material in the sewers, which during higher flows would be resuspended and delivered to the plant as a slug. Such an erratic regime of sediment delivery is difficult for most conventionally designed grit removal processes to accommodate. On the contrary, if sewers are running near to capacity or there are significant problems with excessive inflow and infiltration, a reduction in flow due to water conservation would be welcome.

The effects of lower influent flows on the operation of sewage treatment plants are qualitatively positive, negative or insignificant. A presentation of the positive impacts will be followed by the negative. In effect, however, the impact of lower flows is dependent upon a number of plant-specific features which include the type of treatment method, the operational flexibility of the plant, and the amount of unused capacity in the process facilities. Sewage treatment plants have operating capacity limits, outside of which effective treatment is difficult or impossible. Lower flows carrying the same load would result in higher concentrations of pollutants.

Larger plants usually incorporate a significant amount of activated sludge treatment. This method is inherently more flexible than the use of trickling filters. Lower flows would generally produce beneficial effects by increasing the detention time in the aeration tanks, and offset the higher concentrations of biochemical oxygen demand (BOD). Activated sludge treatment is a function of detention time and the amount of oxygen added to the process. An increase in detention time during aeration allows more biological activity and thus more treatment. If reduced flows brought about BOD concentrations which were too high, more air or oxygen would have to be blown in and the benefits of the longer detention time would be diminished. Most activated sludge plants have some flexibility in controling their processes by manipulating the delivery of air or oxygen, and/or by varying recirculation and diversion rates.

Another benefit of reduced flows would be in lower energy consumption. Most sewage treatment plants rely on pumping sewage into the plant and/or within the plant. Reductions in flow would diminish the operational cost required to lift the sewage. However, as with the biological unit processes, the effect of lower flows on energy consumption varies; it depends on the pump characteristics and configuration at each plant. Variable speed pumps would be operated differently from fixed speed pumps if presented with the same reduction in flow, and would produce different savings in energy use. If a plant is operating near to its hydraulic capacity, any reduction in flow is beneficial to the treatment efficiency, reduces by-passes and overflows, and delays physical expansion.

Larger treatment plants generally serve older and larger cities where sanitary and storm water flows are often combined. This condition produces large variations between wet and dry weather flows. Older sewer systems also generally have more infiltration through cracks and loosened joints. These conditions necessitate wide flexibility in the operation of such plants, and are likely to obscure any practicably obtainable reductions in flow due to water conservation. Thus, there are potential instances where marginally lower flows would produce no significant operational effects at a sewage treatment plant.

On the other hand, reduced influent flows are more likely to cause operational problems at smaller waste water treatment plants. The resultant longer detention times and higher pollutant concentrations might produce septicity in the primary sedimentation tanks. This would be undesirable due to the production of odor and subsequently more difficult treatment conditions. Smaller plants are more likely to use trickling filters than activated sludge as the main treatment process. These filters are less flexible in their operational capacity, and thus would be more susceptible to adverse impact due to lower flows and higher pollutant concentrations. In particular, operational flexibility and treatment efficiency are least during cold weather periods when biological activity is naturally slowest. At plants where the principal design parameter is pounds of BOD loading, a wide range of concentration can be accepted and treated without significant effects on the operation of such plants.

Some sewage treatment plants are being affected by reduced flows and higher pollutant concentrations due to improvements in the collection system. Many districts are actively pursuing programs of eliminating inflow and infiltration of non-sewage flows in order to extent the hydraulic capacity of the receiving plants. These programs have the same operational implications for sewage treatment plants as water use conservation measures.

Another potential problem may arise or increase for plants which receive a significant amount of industrial sewage containing toxic chemicals. Occasionally, the biological processes at a plant are knocked out by high concentrations of industrial chemical pollutants. At plants where this condition may occur, a reduction in sanitary sewage may serve to aggravate the situation. The nation-wide program to reduce toxic pollutants by industrial pretreatment is in part designed to reduce this negative impact on treatment plants.

The preceding discussion has catalogued the potential impacts of reduced influent flow on the operation of waste water treatment plants. It must be re-emphasized that the actual realization of benefits or added costs is dependent upon the treatment process configuration and degree of spare capacity at individual plants. For a quantitative analysis to be performed, the process specifications and present flow ranges at each plant would have to be obtained and operationally modeled. The results of such an analysis across the State, with appropriate costs, would provide a quantitative description of the effects of water conservation on the operation of sewage treatment plants.

References

The following individuals provided valuable insight to answering the question of the effects of reduced flows on the operation of sewage treatment plants.

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