The hydraulics of flow through trash screens: Are we doing the hole thing wrong?

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Abstract

Accurate methods for determining the maximum treatable flow rate (MTFR) and bypass capacity of trash screen devices are required to meet California Statewide Trash amendments and trash total maximum daily loads (TMDL) nationwide. The accuracy of these methods is becoming increasingly important with the impacts of climate change and flood risk.

A review of the current LA County methodology, which has become a proxy standard for hydraulic design in full trash capture certifications, raises concern that misuse of the methodology can overestimate the actual hydraulic capacity of screens. Regulators should have a design standard that sets out requirements for hydraulic calculations and testing methodologies for new and retrofit devices to ensure designs are correct and consistent.

This presentation sets out a comparison of various approaches using numerical and experimental methods. The four methods considered in the evaluation are: 1) calculating flow across a screen using the LA county method (single orifice method); 2) an integrated approach of individual orifices and driving head (multiple orifices and driving head method). 3) laboratory testing of screen capacity; 4) computational fluid dynamics (CFD) modelling of the screen and bypass capacity.

A common 5mm perforated steel screen was modelled using the single orifice method and the multiple orifices driving head method with the commonly used coefficient of discharge (Cd) value of 0.61. These methods gave varied results between approximately 3.0 CFS (8.4 l/s) and 1.0 CFS (2.8 l/s) for the same size screen, respectively. Laboratory testing was then carried out with the screen set in a flume. The screen was in both free discharge and submerged conditions. Lab testing found that the Cd value of 0.61 was unachievable, not linear and followed a logarithmic trajectory. This same apparatus was then modeled with CFD which realized close agreement with the actual lab data. Moreover, CFD found bypass capacities to be overestimated by 10-18%. These results demonstrate that the current method established by LA County can significantly overestimate hydraulic capacity if used out of context. The Cd for trash screens should always be empirically determined for geometry and flow rate.

The data also suggest that the overall hydraulics of a design need to be considered, and that the bypass capacity is not just dependent on the opening but also the overall system hydraulics and catch basin geometry. The ASTM trash testing standard (E 3332-23) is useful for testing smaller units but perhaps large units could be modelled with CFD to better understand how the treatment flow and bypass interact with catch basin geometry.

Climate change is upon us. More intense and prolonged rainfall events mean improved design standards are warranted to ensure flood prevention. If this threat is not addressed the implications of not meeting the TMDLs due to insufficient hydraulic treatment capacity and localized flooding due to inadequate bypass capacities could raise questions about liability for regulatory bodies and manufacturers. This study calls for a reevaluation of design methodologies for trash screen devices and a set of guidelines for the design and testing of these products.