The Los Angeles River Environmental Flows Project: Managing Trade-offs in Water Reuse and Ecosystem Services

J. Wolfand, Ph.D., P.E.[1*], A. Sytsma, Ph.D.[2], Philippus, D.[2], Taniguchi-Quan, K., Ph.D.[2], Abdi, R., Ph.D., P.E.[2,4], Gallo, E.[2], Irving, K., Ph.D.[3], Rogers, J.B., Ph.D.[3,5], Stein, E.D., Ph.D.[3], Hogue, T.S., Ph.D.[2]

[1]*Shiley School of Engineering, University of Portland, Portland, OR, USA*
[2]*Civil and Environmental Engineering, Colorado School of Mines, Golden, CO, USA*
[3]*Southern California Coastal Water Research Project, Costa Mesa, CA, USA*
[4]*US National Center for Atmospheric Research, Boulder, CO, USA*
[5]*Neponset River Watershed Association, Canton, MA, USA*
**Corresponding author email: wolfand@up.edu*

Highlights

- Functional flow metrics were calculated based on a calibrated hydrologic model for the LA River watershed, and show existing conditions support ecologic indicators and recreational uses.
- Wastewater reuse scenarios indicate limited opportunities exist for reductions in discharge of treated wastewater without impacts to beneficial uses, especially during dry weather.
- Channel restoration can offset some of the negative impacts of increased wastewater reuse for indicator species.

Introduction

Flows in urban rivers should be managed to support water supply needs while also protecting and/or restoring instream ecological functions, goals that are often in opposition to each other. Effluent-dominated rivers pose a particular challenge as any changes in effluent discharge may impact river ecology. While there are numerous success stories of wastewater recovery and reuse, management decisions for water supply and environmental flows are often made independently of one another, and there is a critical need for tools and approaches to balance potentially competing goals of reuse and supporting ecological communities. The majority of studies on effluent dominated streams focus on water quality and stream temperature issues, and very few studies are focused on flow management applications (Hamdhani et al. 2020).

Existing approaches for managing environmental flows in effluent-dominated rivers typically consist of limiting withdrawals to a fixed proportion of the natural flow regime. This approach may maximize water for reuse but may not guarantee that ecological objectives can be achieved (Richter et al., 2012). A *functional flows* approach offers a more holistic method that accounts for the complexity and variability of flow over space and time and aims to protect overall ecological integrity with the flexibility for water reuse during optimal times of the year. A functional flows approach focuses on identifying discrete aspects of the annual hydrograph that have documented relationships with ecological, geomorphic, or biogeochemical processes in riverine systems (Yarnell et al., 2015).

Using the Los Angeles (LA) River as a case study, we assess the relationship between wastewater discharge and functional flow metrics, which we then use to evaluate the impact of reduced wastewater discharge on aquatic life and recreational uses within the river. The specific research questions addressed in this study are: (1) how sensitive are functional flows in the LA River to changes in wastewater discharge? (2) what is the impact of wastewater reuse and stormwater capture on aquatic life and recreational uses in the river? and (3) to what extent can channel restoration offset these flow reductions?

Methodology

The methods used for this study are based on the coupling three models: (1) a hydrologic model of the LA River watershed; (2) a hydraulic model of the LA River and major tributaries; and (3) an ecological model. Baseline condition models were calibrated and validated under existing conditions. The baseline condition models were then altered to simulate the impact of water reuse and flow reductions and channel restoration.

Baseline conditions

A hydrologic model was created in EPA SWMM for the LA River watershed with an hourly time step from WY 2011 to 2017. The model was calibrated from WY 2011 to 2013 and validated from WY 2014 to 2017 at 7 gaged locations throughout the watershed (4 on the mainstem, 3 on tributaries). A hydraulic model was created by combining existing HEC-RAS models for the river and updating channel geometry and Manning's roughness based on field observations. The hydraulic model was run under steady state conditions and produced rating curves linking discharge to velocity, channel depth, and shear stress.

Priority focal habitats and endmember species that represent a range of tolerances for each habitat were identified using observational data from the LA region. "Flow-ecology" curves relating key hydrologic and hydraulic conditions to the probability of occurrence, or the probably of being able to complete specific life-history requirements, were then created for each focal species.

Water re-use scenarios

Potential wastewater discharge scenarios were generated using a Monte Carlo approach. Historic discharge timeseries from the wastewater treatment plants from WY 2011 to 2017 were randomly scaled by 0 to 100%. In addition, 100% and 50% reduction of dry-weather stormdrain discharge scenarios were simulated. Discharge was evaluated at 12 reporting nodes along the mainstem to evaluate the impact of reduced wastewater discharge on recreation and aquatic life. Functional flow metrics, such as dry-season baseflow magnitude and wet season timing, were determined using the Functional Flows Calculator API client package in R (version 0.9.7.2, https://github.com/ceff-tech/ffc_api_client).

Using the results of the hydrologic modelling for a range of treatment plant discharge and stormwater reuse conditions (i.e., 0%, 25%, 50%, 75%, and 100% reduction in discharge) for wet and dry seasons, the hydraulic model was used to simulate the effects of in-stream and riparian restoration alternatives, including reshaping of low flow channels, terraces banks, and changes to channel bed material. The potential for these restoration alternatives to offset negative impacts to indicator species was evaluated by comparing the results to two thresholds: (i) baseline condition velocity, channel depth, and shear stress; and (ii) ideal velocity, channel depth, and shear stress for existing and potentially supported species.

Results and discussion

Sensitivity curves that relate potential changes in treated wastewater discharge to changes in functional flows show that a 4% decrease in current treated wastewater discharge may negatively impact habitat for indicator species during the dry season (Figure 1). More opportunity exists for wastewater reuse during the wet season, when current treated wastewater discharge may be reduced by 24% with minimal impacts to ecology and recreation. Initial results show that in-stream restoration (e.g., low flow channel modification, changes to channel substrate) has the potential to offset some of the negative impacts of increased wastewater reuse for indicator species during the dry and wet seasons.

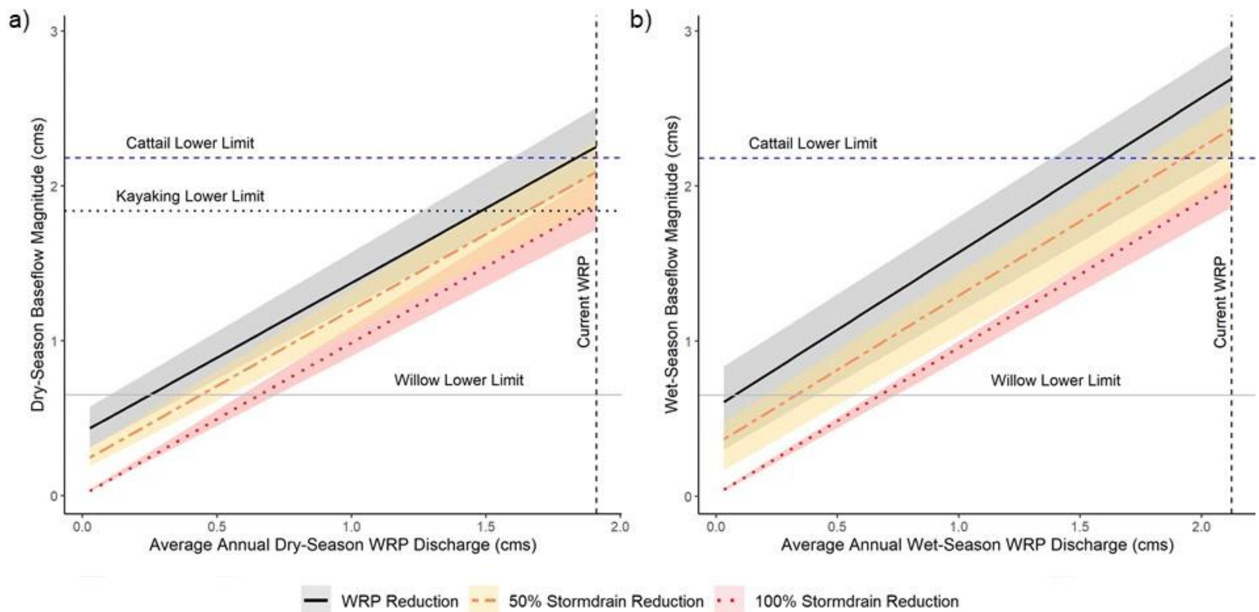

Figure 1. Sensitivity curves at Glendale Narrows for dry-season (a) and wet-season (b) baseflow magnitude. The black line represents the median baseflow magnitude calculated across the simulation period. The yellow dashed line shows median baseflow under 50% dry-weather stormdrain reduction, and the red dotted line shows median baseflow under 100% dry-weather stormdrain reduction. The bands represent the 90th to 10th percentile of baseflow magnitude. Current average annual WRP discharge in the dry-season and wet-season are 1.91 and 2.12 cms, respectively.

Conclusions and future work

We developed hydrologic, hydraulic, and ecology models of the LA River basin to investigate how changes in wastewater reuse, stormwater management, and in-channel habitat restoration impact river flows and subsequently the viability of ecosystems and beneficial uses in the river. The developed approach has potential to inform similar tradeoff decisions in other urban rivers where flows are dominated by wastewater or storm drain discharge.

References

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