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Analytical estimates of hydraulic parameters for an urbanized estuary — Flushing Bay

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Summary Prediction of water quality improvements in urban estuaries is an urgent priority for decision making about alternative mitigation measures, especially in the context of changing pollutant loadings and freshwater discharges. Flushing Bay, an embayment of the New York—New Jersey Harbor Estuary, is a ''short'' estuary (a special class of coastal plain estuary with specific geometric characteristics), in which source loading is changing and little is known about resultant mixing processes and characteristics. First-order values of longitudinal dispersion coefficient, tidal excursion and tidal prism for this estuary have been estimated from non-synoptic salinity data using an adaptation of a one-dimensional theoretical salinity intrusion model. Results indicate that ranges of longitudinal dispersion coefficient are highly dependent on estimates of groundwater discharge, and the spatial distribution of salinity and dispersion coefficient values is most sensitive to conditions at low water slack (LWS). These findings represent a starting point for further investigation of either groundwater discharge to the bay using numerical modeling or field studies of longitudinal dispersion coefficient and mixing using sophisticated tracer methods.

Introduction

Water quality is of paramount concern in large urban estuaries where wastewater has been discharged for many decades (Garcia-Barcina et al., 2006; Jeng et al., 2005). Traditional contaminant sources from industrial and urban sewage and stormwater are being reduced due to more stringent regulation. As treatment technologies have improved, the sources and overall quality of water discharging to these receiving bodies are changing. Numerical simulation of coastal circulation in bays and estuaries is often used to anticipate future trends in water quality, and requires an understanding of the principal hydraulic parameters controlling mixing, such as the coefficient of dispersion, tidal excursion and tidal prism. Although dispersion coefficients can also be estimated using large-scale tracer experiments (Caplow et al., 2003; Ho et al., 2002), these experiments are logistically complex and time consuming. However, the spatial and temporal distribution of salinity in an estuary, even when sampled non-synoptically, contains information on circulation and mixing that can be applied to other

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substances in estuarine waters, such as contaminants that degrade water quality.

Here, an adaptation of the theoretical salt intrusion model developed by Savenije (1989, 1993a, 2005) for alluvial estuaries has been applied to salinity data in order to constrain estimates of these parameters for Flushing Bay, an embayment of the New York—New Jersey Harbor Estuary adjacent to New York City (Fig. 1). Since the magnitude of freshwater discharges (in this case, groundwater) to estuaries is linked to the variation in salinity, preliminary discharge values from numerical simulation and field measurement are used to estimate ranges of longitudinal dispersion. Flushing Bay is a one of a particular class of estuary, a ''short estuary'' similar to that described by Wright et al. (1973) to which this method is not believed to have been applied. The extension of Savenije's (2005) method described here presents some innovations which may be crucial to understanding the circulation in this type of estuary. Specifically, the cross-sectional area assumed for the shallow Flushing Bay differs significantly between high and low tide, which required a modification of the method. Furthermore, rather than calibrating the model to measurements of salinity at specific equilibrium times during the tidal cycle, the approach used here is to fit envelope curves to the non-synoptic field data. Yet, despite these relaxations of the assumptions of the theoretical framework, the model is shown to be useful for deriving important tidal mixing parameters, demonstrating its robustness.

Flushing Bay discharges into the East River (ER) which separates the island of Manhattan from Long Island, and is a tidal strait that connects western Long Island Sound (WLIS) to the Atlantic Ocean through New York Harbor. Flushing Bay is the westernmost and historically the most contaminated of several embayments on the north shore of Long Island (Fig. 1). Prior to the 20th century urbanization of the watershed when LaGuardia International Airport was built extending into the bay, it was fed by a stream, Flushing Creek, of which the remnant is now just a narrow extension of the southern end of the Bay. The ER-WLIS system has had a large historical contaminant loading (IEC, 2002) from 18 municipal water pollution control plants (WPCP) and dozens of combined sewage overflow (CSO) discharge points. Flushing Bay has long been the receiving waters for 14 of these CSO outfalls (Fig. 1) from which the fate and transport of CSO particulates has been tracked (Fugate and Chant, 2006) on at least one occasion.

Hydrologic setting

Nevertheless, the water quality in Flushing Bay is likely to improve considerably over the next few years because of a combination of less wastewater input due to increasing regulation, and more groundwater discharge due to changing water supply and aquifer conditions in the surrounding borough of Queens.

New York City Department of Environmental Protection (NYCDEP) is making major infrastructure investments in large-capacity retention facilities under a consent agreement with the US Environmental Protection Agency to reduce storm event CSO overflows into the NY—NJ Harbor

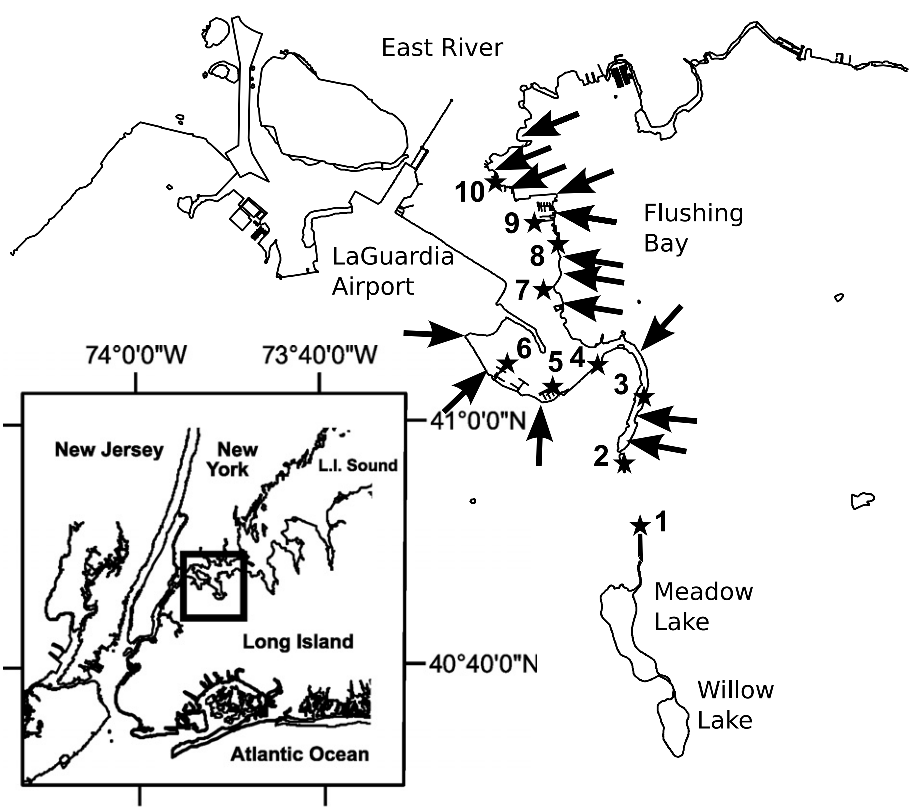

Figure 1 Location map of Flushing Bay in the New York—New Jersey Harbor Estuary. Numbered stars indicate field sampling sites, and small arrows indicate combined sewage overflow (CSO) discharge points.