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Stability of a Tidal Marsh Under Very High Flow Velocities and Implications for Nature-Based Flood Defense

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Nature-based strategies, such as wave attenuation by tidal marshes, are increasingly proposed as a complement to mitigate the risks of failure of engineered flood defense structures such as levees. However, recent analysis of historic coastal storms revealed smaller dike breach dimensions if there were natural, high tidal marshes in front of the dikes. Since tidal marshes naturally only experience weak flow velocities (~0-0.3 ms^{-1} during normal spring tides), we lack direct observations on the stability of tidal marsh sediments and vegetation under extreme flow velocities (order of several ms^{-1}) as may occur when a dike behind a marsh breaches. As a first approximation, the stability of a tidal marsh sediment bed and winter-state vegetation under high flow velocities were tested in a flume. Marsh monoliths were excavated from *Phragmites australis* marshes in front of a dike along the Scheldt estuary (Dutch-Belgian border area) and installed in a 10 m long flume test section. Both sediment bed and vegetation responses were quantified over 6 experimental runs under high flow velocities up to 1.75 ms^{-1} and water depth up to 0.35 m for 2 hours. These tests showed that even after a cumulative 12 hours exposure to high flow velocities, erosion was limited to as little as a few millimeters. Manual removal of the aboveground vegetation did not enhance the erosion either. Present findings may be related to the strongly consolidated, clay- and silt-rich sediment and *P. australis* root system in this experiment. During the flow exposure, the *P. australis* stems were strongly bent by the water flow, but the majority of all shoots recovered rapidly when the flow had stopped. Although present results may not be blindly extrapolated to all other marsh types, they do provide a strong first indication that marshes can remain stable under high flow conditions, and confirm the potential of well-developed tidal marshes as a valuable extra natural barrier reducing flood discharges towards the hinterland, following a dike breach. These outcomes promote the consideration to implement tidal marshes as part of the overall flood defense and to rethink dike strengthening in the future.