# A look under the hood of EMOVER

## Description of the model in EMOVER, a visual estuary management simulation tool


March 2015

# Introduction

**EMOVER is an estuary management simulation game. It was built as part of the international Interreg North Sea Program IVb project EMOVE with the purpose to let people that are interested or involved in estuary management get a grasp of the complexity of managing an estuary. More information about EMOVE can be found on http://www.emove-project.eu. On this website, links are provided to the game itself.**

Under the hood of the simulation is a simple model at work that calculates effects caused by changes in estuarine management. This model is based on a number of calculation rules that are very crude simplifications of the knowledge we have of an estuary with multiple channels, shoals, an inland port and embankments along all its banks. The majority of them is based on a few discussions with M. Taal, expert Coastal and estuarine policy and management at Deltares. These rules are described in this short document.

# List of calculation rules

1. The estuary is divided into seven sections. The lower five sections all have a main (shipping) channel, a secondary channel and a tidal flat. The upper (most upstream) two sections only have one channel.
2. Marshes are connected to and are, in the calculations, regarded as part of the neighbouring sections, like many sills are in a multiple channel system.
3. Dredging locations are positioned halfway between two sections. Dredged sand is extracted in equal amounts from both sections.
4. Sand mining is solely positioned in secondary channels. Mining increases water volume.
5. Locations for deposition of sand are situated in main channels and in secondary channels. The latter are situated either close to tidal flats or in the deeper parts. Deposition of sand decreases water volume.
6. All channels have an equilibrium water volume and all tidal flats have an equilibrium height.
7. The equilibrium height of tidal flats is relative to actual high water levels. Therefore, tidal flats have the tendency to grow upward when sea level rises, as their equilibrium height rises accordingly.
8. Before the simulation starts, 50 years of constant initial dredging, deposition and sand mining are calculated to bring the estuary into a state where channels and flats are out of equilibrium. This is done to reflect long term human influence.
9. Once in every (simulated) year, the simulation calculates sand transport between channels, flats and marshes. The amount of transport depends on relative divergence from equilibrium state.
10. The simulation runs for 200 years. In reality, over such a long period of time, changes in large scale morphology (i.e. position of tidal channels and flats) would take place. These are not part of the simulation.
11. No sand is transported over the upstream and downstream limits of the estuary. No sand is imported from the ebb tidal delta, even when sea level rise causes a sand shortage.
12. Sand transport rates increase when relative divergence from equilibrium increases. Sand moves from places with a relative surplus to places with a relative shortage.
13. Growth of tidal marshes depends on the difference between the height of the marshes and high water level. Each year marshes grow with a set percentage of this difference. 10% of the sediments gets extracted as sand from the neighbouring section, the other 90% is mud that does not influence estuary sand balance and transport.
14. The tidal range at the seaward edge of the estuary is constant over the simulation.

15. The estuary is subject to increased sea level rise. The rates are:
    a. 0.2 m/100yr from 2000-2050,
    b. 0.4 m/100yr from 2050-2100,
    c. 0.6 m/100yr from 2100-2150,
    d. 0.8 m/100yr from 2150-2200.

    These rates are small compared to official IPCC scenario’s. These smaller rates were chosen because the influence of sea level rise would otherwise dominate changes in the estuary that are caused by the player’s estuarine management.
16. Inside the estuary, the tidal range is amplified. Amplification is based on
    a. the water volume of the main channel (increased amplification with increased water volume),
    b. the presence of tidal marshes in each section and the height of these marshes. Big, low marshes dampen amplification whereas small, high marshes do not.
17. Salt water intrusion in the estuary depends on tidal amplification: higher amplification means further intrusion, although in reality the fresh water discharge is likely to be the most influencing factor.
18. Converting marshes into polders increases overall dike length, based on the actual shape of the polder. Converting polders into marshes has the opposite effect.
19. Polders that are low relative to high water levels experience salinization because of salt water seepage. Salinization increases with height difference, water salinity and dike length.
20. Polders that previously were marshes, derive their height from the marshes just before they were converted.

All these rules were tuned and matched together in such a way that trends and speed of changes seemed acceptable for the purpose of the simulation: to provide a visual tool to get a grasp of the way management decisions are connected to all kinds of functions, in the short and in the long run. The simulation should not be used to take real management decisions.