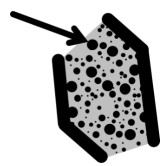# Harbour Siltation

Introduction & summary

This tool calculates the yearly siltation inside the harbour basin based on the theory of Van Rijn (Harbour siltation and control measures, 2012). The tool uses tidal characteristics (mean high water MHW, mean low water MLW and ebb/flood flow velocities) and harbour characteristics (Total surface area, entrance width and entrance configuration) to calculate the exchanged volumes of water and suspended sediment, variable concentrations and the yearly sedimentation within the harbour basin.

Default values for input parameters are presented in the long descriptions (place your mouse on input parameter name).

Measurements from reference projects reported in Van Rijn (2012) show the following typical range of yearly siltation (m sediment thickness):

| Salt/brakish conditions	Lower range	Upper range
Harbour basin	1.0 m	2.0 m
Harbour entrance	2.0 m	5.0 m
Fresh conditions	**Lower range**	**Upper range**
Harbour basin	0.3 m	0.4 m
Harbour entrance	1.0 m	3.0 m

How to use the tool

1. Open a new project

2. Start in Generic Data by defining a Bathymetry or Coastline in combination with a Cross-shore profile (slope), a Wave climate, Vertical and Horizontal Tidal characteristics and sediment characteristics

   Please note: Only the wave climate and not the extreme wave climate is considered in the calculation.

3. Under "Structures", draw a polygon element of type "Harbour Basin" covering the complete wet area of the harbour in open connection with the sea
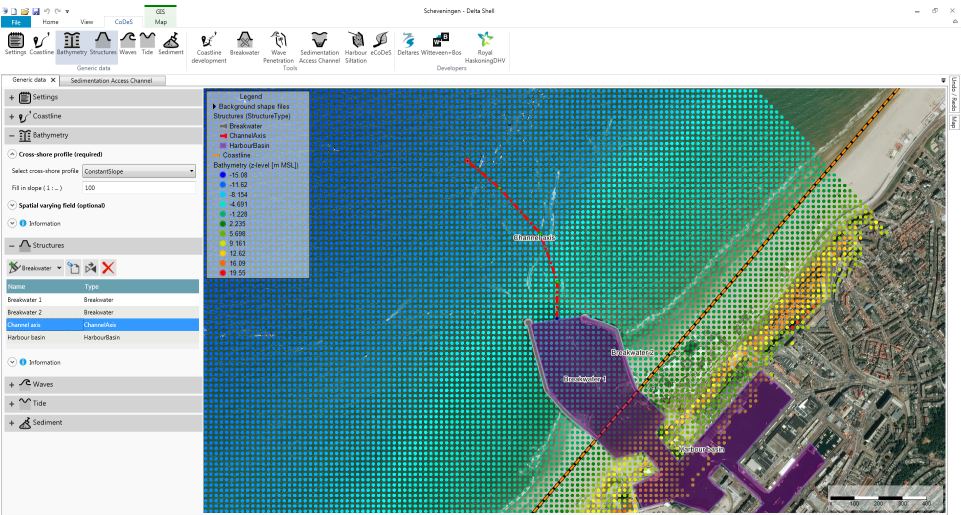
4. Open the Harbour Siltation tool

5. Provide input according to the user input field descriptions below.
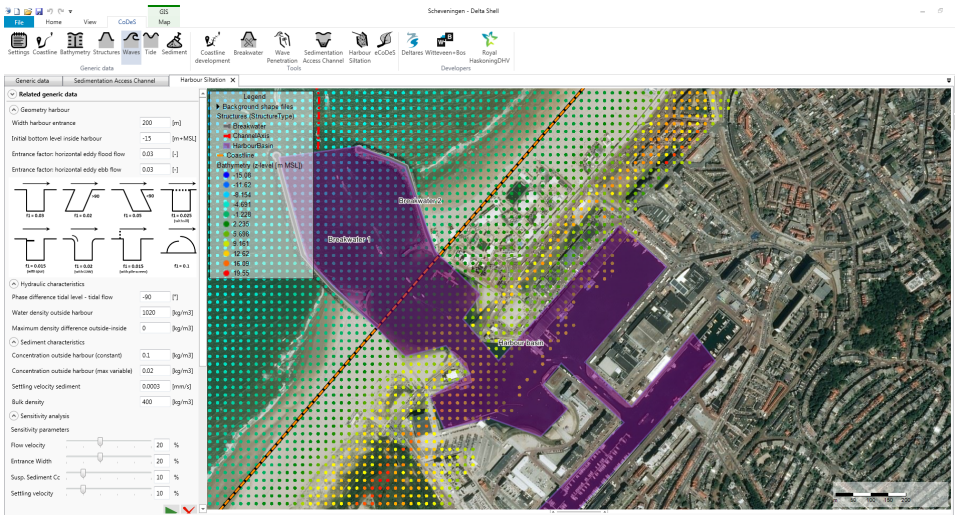
The horizontal eddy exchange volume depends strongly on the shape of the harbour entrance compared to the tidal flow direction/velocity. This factor needs to be given by the user (default = 0.03). The figure below helps to define this factor.
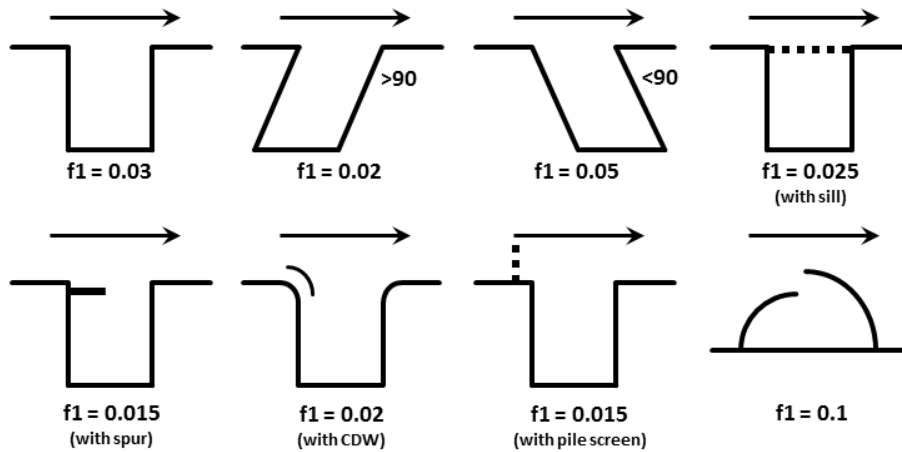
6. Press the 'play' button to start the Harbour Siltation calculation

7. After the calculation, four subwindows are shown below the map which hold the following information:

   a. **Tidal conditions outside of harbour**

      This plot shows the Tidal water level [cm+MSL] and the Tidal Current Velocity [cm/s] over 2 tidal periods. Time series of tidal water level and current velocity are based on the input data from Generic Data: tidal water level based on "MHW" and "MLW" and tidal current velocity based on "Maximum ebb flow" and "Maximum flood flow". The input "Phase difference tidal level-flow" will define the time difference in phasing.
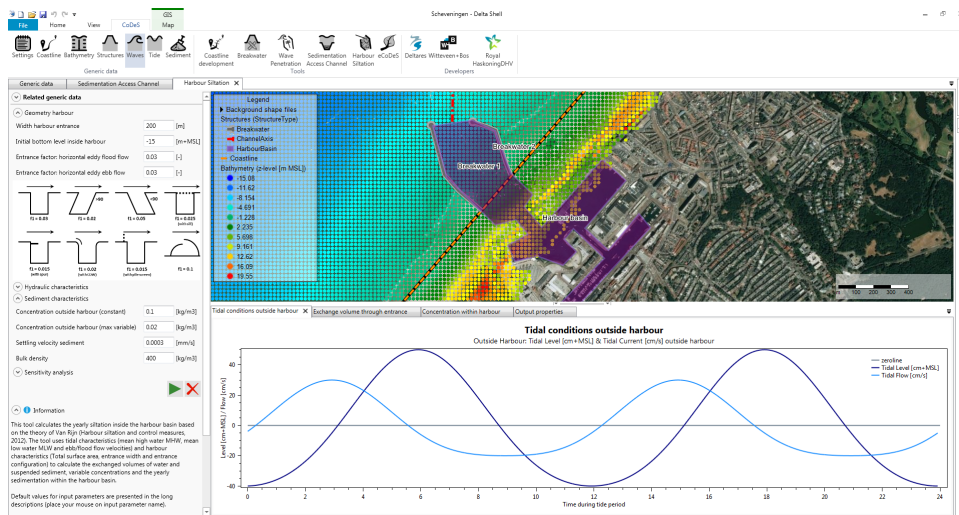
b. **Exchange volume through entrance**

This plot shows the total exchange flow through the entrance of the harbour during two tidal cycles. It presents the total exchange due to changes in tidal water levels (dark blue), the exchange volumes due to horizontal eddies caused by tidal flow along the harbour entrance (blue) and the additional exchange caused by salinity differences outside-inside (light blue). The latter two exchange volumes are only presented in positive values.
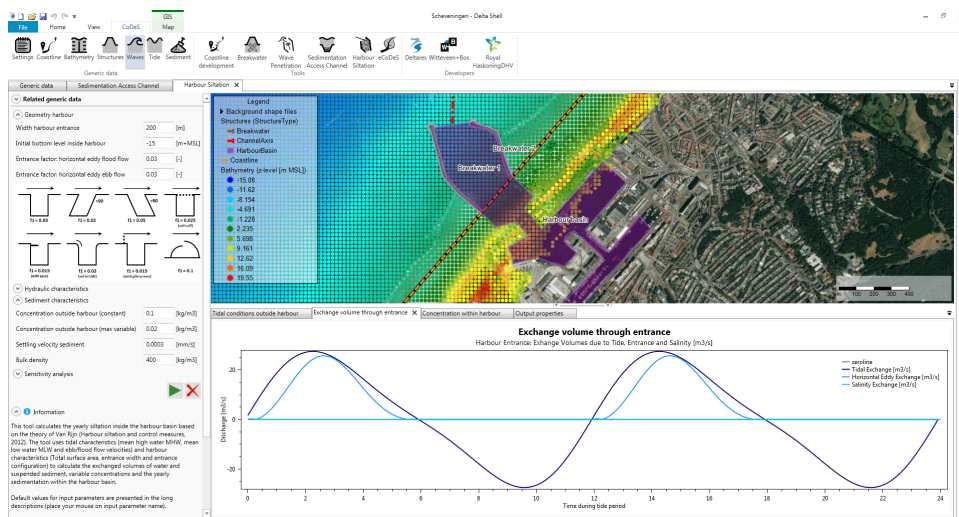

c. **Concentration inside harbour**

This plot shows the average suspended sediment concentration outside and inside the harbour over the duration of 2 tidal cycles.
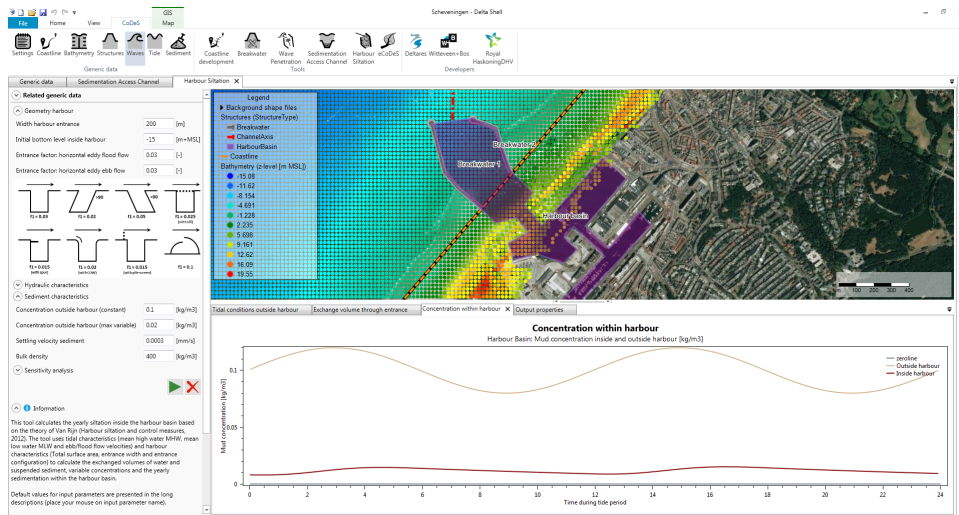
d. **Output properties**

This panel shows a summary of the input parameters and total tidal exchange volumes in combination with total yearly sedimentation layer thickness and sedimentation volume. The last column presents the results from the sensitivity analysis for each of the included parameters. A comparison of the thickness of the final sedimentation layer and yearly sedimentation volumes are presented here.
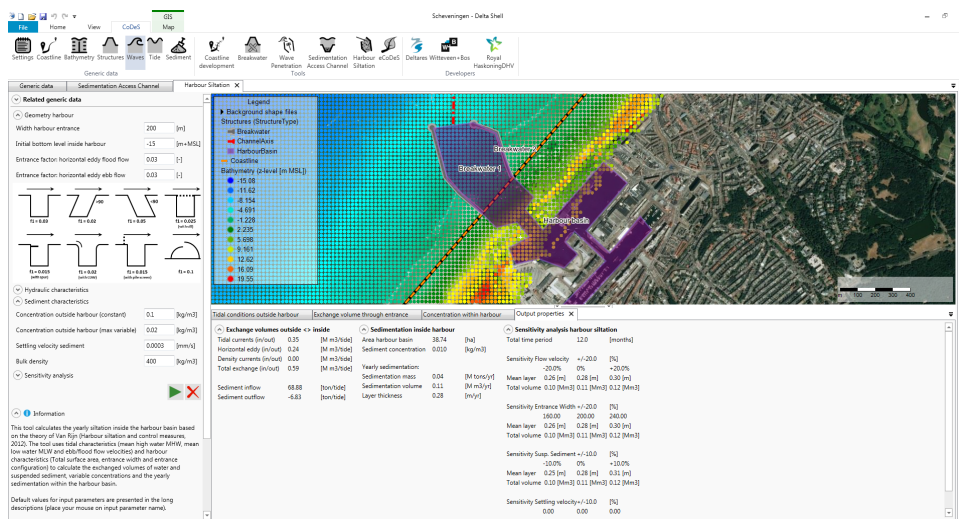
User input fields

A number of user input fields are provided which can be used to adjust the calculation according to the local situation. Default values are provided for each input field. The following inputs are defined:

Geometry harbour

	Default Value	Unit	Min.	Max.	Brief Description
Width harbour entrance	200	m	0	1000	Width of the harbour entrance (distance between breakwaters).
Initial bottom level inside harbour	-15	m+MSL	-50	-0.5	Level of bottom of harbour (constant).
Entrance factor: horizontal eddy flood flow	0.03	-	0	0.25	Entrance factor inducing horizontal eddy during flood flow.
Entrance factor: horizontal eddy ebb flow	0.03	-	0	0.25	Entrance factor inducing horizontal eddy during ebb flow.

Hydraulic characteristics

	Default Value	Unit	Min.	Max.	Brief Description
Phase difference tidal level-flow	-90	°	-360	360	Phase difference in tidal level versus tidal flow. In case of 0° flow velocity is peaking together with the maximum water level.
Water density outside harbour	1020	kg /m3	500	2000	Density of water outside harbour.
Maximum density difference outside-inside	0	kg /m3	0	100	Maximum density difference between outside and inside the harbour. Water density inside harbour will be lowered with this value.

Sediment characteristics

	Default Value	Unit	Min.	Max.	Brief Description
Concentration outside harbour (constant)	0.1	kg/m3	0	10	Constant mud concentration outside harbour
Concentration outside harbour (max variable)	0.02	kg/m3	0	10	Maximum variable mud concentration outside harbour
Settling velocity sediment	0.0003	m/s	0	1	Settling velocity of suspended sediment (silt/clay)
Bulk density	400	kg/m3	0	3000	Bulk density after sedimentation of sediment (silt/clay)

Sensitivity Analysis

	Default Value	Unit	Min.	Max.	Brief Description
Sensitivity parameter: Flow velocity	0	%	0	50	Possible change or uncertainty in Flow velocity
Sensitivity parameter: Entrance Width	0	%	0	50	Possible change or uncertainty in Entrance width harbour
Sensitivity parameter: Susp. Sediment Concentration	0	%	0	50	Possible change or uncertainty in Suspended Sediment Concentration
Sensitivity parameter: Settling velocity	0	%	0	50	Possible change or uncertainty in Settling velocity sediment

Tool limitations

The main limitation of this tool is that both hydrodynamics and harbour are strongly simplified. Simplifying the harbour to one unit results into an average concentration and average sedimentation over the complete area of the harbour. Both concentration and sedimentation will differ significantly over the total harbour.

Example cases

The following files (.dsproj) can be downloaded and loaded into CoDeS to serve as examples. They are not based on actual projects, but are intended as illustration.

Unzip the files to an convient folder (but make sure the file structure does not change), and open the .dsproj file from within CoDeS.

example.zip