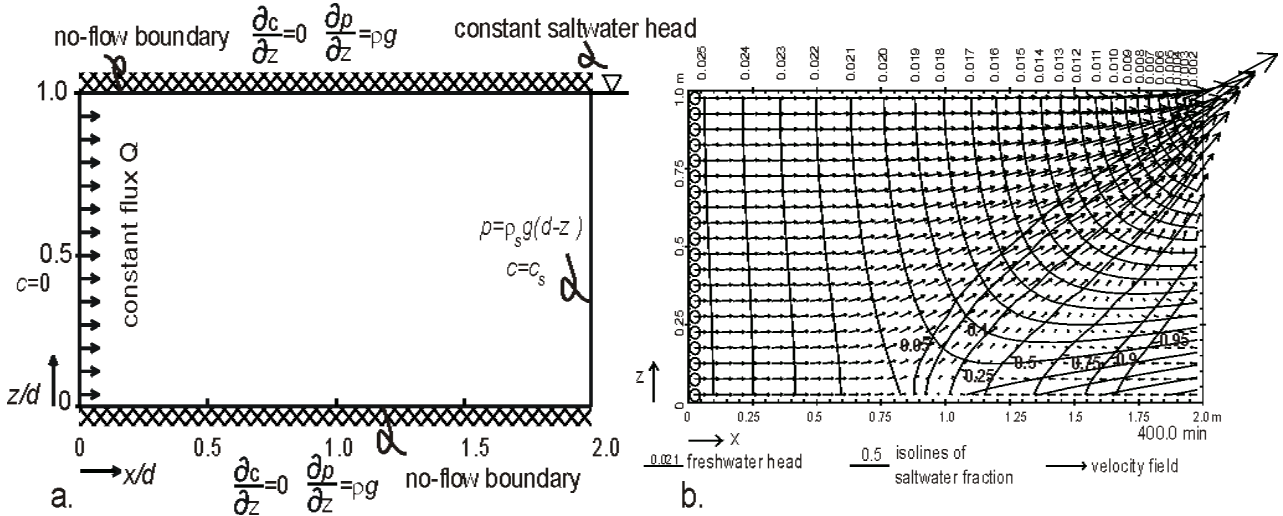


# Henry's case: Biscayne aquifer, Florida USA

Variable-density groundwater flow modelling with SEAWAT

Location model: <https://publicwiki.deltares.nl/display/FRESHSALT/Download>



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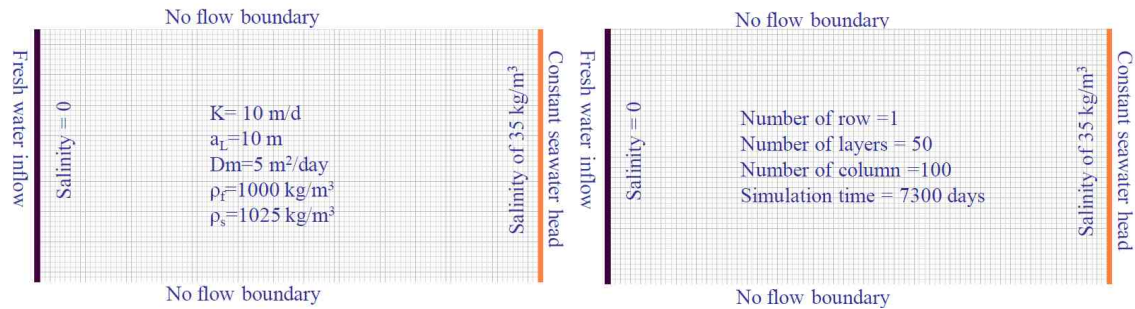
## Introduction

Henry's problem addresses the steady-state solution of a diffused saltwater wedge within a confined aquifer. Fresh water enters the confined aquifer at a constant rate from inland boundary and discharges into coastal boundary. Saltwater from the coastal boundary advances and mixes with the discharging fresh water.

The profile (cross-section) of Henry's case contains an aquifer with thickness=500m and length=1000m. In the table below, you see the parameters.

Parameters			
Layers	50	$K_{hor}$	10 m/d
Rows	1	Anisotropy $K_{hor}/K_{ver}$	1
Columns	100	Eff. porosity $n_e$	0.35
$\Delta x$	10 m	$\alpha L$	10.0 m
$\Delta y$	1 m	$\alpha T$	1.0 m
$\Delta z$	10 m	Moleculair diffusion	5 m <sup>2</sup> /d
Stress period	1	Specific storage	0.0001
Length of time	7300 days	Salinity seawater	35 kg/m <sup>3</sup>
		Buoyancy	0.025

## Overview boundary conditions of the model



### Step 1 Numerical model grid

- (1) Mesh size:
  - a. Number of layers=50; Model thickness=500m; Model top elevation=500m
  - b. Number of rows=1; Model extent=1m
  - c. Number of columns=100; model extent=1000m
  - d. Vertical exaggeration=1
- (2) Layer property
  - a. All layers=confined
- (3) Boundary (IBOUND-MODFLOW)
  - a. Cell values = 1 (active) for columns 1 to 99
  - b. Cell values =-1 (constant head) for column=100
- (4) Boundary (ICBUND-Transport models)
  - a. All cell values=1 (active)
- (5) Top elevation
  - a. Layer 1=500m; ....., layer 50=10m
- (6) Bottom elevation
  - a. Layer 1=490m; ...; layer 50=0m

### Step 2 Parameters

- (1) Time:
  - a. Time unit=days
  - b. Simulation=transient
  - c. Stress period=1
  - d. Period length=7300 days
  - e. Number of time steps=730
- (2) Initial hydraulic heads
  - a. All cells=1m
- (3) Horizontal hydraulic conductivity
  - a. All cells=10m/d
- (4) Vertical hydraulic conductivity
  - a. All cells=10m/d
- (5) Specific storage
  - a. All cells=0.0001m
- (6) Effective porosity
  - a. All cells=0.35

### Step 3 MODFLOW packages

- (1) Well
  - a. Injection rate at all cells in the first column = 1 m<sup>3</sup>/d to simulate inflow from east boundary

- (2) Solver package
  - a. PCG2

#### **Step 4 MT3DMS/SEAWAT packages**

- (1) Simulation settings
  - a. Species: Salt
  - b. SEAWAT (default)
- (2) Initial concentration
  - a. All cells =0
  - b. Cells in the last column=35kg/m<sup>3</sup> for seawater
- (3) Advection
  - a. Use default
- (4) Dispersion
  - a.  $\alpha_T/\alpha_L=0.1$
  - b.  $\alpha_L=10\text{m}$  for all cells
- (5) Species dependent diffusion
  - a.  $D_m=5\text{m}^2/\text{d}$  for all cells
- (6) Sink/Source concentration
  - a. Constant head cells: Salt=35 kg/m<sup>3</sup>; (other cells: Salt=0)
  - b. Well: salt=0
- (7) Solver
  - a. GCG
- (8) Concentration observations
  - a. OBS1: x=795m, y=1m, layer=35
  - b. OBS1: x=845m, y=1m, layer=40
  - c. OBS1: x=995m, y=1m, layer=44
- (9) Output control
  - a. Output times: minimum=365; maximum=7300 with interval=365

#### **Step 5 Please place the model in a directory with the name 'hen01', and run the models**

- (1) Run MODFLOW
- (2) Run SEAWAT (takes ~2 minutes)

#### **Step 6 Presentation of model results**

- (1) Contour map of salt concentrations
- (2) Break-through curves
- (3) Animate evolution of mixing

#### **Step 7 Implement a shallow groundwater extraction well in the coastal zone, 250m from the sea.**

Copy the old model to a new one in another subdir (!) and rename this model  
What are the effects?

#### **Step 8 Insert a measure to reduce salt water intrusion**

Copy the old model to a new one in another subdir (!) and rename this model  
What could be measures, what do you expect and are the effects?

#### **Step 9 Due to climate change it is getting drier. The freshwater inflow flux is 30% less**

Copy the old model to a new one in another subdir (!) and rename this model  
Reduce in Models, Flow Packages, Wells the rate of all wells with 30%. What are the effects?