

# PIANC



## The World Association for Waterborne Transport Infrastructure

### Salinity and Locks

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**PIANC Workshop**  
**15-16th October 2009**

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## Salinity and Locks

Innovations in Navigation Lock Design  
Brussels 15-17/10/2009  
Marc Sas



1. Salinity and nautical aspects
2. Salinity and the environment
3. Salinity and sedimentation
4. Mitigating measures

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## 1. Salinity and nautical aspects

- Salinity differences causes density currents
- Major phenomena :
  - Spilling (leveling of the chamber)
  - Exchange current (opening of the doors)
- They have impact on the navigation :
  - What you see is NOT what you get
  - Asymmetric flow distribution in the tail bay/ access channel of the lock
  - Increased hawser forces

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## 1. Salinity and nautical aspects



Spill in East Tail bay (Miraflores Locks – Panama)

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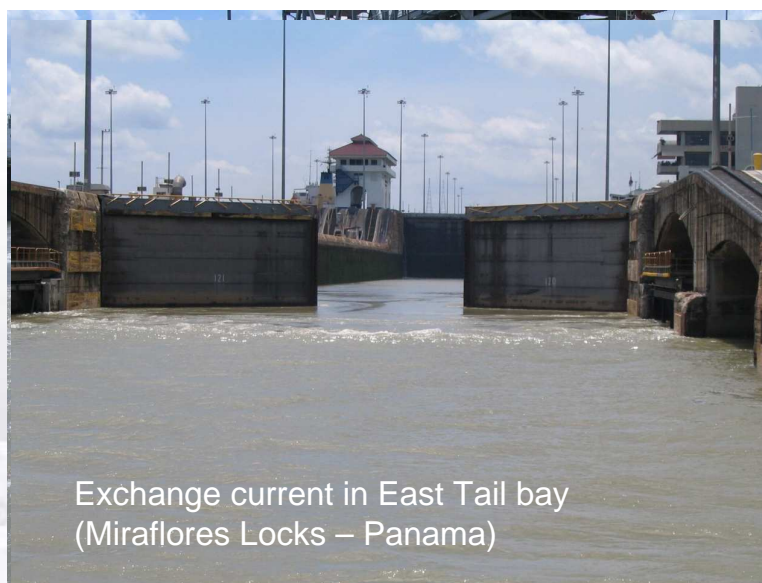
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## 1. Salinity and nautical aspects



Exchange current in East Tail bay (Miraflores Locks – Panama)

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## 1. Salinity and nautical aspects

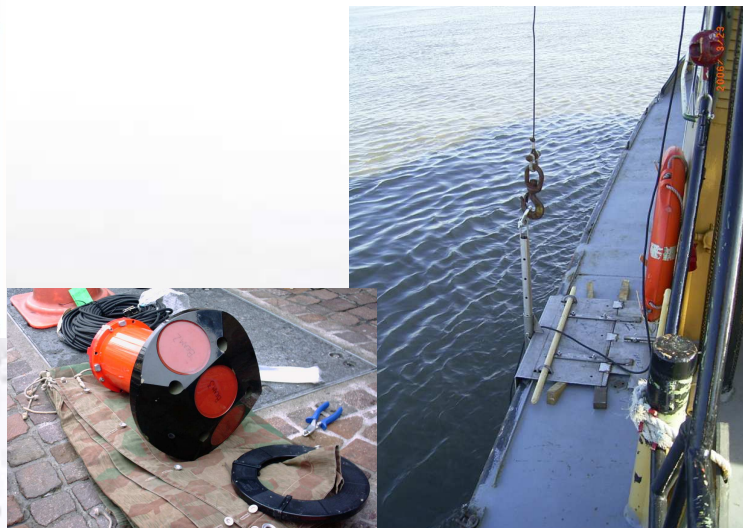
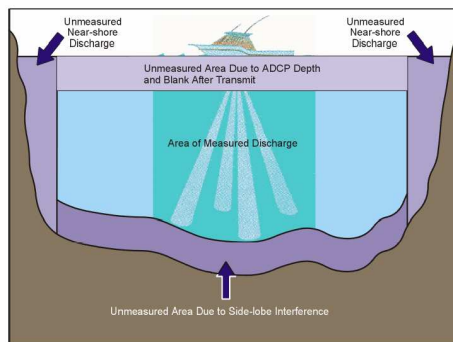
### Study approach

- Data collection
  - To better **understand flow and salt exchange** between chamber and the ocean during leveling (spilling) and after opening the gates (density current);
  - To determine the **velocities** caused by **density currents** that effect ship navigation;
- 3D Modeling of present situation
  - Set-up, validation and results
- 3D Modeling of future situation
  - Set-up, scenarios and results



## 1. Salinity and nautical aspects

### Current Measurements - ADCP





## 1. Salinity and nautical aspects

### Salinity Measurements – rapid drop SiltProfiler

High Frequency (100 Hz)

Wireless (acquisition & transmission)

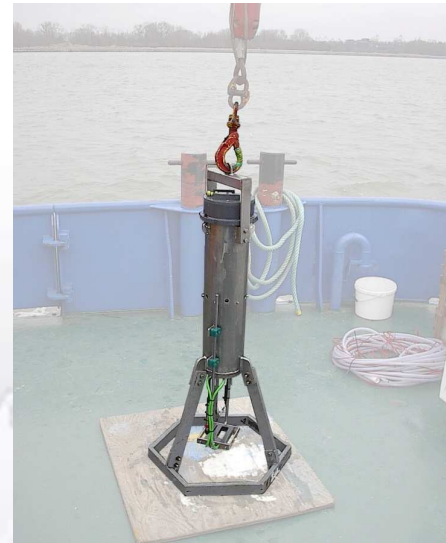
Freefall Profiling

3 Silt sensors:

1 Seapoint BS sensor (0-700 mg/l)

2 Transmittance Extinction Sensors (500-5000 mg/l & 5000 – 35000 mg/l)

CTD sensor + backup sensor



## 1. Salinity and nautical aspects

### Study approach

- 3D Modeling of present situation (Set-up, validation and results)
  - far field model (global hydrodynamics)
  - Near field (density currents)

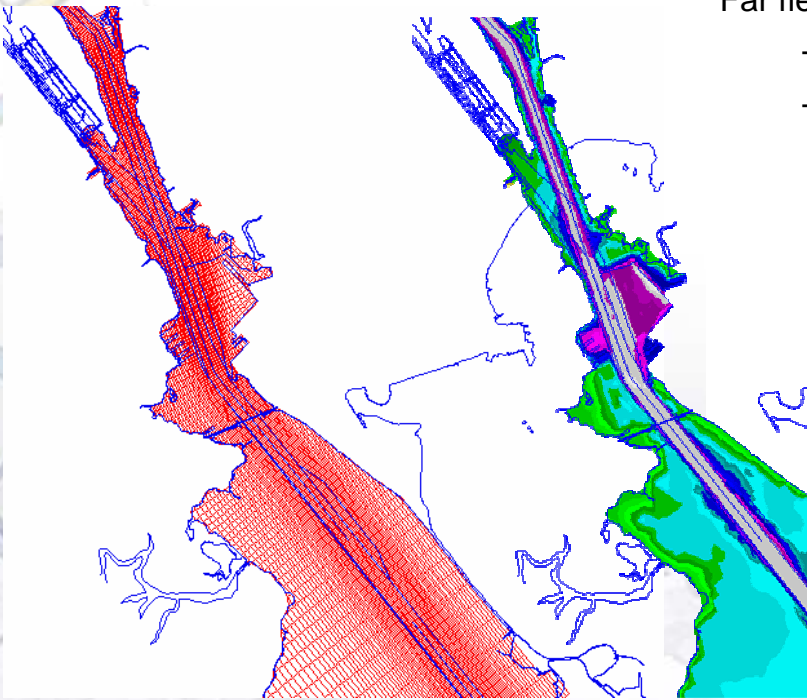
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Far field Grid cells:

- Width : 20m in channel
- Length : 40m – 80m



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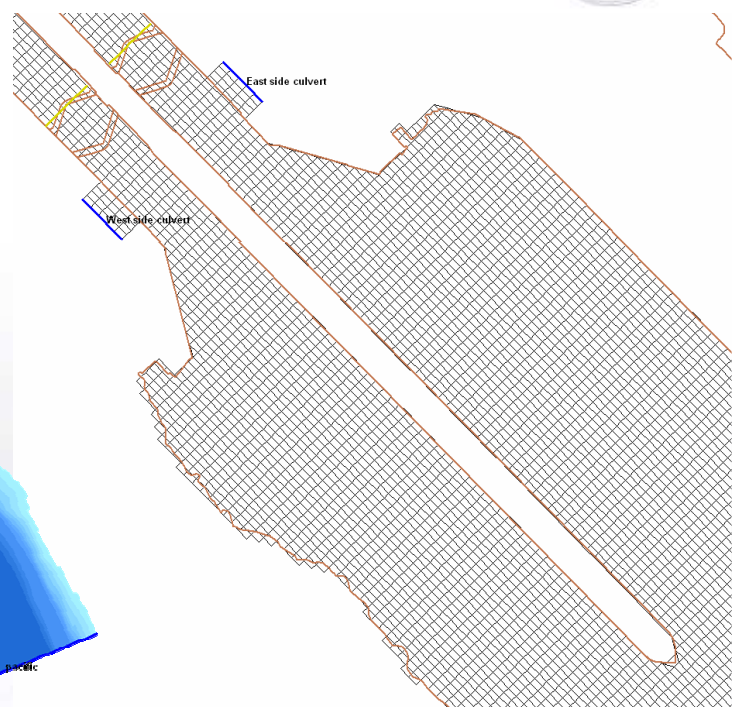
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- Near field :Grid cells:
  - Width 3.7m
  - Length 6.5 m



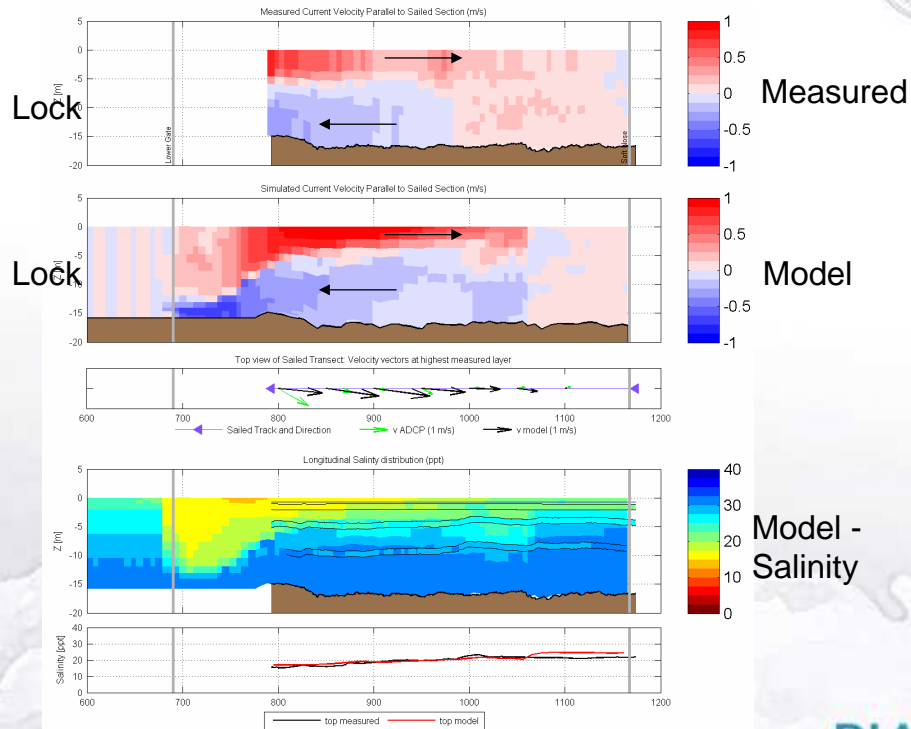
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## 1. Salinity and nautical aspects

### Study approach

- 3D Modeling of future situation (Set-up, scenarios and results)
- Focus on alternative designs of the tail bay and the centre wall

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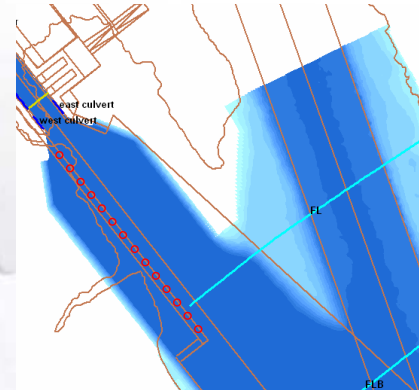
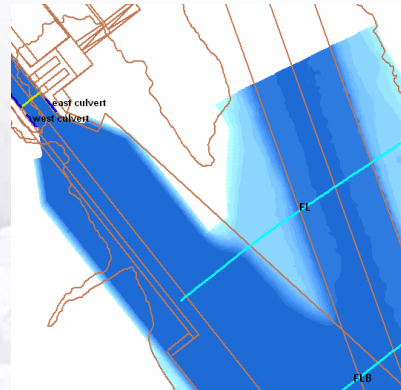
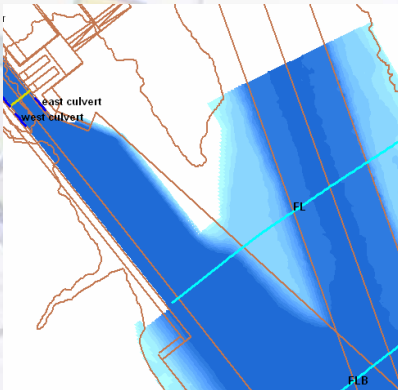
## 1. Salinity and nautical aspects

- Base line scenarios
- To study the effect of the permeability of the center wall
- Invisible wall without and with Water Saving Basins

closed center wall

no center wall

invisible center wall



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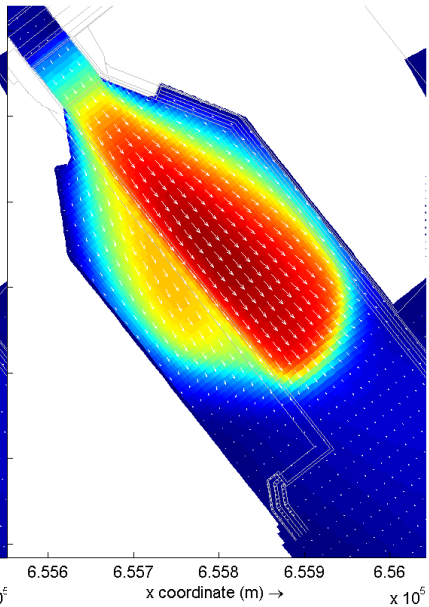
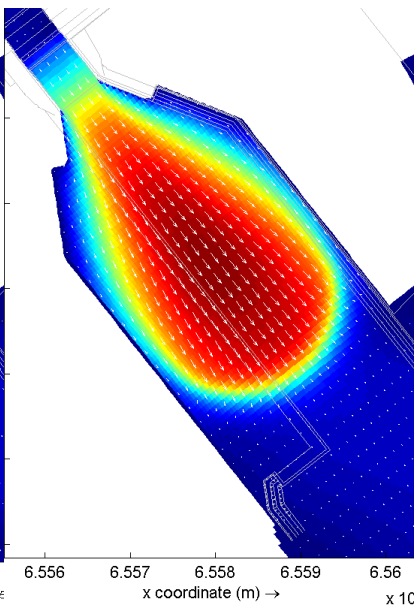
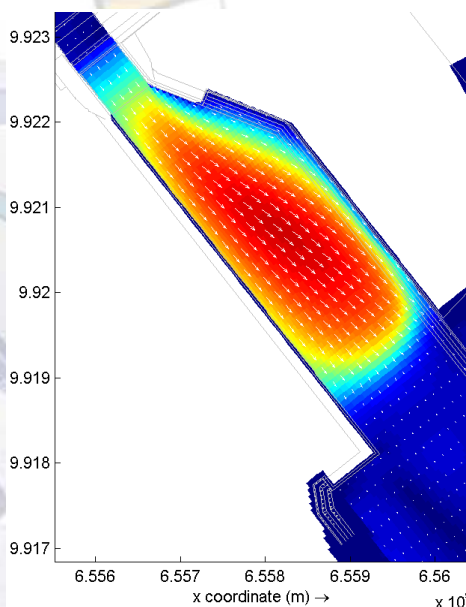


## 1. Salinity and nautical aspects

closed center wall

no center wall

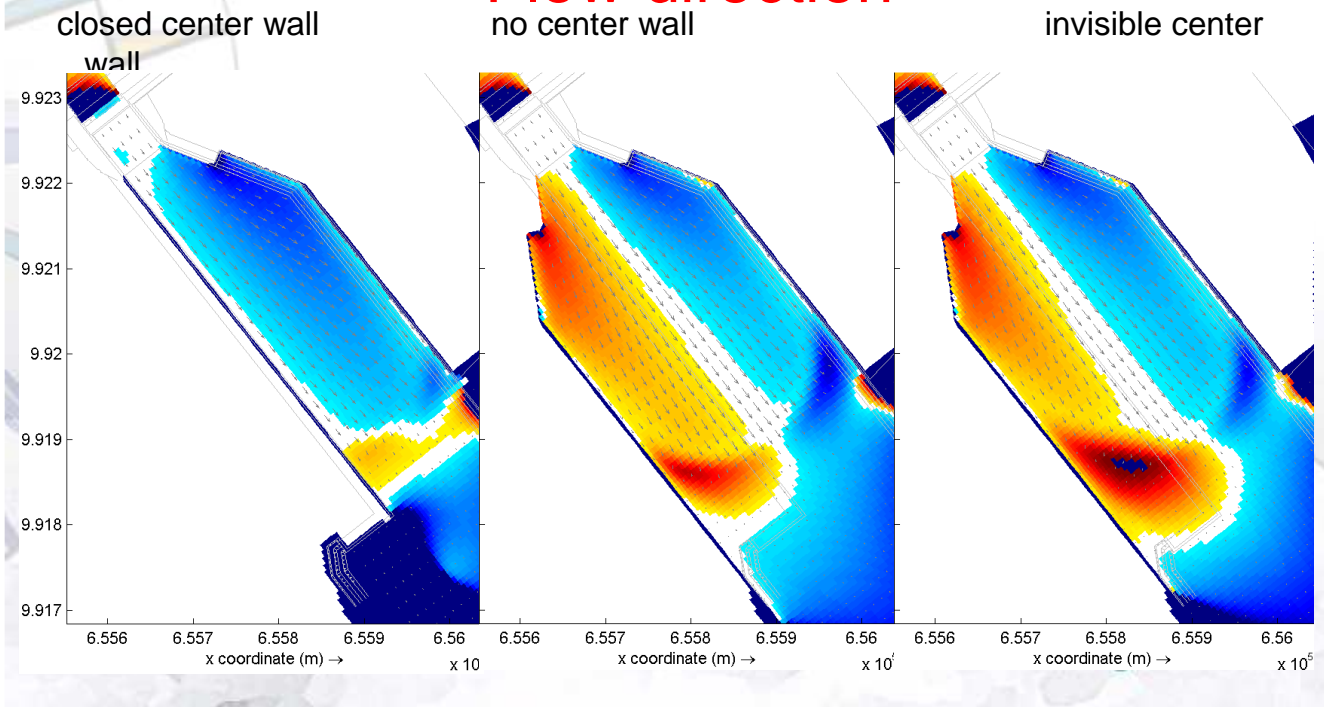
invisible center wall





## 1. Salinity and nautical aspects

Flow direction



1. Salinity and nautical aspects
2. Salinity and the environment
3. Salinity and sedimentation
4. Mitigating measures



## 2. Salinity and the environment

Salt water intrusion from sea locks into inland waterways induces problems :

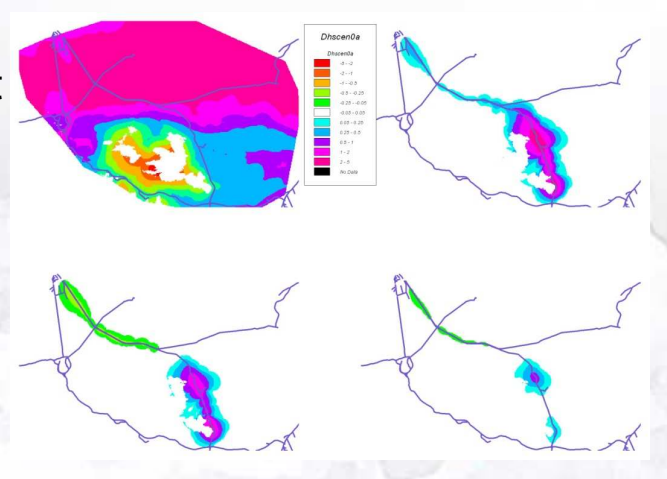
- **Surface** water (drinking, agriculture, industry, ecosystem)
- Examples :
  - Saline intrusion into Gatun lake (from the Pacific)(Panama)
  - Saline intrusion into canal Gent-Terneuzen (the Netherlands)



## 2. Salinity and the environment

Salt water intrusion from sea locks into inland waterways induces problems :

- **Ground**water (drinking, agriculture, industry, ecosystem)
- Example :  
Seine-Scheldt West canal study





## 3. Salinity and sedimentation

- Density currents entrain fine sediments into the lock chamber

Examples :

- Deposition of mud on the doors (e.g. rolling gates Zandvliet/Berendrecht)
- Density currents entrain fine sediments in the access channels tot the locks, and are responsible (in general) for more than 50% of the sedimentation rate (see PIANC WG 43 on Minimisation of harbour Siltation)

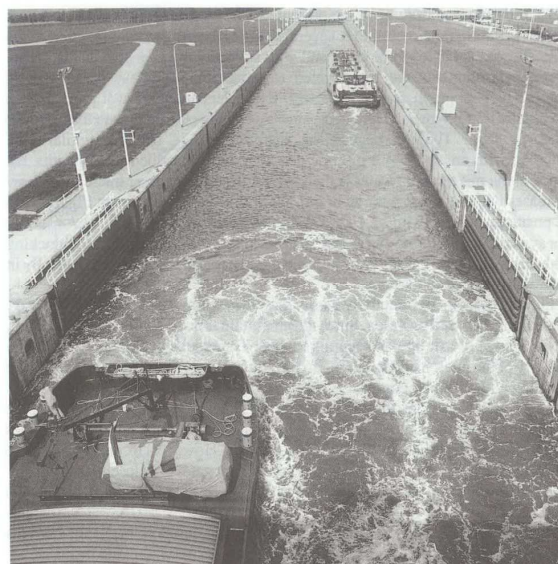
Examples :

- Kallø lock (river Scheldt – Belgium) :
  - o tidal filling : 20%
  - o Eddy : 10%
  - o Density currents : 70%



## 4. Mitigating measures

- Pumping back the saline lockage prism
- Use of air bubble curtain (Volkerak locks – the Netherlands, Kerstma et al.)



# Salinity and Locks



## 4. Mitigating measures

- Gravitational discharge of saline water via receptor basin (Terneuzen, PIANC 1986)

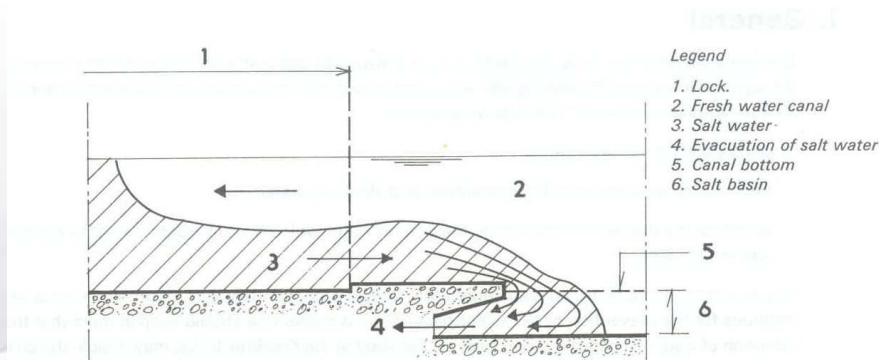


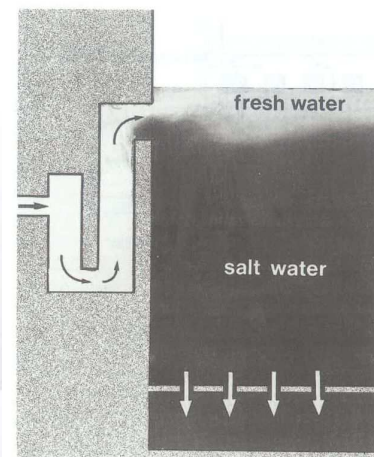
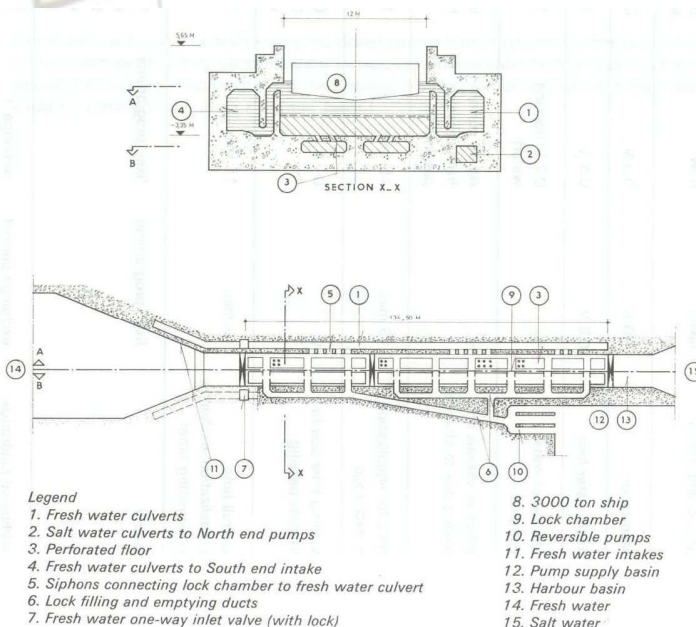
Fig. 2 - System of Terneuzen: Selective withdrawal of salt water intruded in the fresh water canal

# Salinity and Locks



## 4. Mitigating measures

- Complete lock chamber exchange (Dunkirk - France, Kreekrak and Krammer – the Netherlands) (PIANC 1986, Kerstma et al.)



# Many Thanks

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