8th DualSPHysics Workshop
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SPH Modeling of Salinity Transport Phenomena in Navigation Locks

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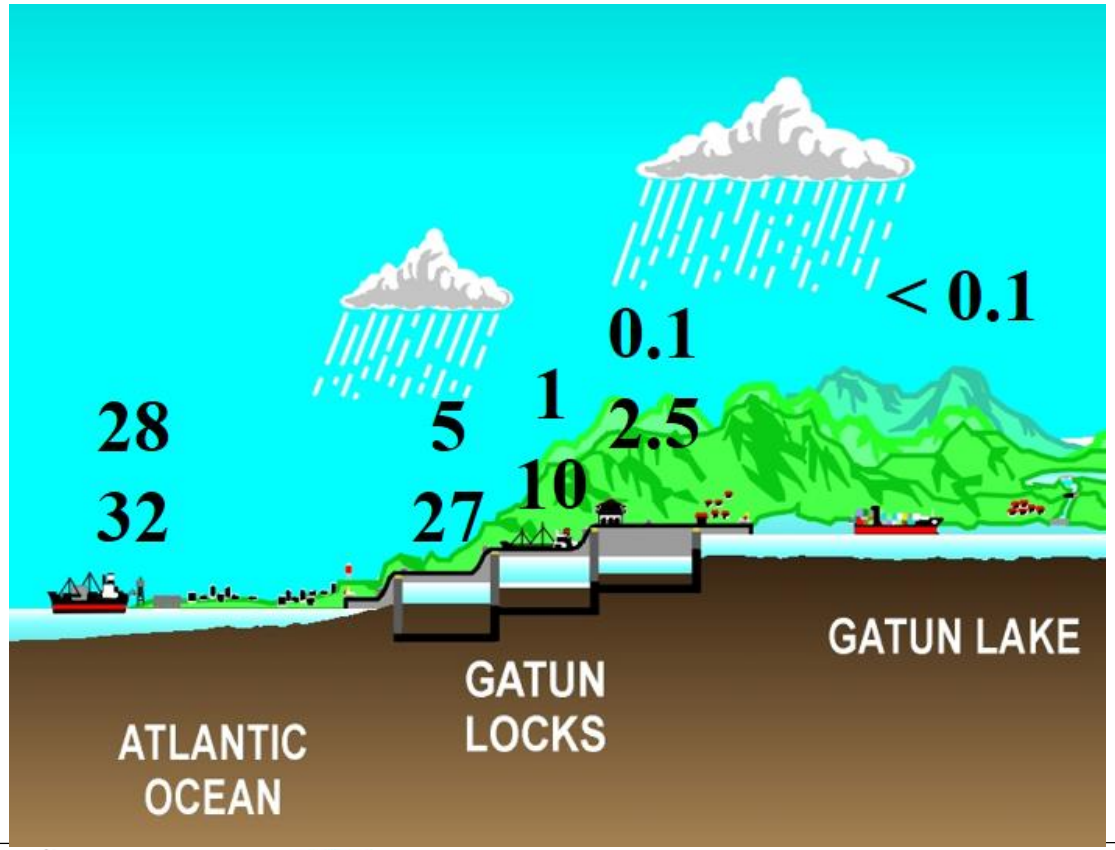
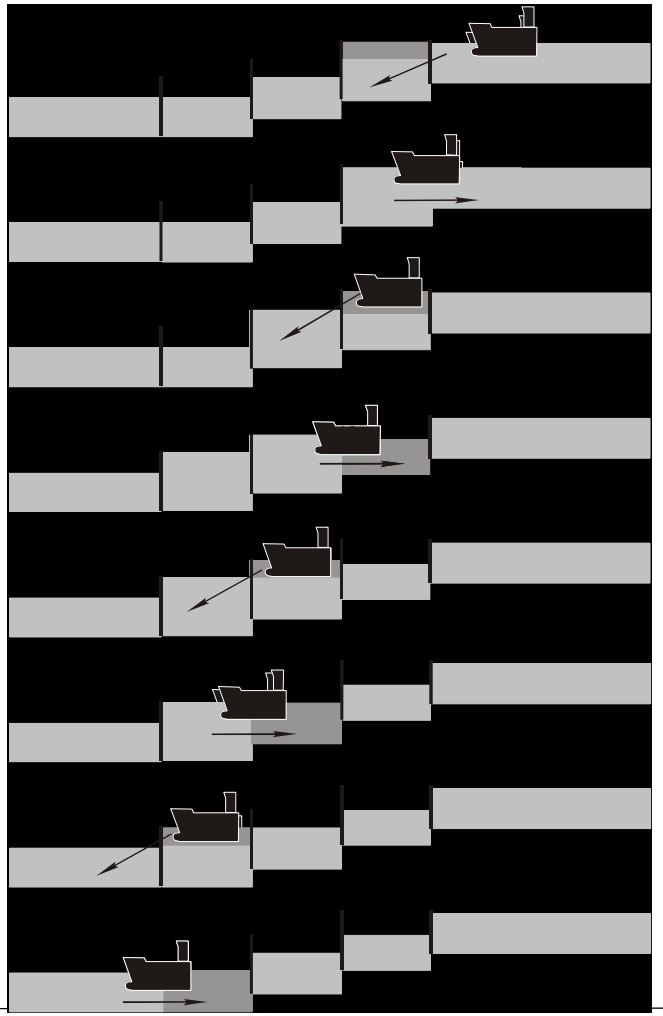
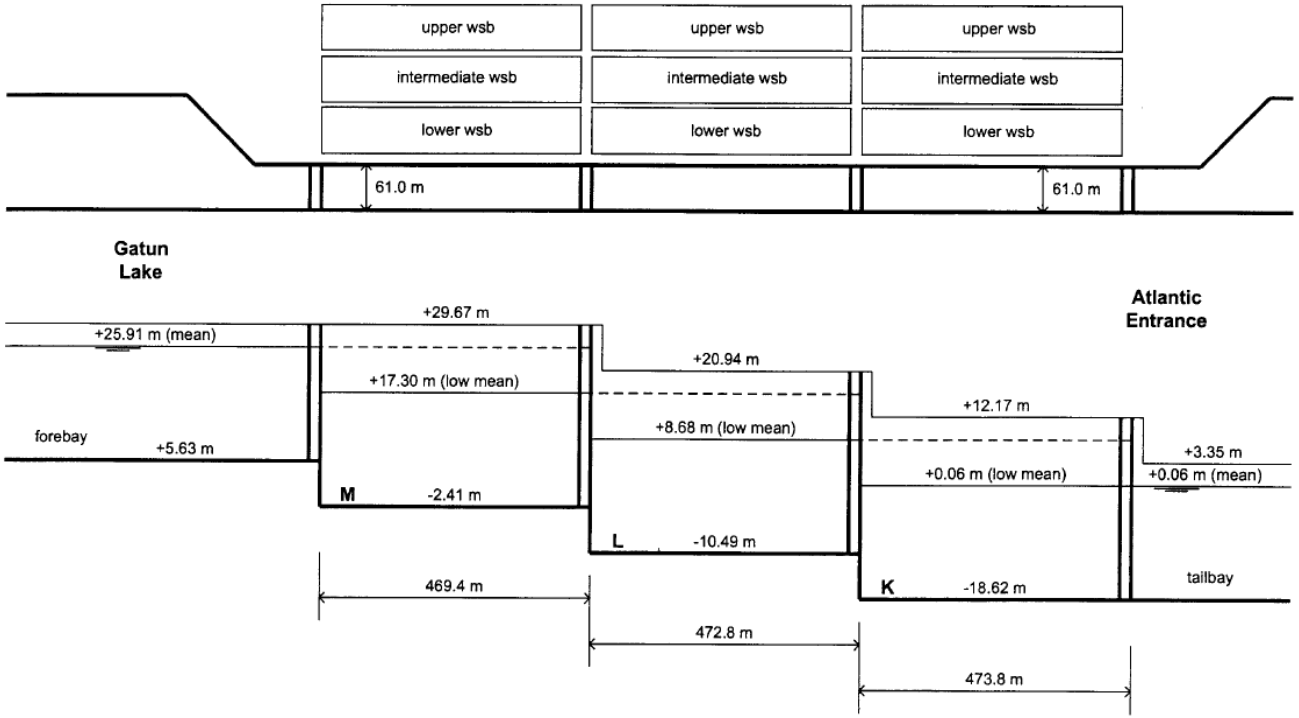
Salinity Intrusion in the Old Panama Canal Locks

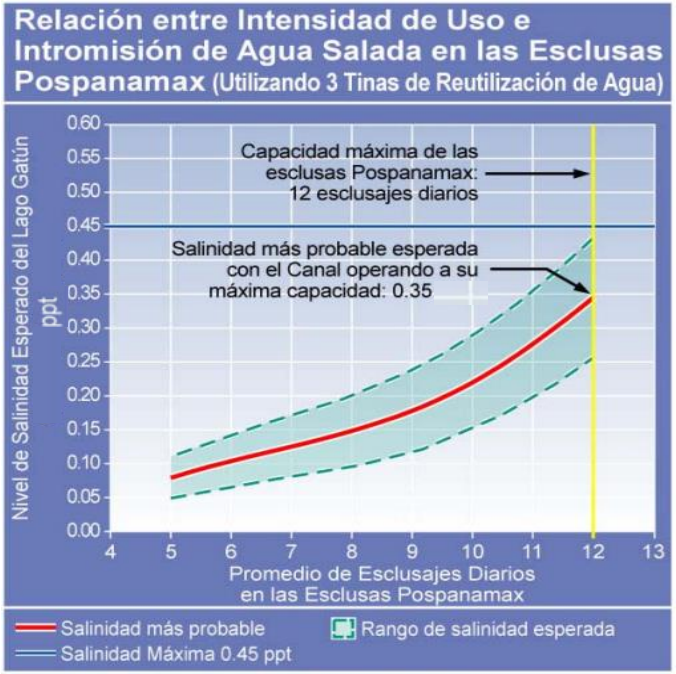


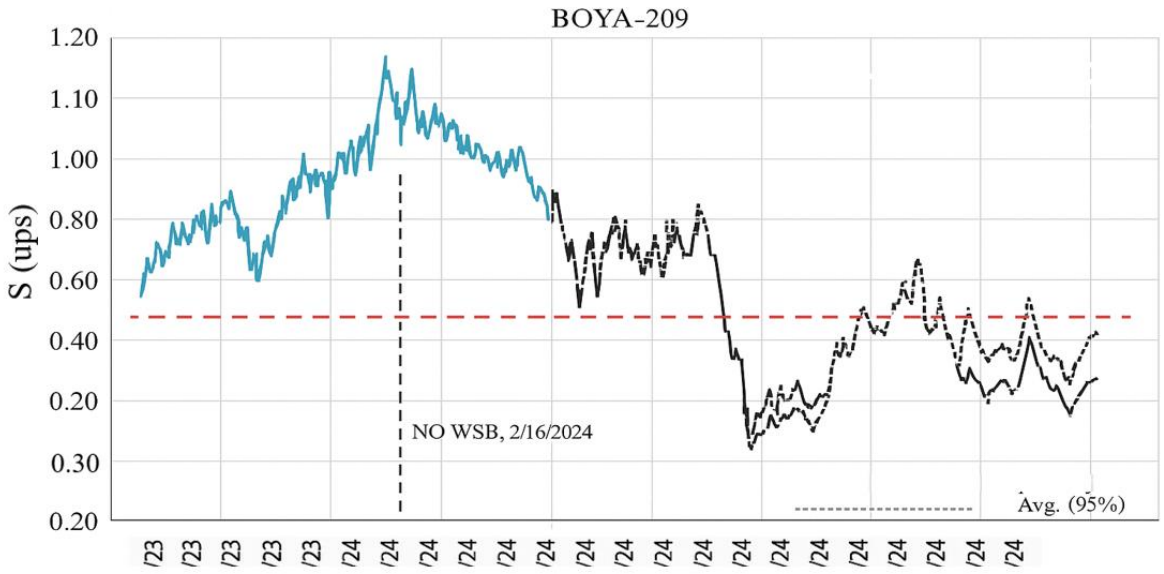


New Panama Canal Locks



Salinity Intrusion in the New Panama Canal Locks





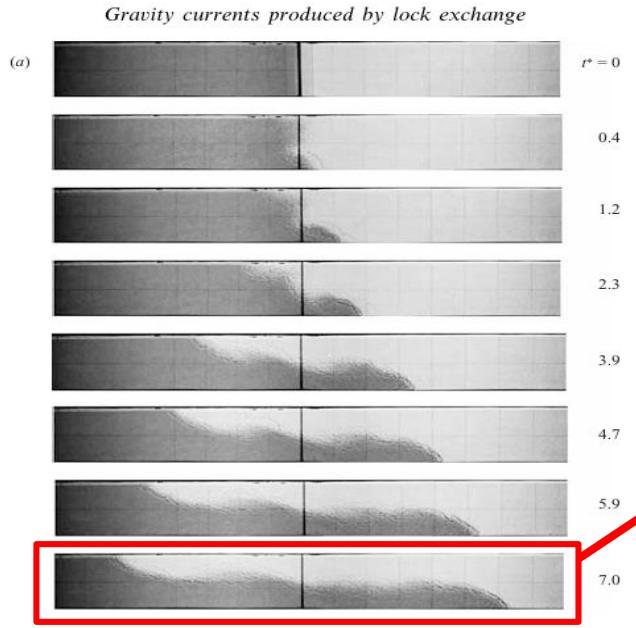
Expectation

Reality

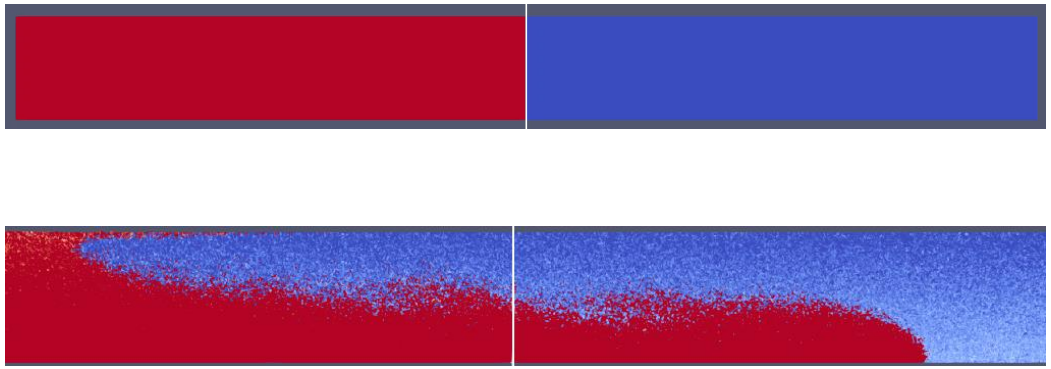
Salinity Intrusion in the New Panama Canal Locks

Current mitigation measure

DualSPHysics® Salinity Transport Model

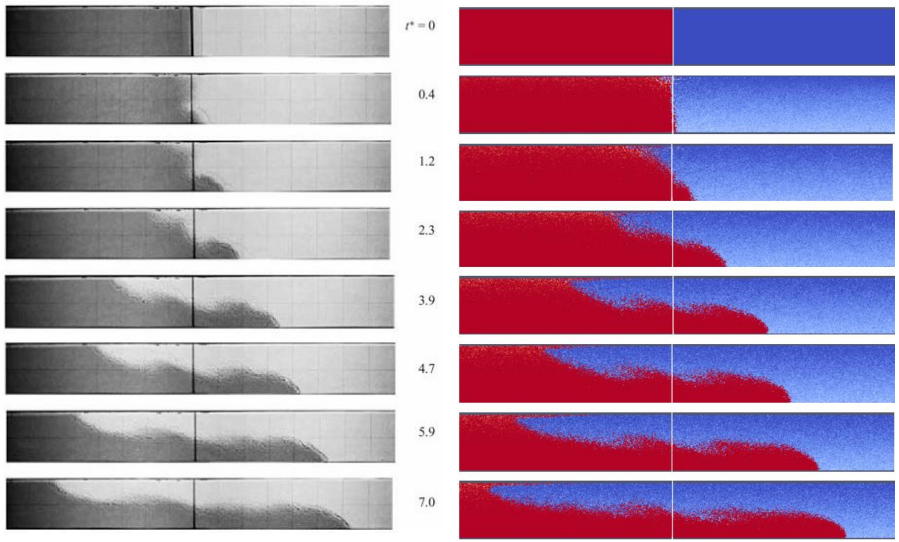


Gravity currents produced by lock exchange
Source: Shin et al. (2004)

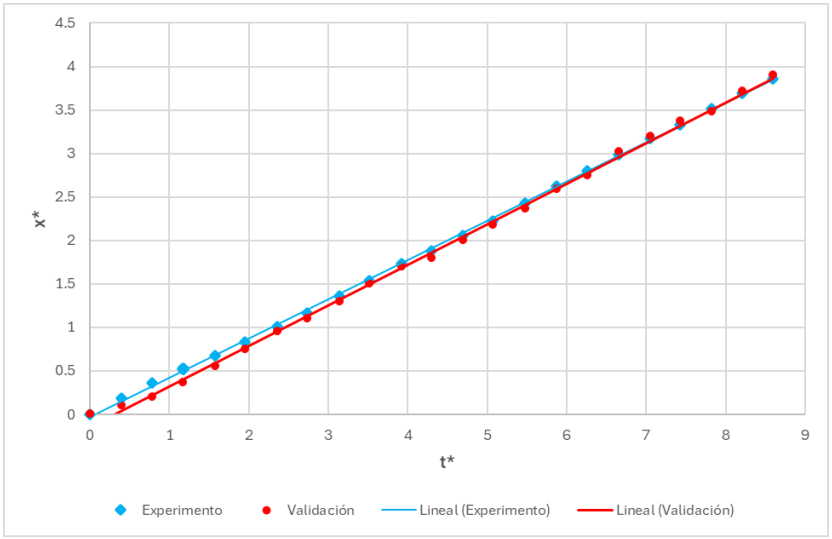


- Rectangular channel: 2 m long and 0.2 m deep
- Multiphase DualSPHysics model: $\frac{\rho^{fresh}}{\rho^{salt}} \approx 0.993$
- No shifting
- CFL = 0.05
- Interparticle distance, Dp = 0.001 m
- Constitutive viscosity treatment

Validation of the Salinity Transport Model



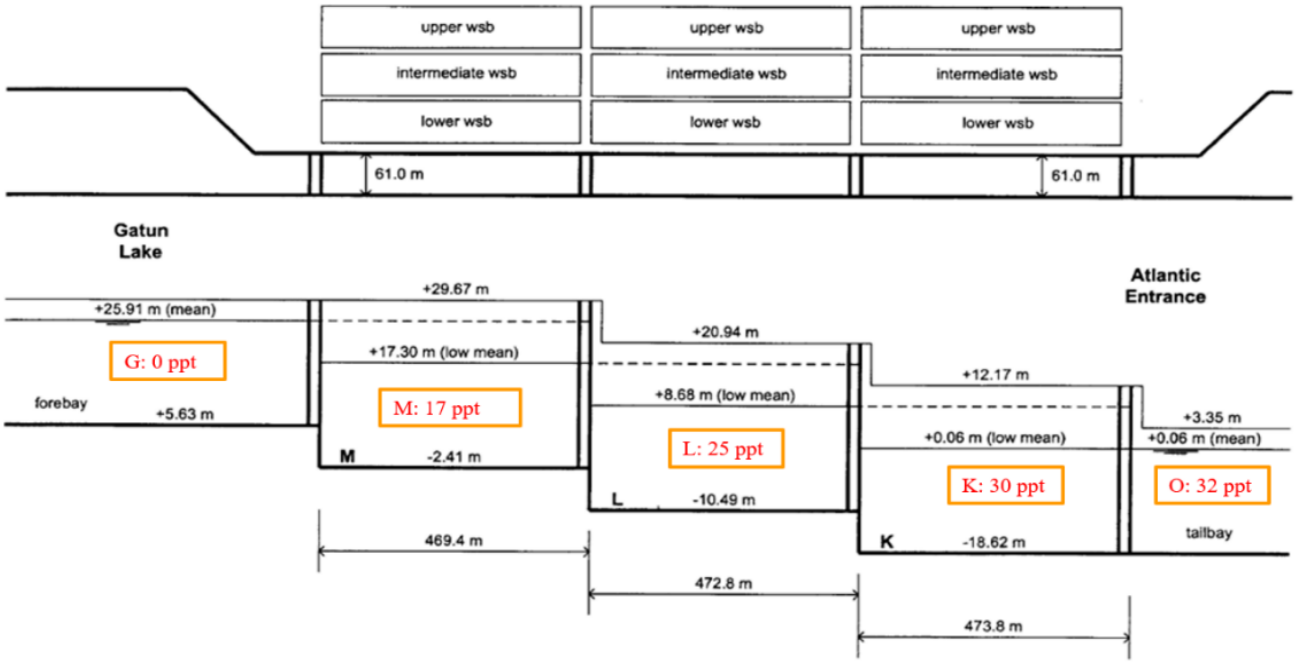
Experiments



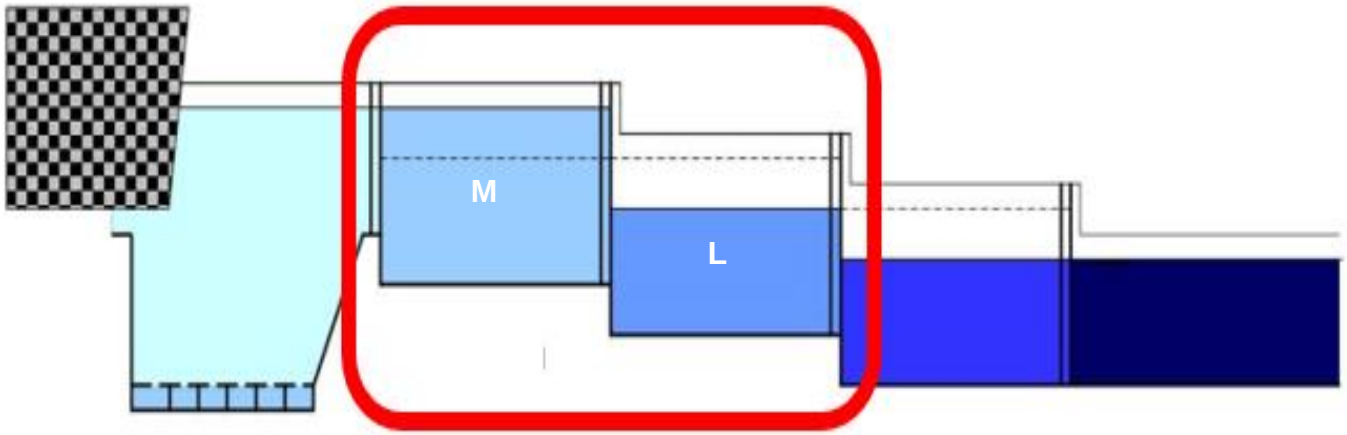
Gravity currents produced by lock exchange
Fuente: Shin et al. (2004)

$$x^* = x / H \qquad t^* = t\sqrt{g(1-\gamma) / H}$$

Simulation of Salinity Transport in Lock Operations

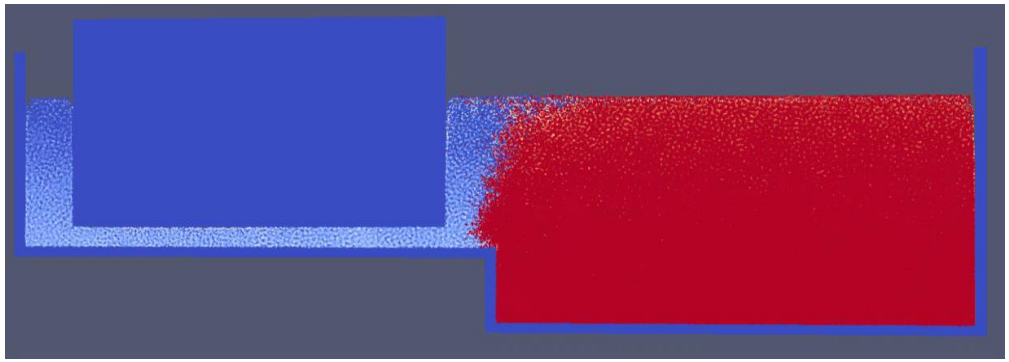


Upper - Middle Lock Operations

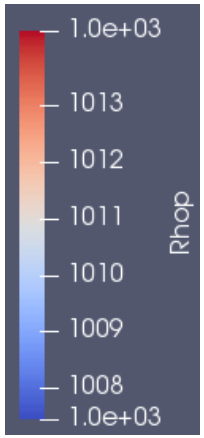


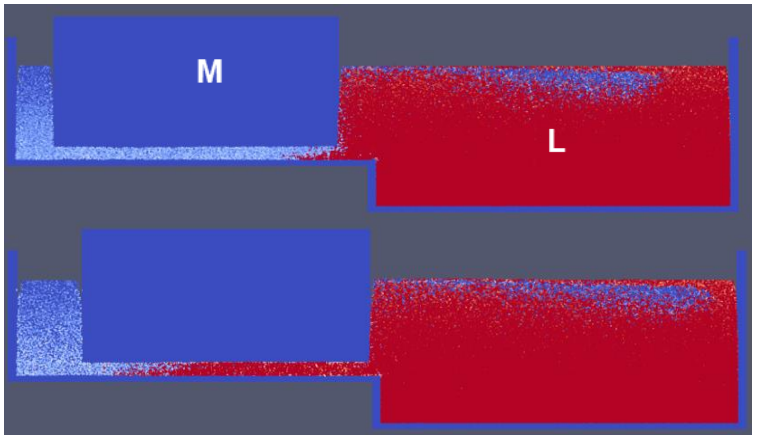
- Scales: 1: 500 horizontal; 1:50 vertical
- 2D (55 m wide ship in a 61 m wide lock)
- 5-minute gate opening
- Ship entering the lock at 2 knots
- Interparticle distance, Dp= 0.002 m; 1.2 million particles

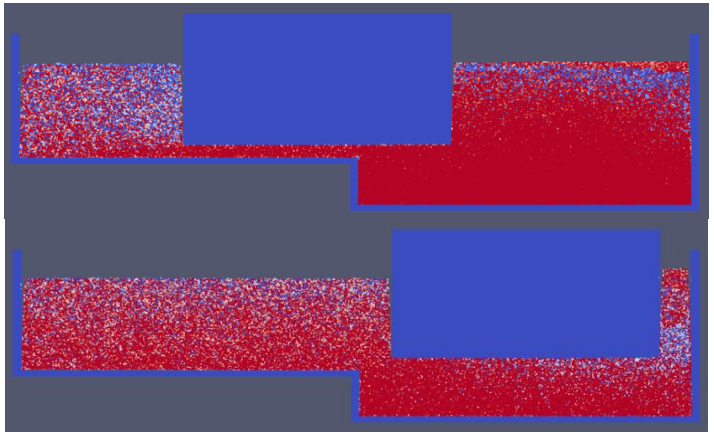
Upper - Middle Lock Operations



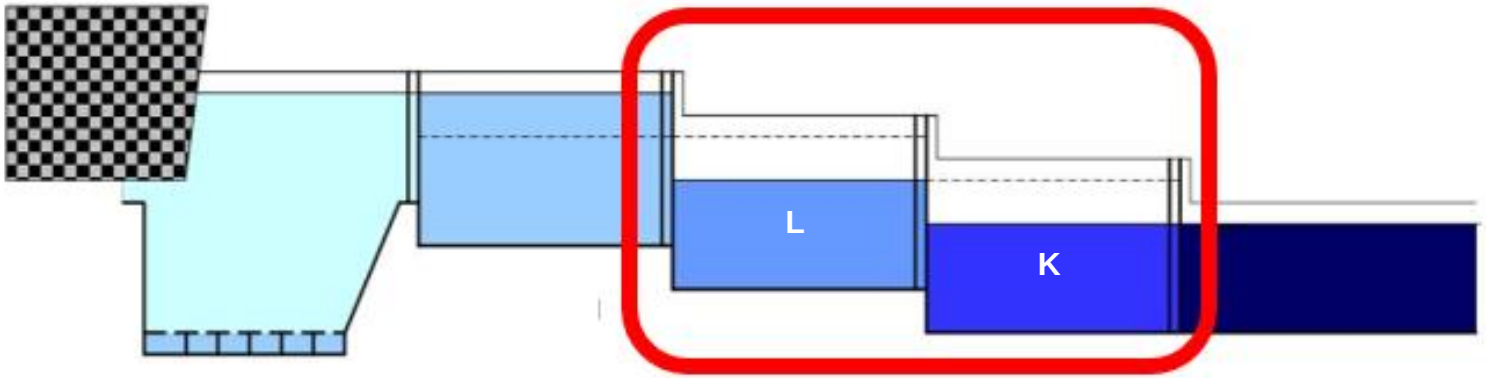
Lock M (S = 12 ppt): 1007.44 kg/m3
Lock L (S = 21 ppt): 1014.29 kg/m3



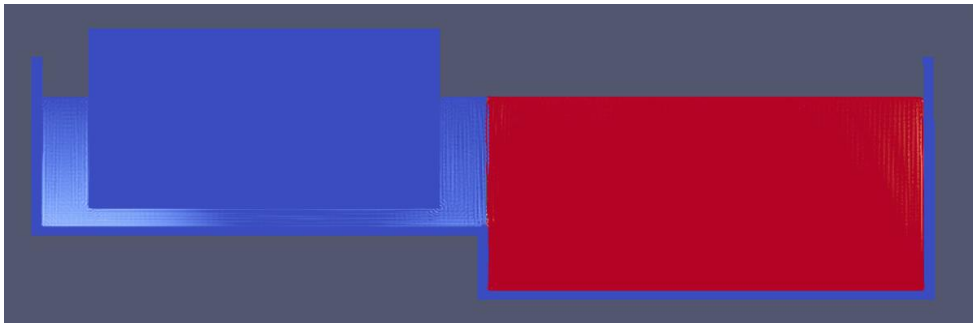




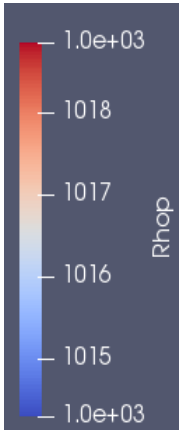
Middle - Lower Lock Operations

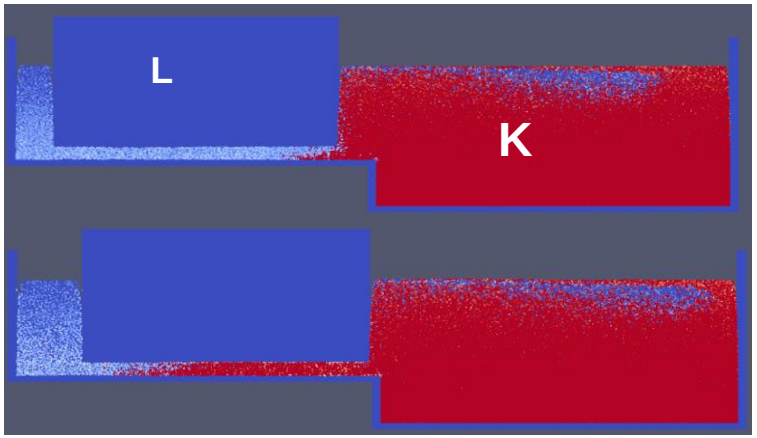


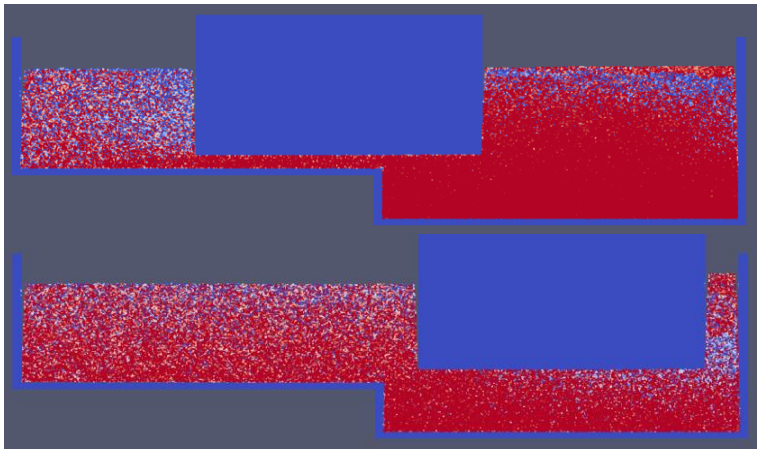
Middle - Lower Lock Operations



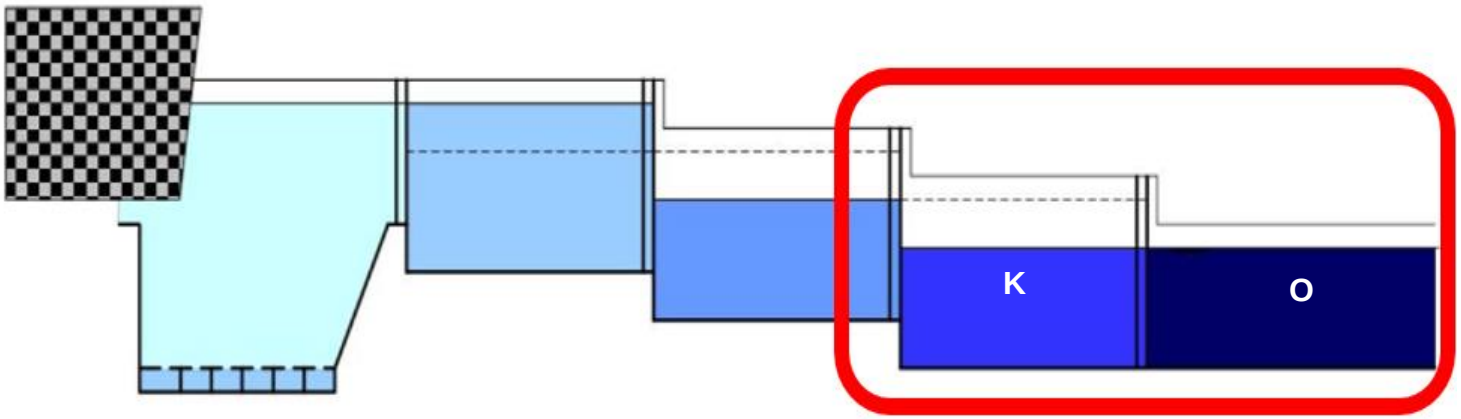
Lock Chamber K (S = 27 ppt): 1018.84 kg/m3
Lock Chamber L (S = 21 ppt): 1014.29 kg/m3



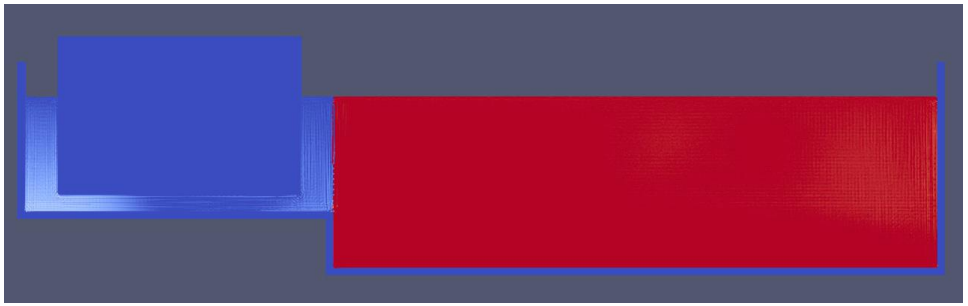




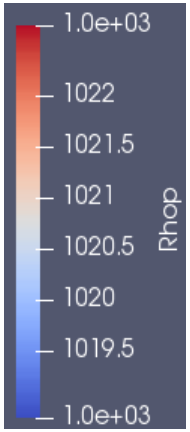
Lower Lock - Ocean Operations

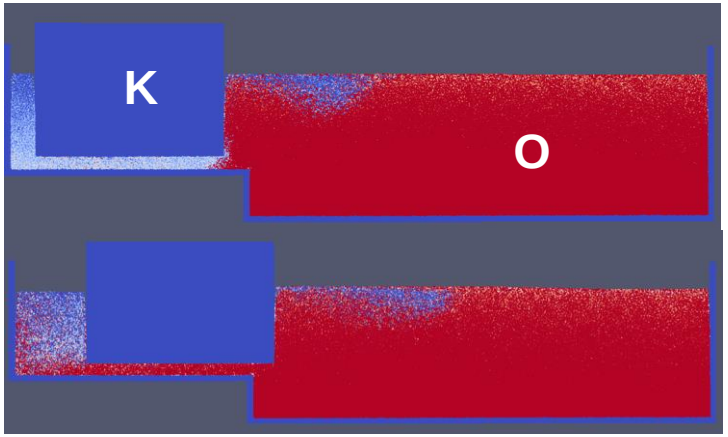


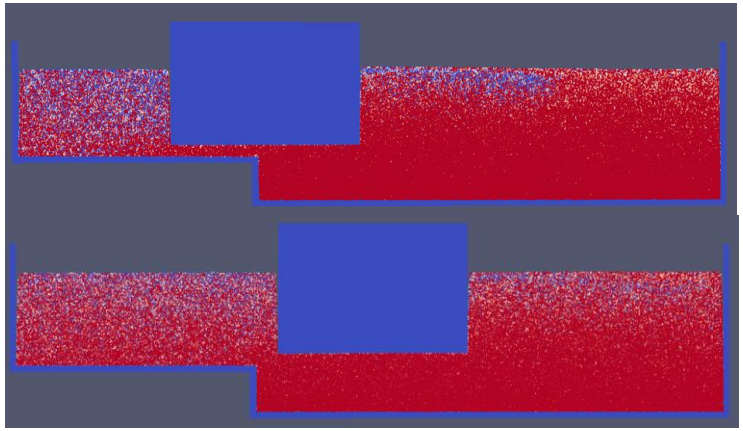
Lower Lock - Ocean Operations (Towards the Ocean)



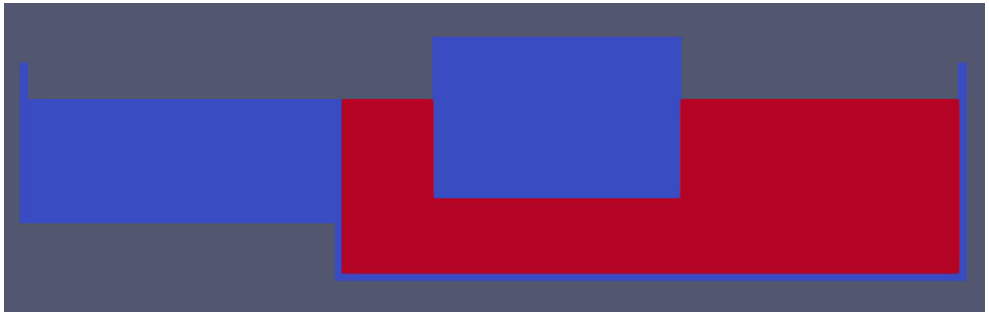
Ocean O (S = 32 ppt): 1022.68 kg/m3
Lock Chamber K (S = 27 ppt): 1018.84 kg/m3







Lower Lock - Ocean Operations (Towards the Locks)



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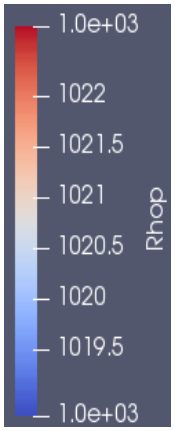
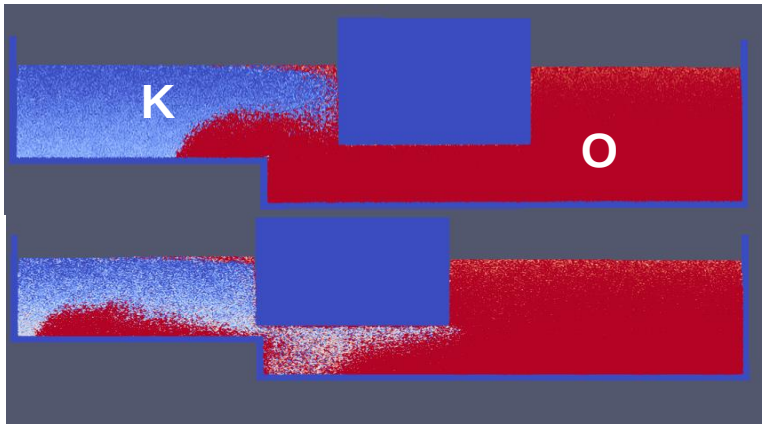
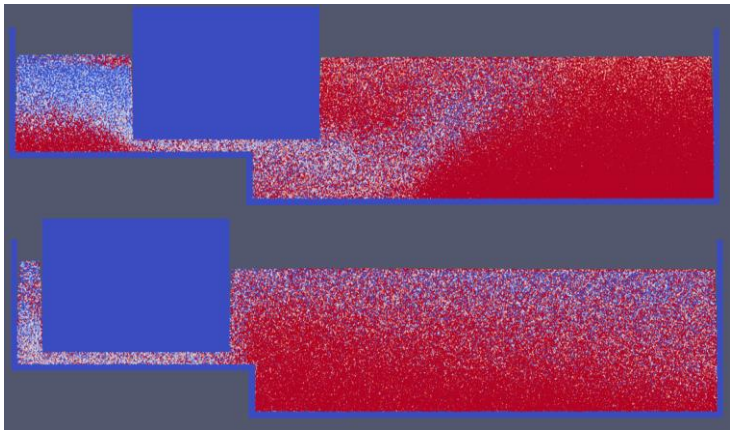
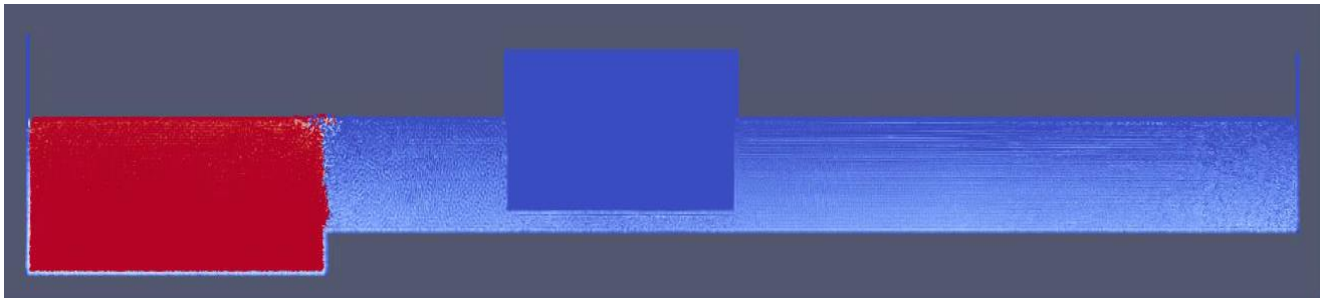


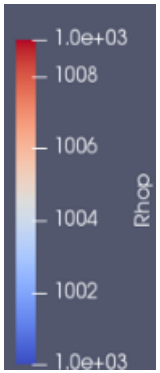


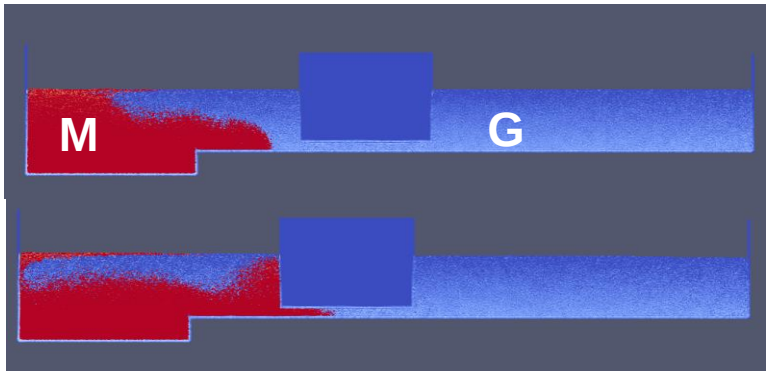


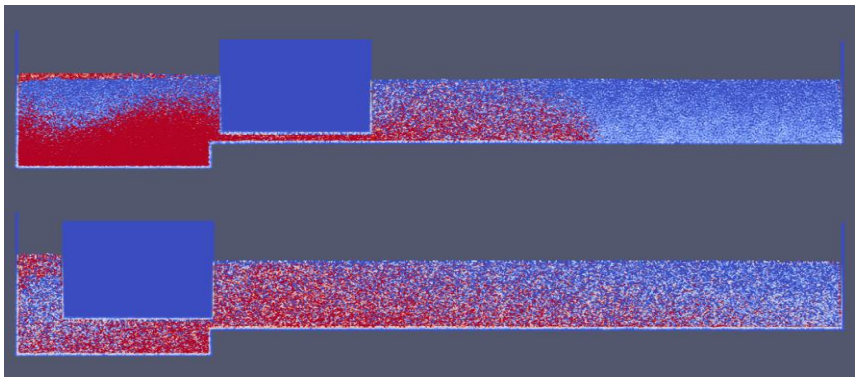
Gatun Lake – Upper Lock Operations



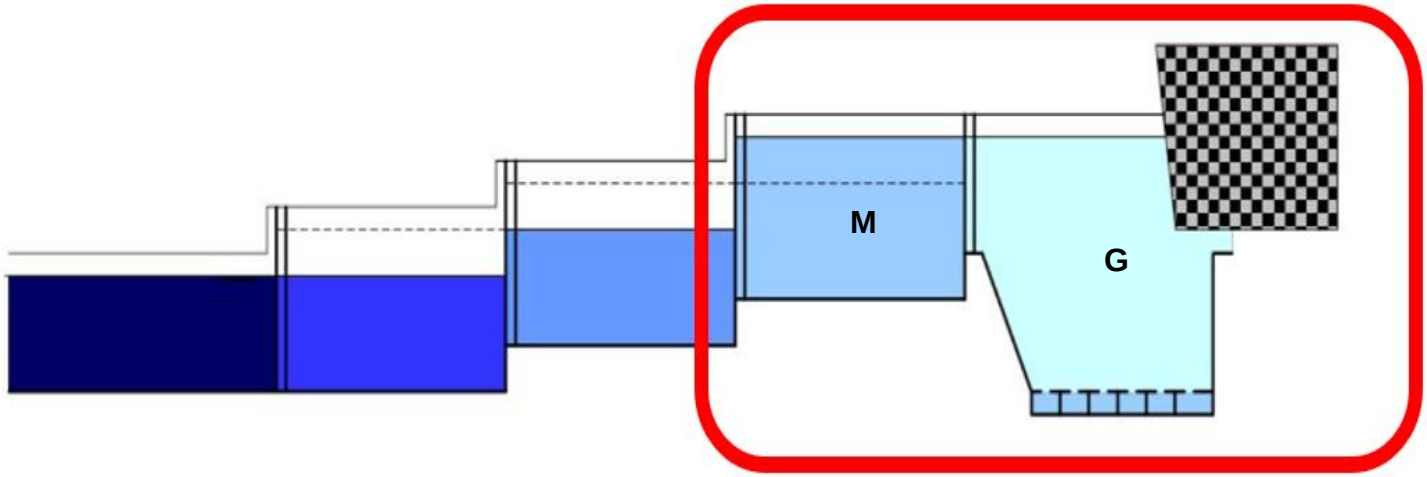
Lock Chamber M (S = 12 ppt): 1007.44 kg/m3
Gatun Lake G (S = 0 ppt): 1000 kg/m3







Salt Water Pit Mitigation System



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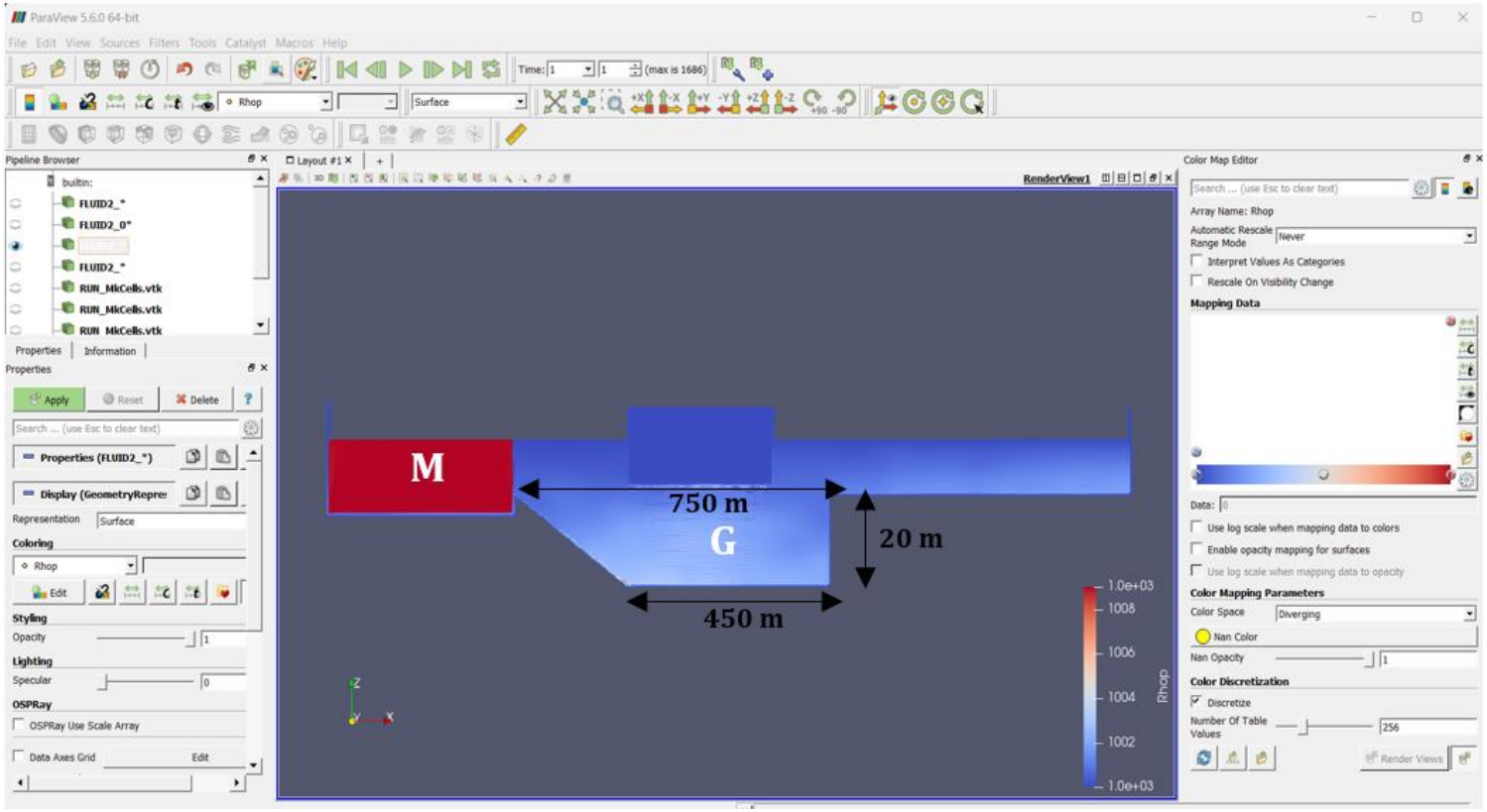

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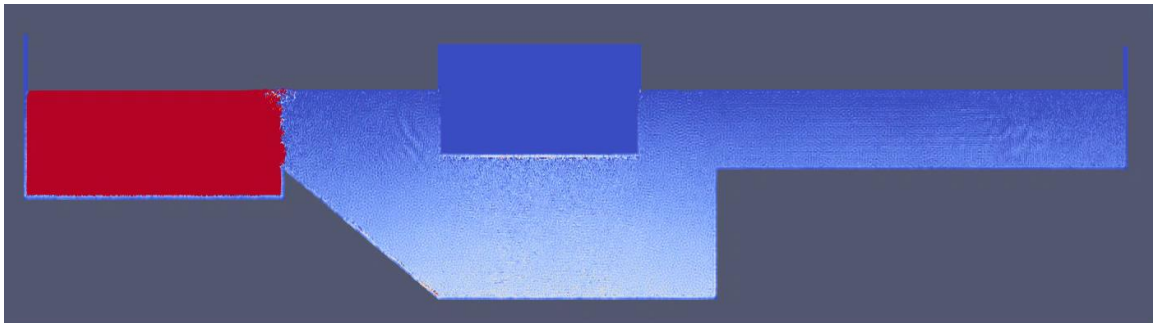

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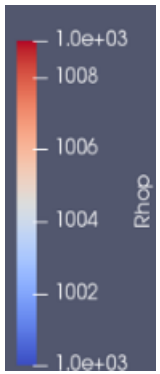

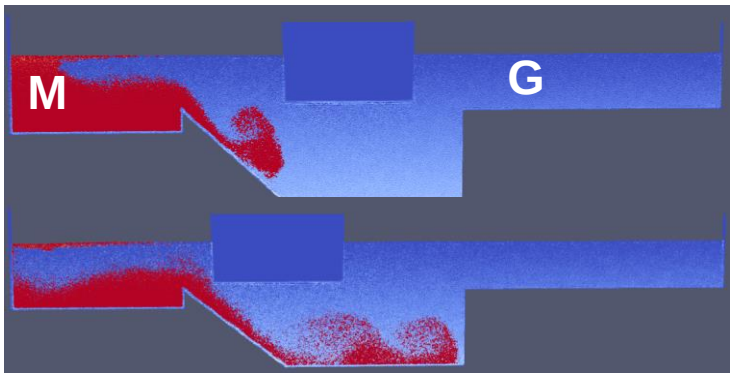

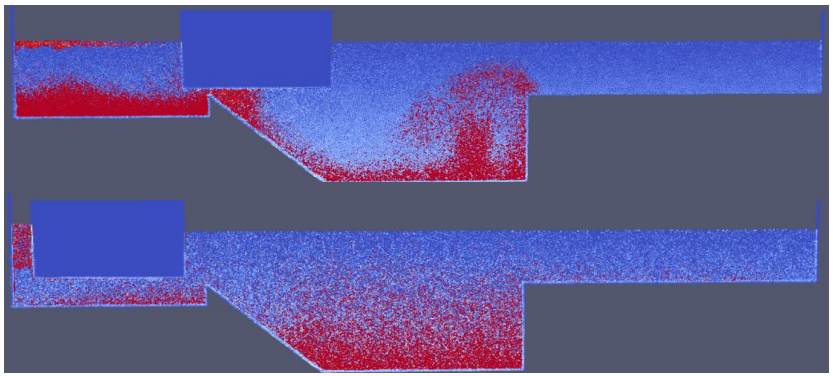

Thanks for your attention!

Acknowledgements
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References:

- Shin, J., Dalziel, S., Linden, P. (2004) “Gravity currents produced by lock exchange”. *J. Fluid Mech,* 521, pp. 1-34.