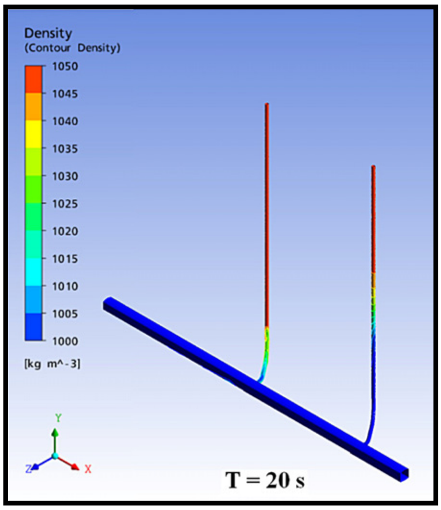
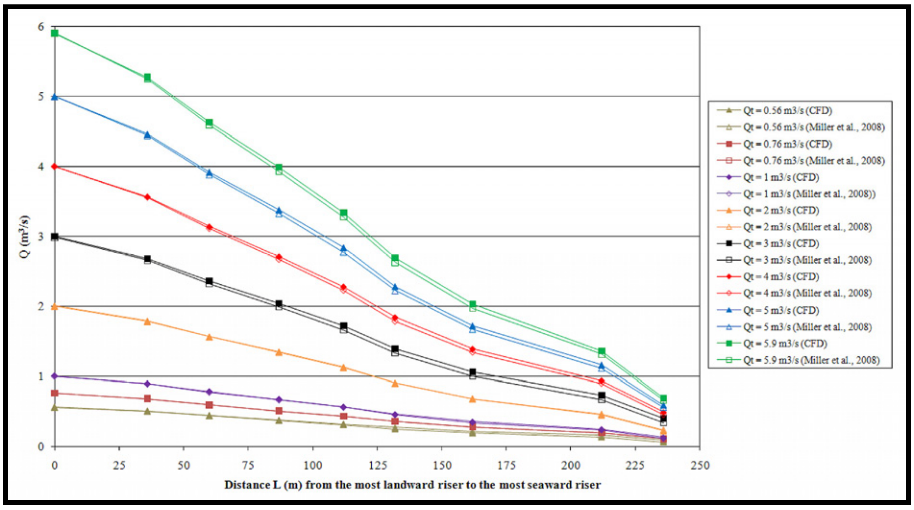
CFD Modelling of Ocean Outfall Purging





(L-r) Density in the Malabar Ocean Outfall; Discharge along the tunnel over varied flow rates in the Burwood Beach Ocean Outfall

After initial construction or following maintenance work ocean outfalls may be filled with seawater that must be purged with less dense effluent. Experience with long riser outfalls has shown that seawater intrusion and purging can pose special problems for this type of outfall. Indeed, if the outfall is not properly purged it may not operate as designed and seawater could be drawn into the risers. The buoyancy of the effluent inside a riser reduces pressures in the tunnel causing seawater contained in unpurged risers to recirculate through the riser section which impacts the outfall performance and reduces effluent dilution. This reduced performance may lead to partial blockage of the outfall due to the build-up of marine growth and sediments.

Over many years, outfall purging has been successfully studied at the Water Research Laboratory through physical modelling and hydraulic assessments using in-house Fortran programs developed at WRL. Recent advances in computer power and Computational Fluid Dynamics (CFD) provide a useful alternative method for outfall purging assessments and design methods. A 3-Dimensional (3D) numerical model using the CFD software ANSYS-CFX has been developed at WRL to simulate the purging process in two different ocean outfalls to validate the CFD software and verify its accuracy and sensitivity for future outfall assessment. As a case study the model has been applied to the deep water Malabar Ocean Outfall in Sydney and the Burwood Beach Ocean Outfall near Newcastle.

Results over three varied flow rates for the Malabar Ocean Outfall showed that the time for purging the riser and the effluent flow rate for when the purging of the riser occurred were in agreement with the experimental values of Wilkinson et al. (1989, 1992) and with the purging condition for long riser outfalls found by Wilkinson et al. (1985).

Results along the tunnel and in the risers of the Burwood Beach Ocean Outfall, applying two types of outlet at the riser boundaries and two depths of effluent - seawater interface, were compared to the hydraulic assessment of Miller et al. (2008) over eight varied flow rates. Mass flow outlet conditions at the riser boundaries, discharge and velocity values along the tunnel and in the risers were very close to the results of the hydraulic assessment, regardless of the initial depth of effluent - seawater interface and the tunnel flow rates being modelled.

By applying pressure outlet conditions at the riser boundaries, numerical results varied according to the tunnel flow rates and the initial depth of effluent - seawater interface modelled. For a ‘no interface’ initial condition, the flow rates did not influence the numerical modelling as the discharge and velocity values along the tunnel and in the risers matched very well the results of the hydraulic assessment. But for an ‘effluent - seawater’ interface initial condition the flow rates seemed to have a greater influence on the hydraulics of the outfall, as a characteristic flow rate of 2 m3/s was shown to affect the numerical modelling, which was also the flow rate to start purging at least one riser of the Burwood Beach Ocean Outfall. Single phase modelling was not sensitive to the boundary type conditions and flow rates and showed very good hydraulics results in agreement with the hydraulic assessment. However multi-phase modelling was clearly sensitive to the boundary type conditions and flow rates.

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