Skimmer capacity for viscous oil spills

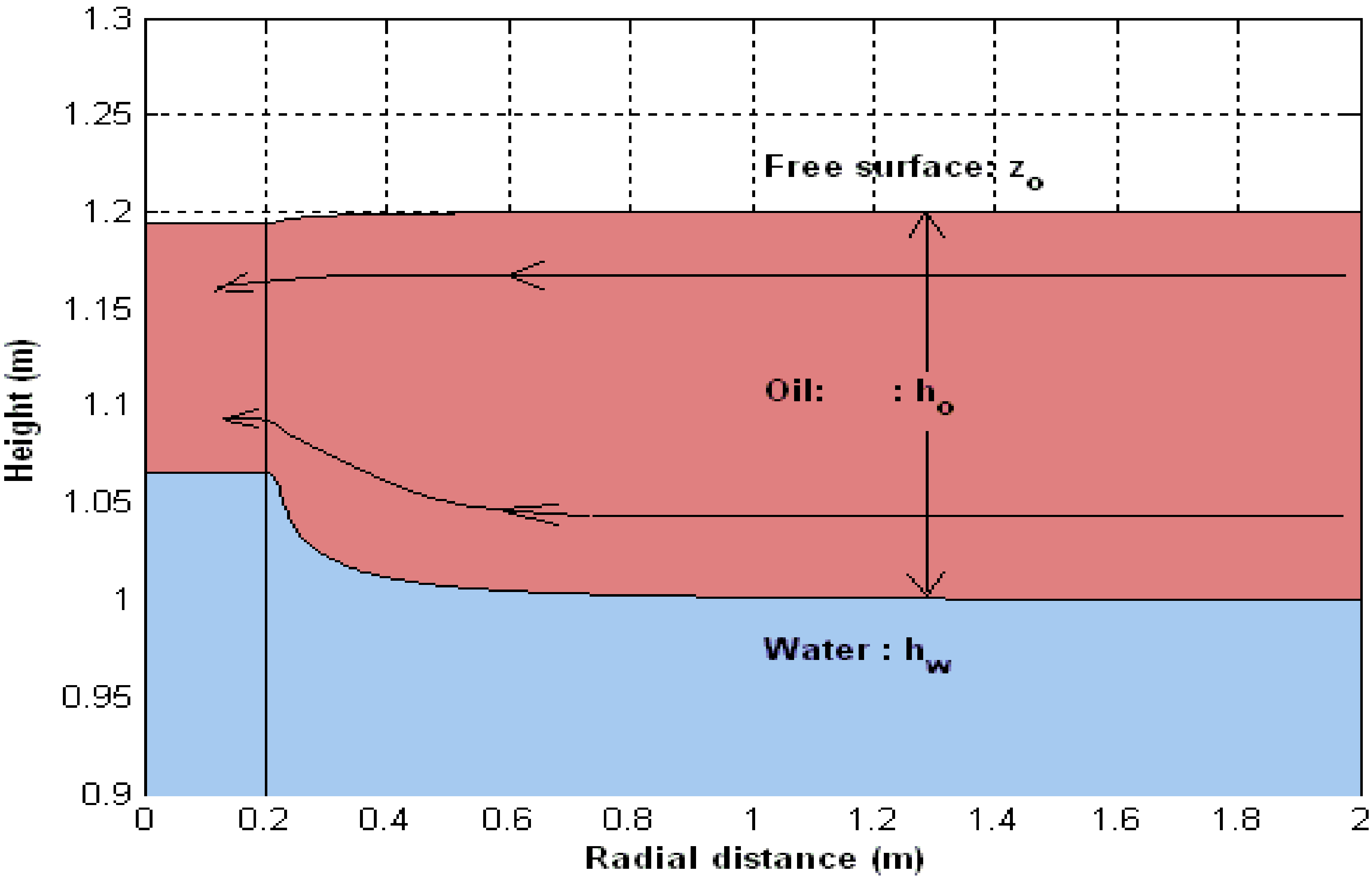
Accounting for viscous forces in skimmer design

Flow of floating, viscous oil towards a skimmer

Observed from above

Flow of floating oil towards a skimmer

x-section



Skimmer design

Traditional formulae

-Static, vertical equilibrium between oil and water

-Flow driven by height and density differences

-Flow opposed by inertia

Sludge recovered from the EKOFISK tank in the North Sea

The fork will fall down, eventually

Skimmer design

Proposed model/formula

-Vertical equilibrium between oil and water

-Flow driven by height and density differences

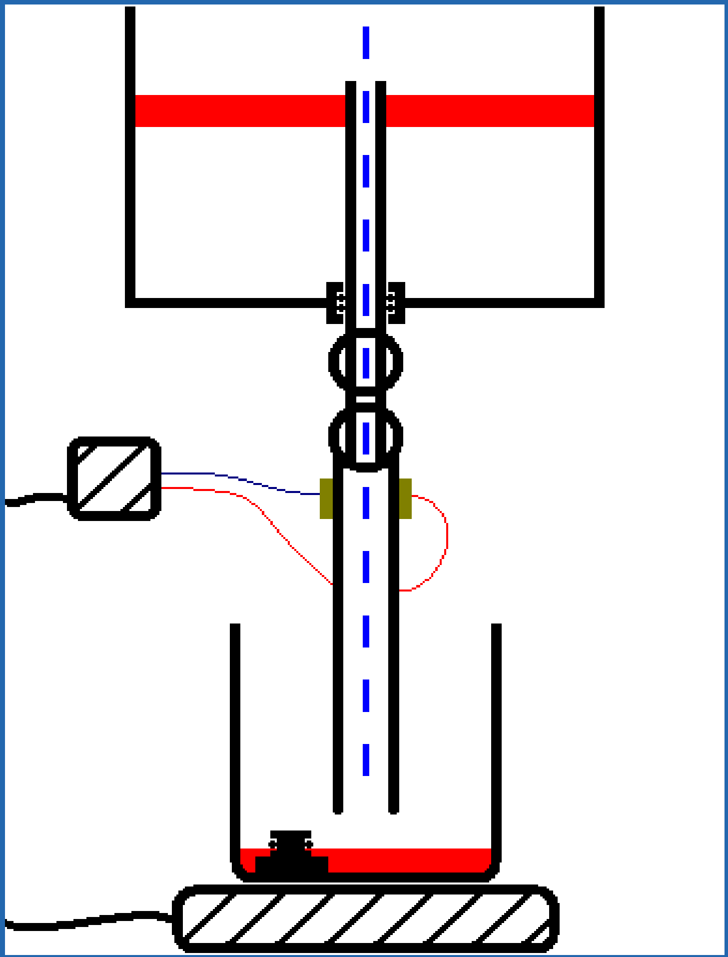
-Flow opposed by inertia and viscous resistance

Experimental facility

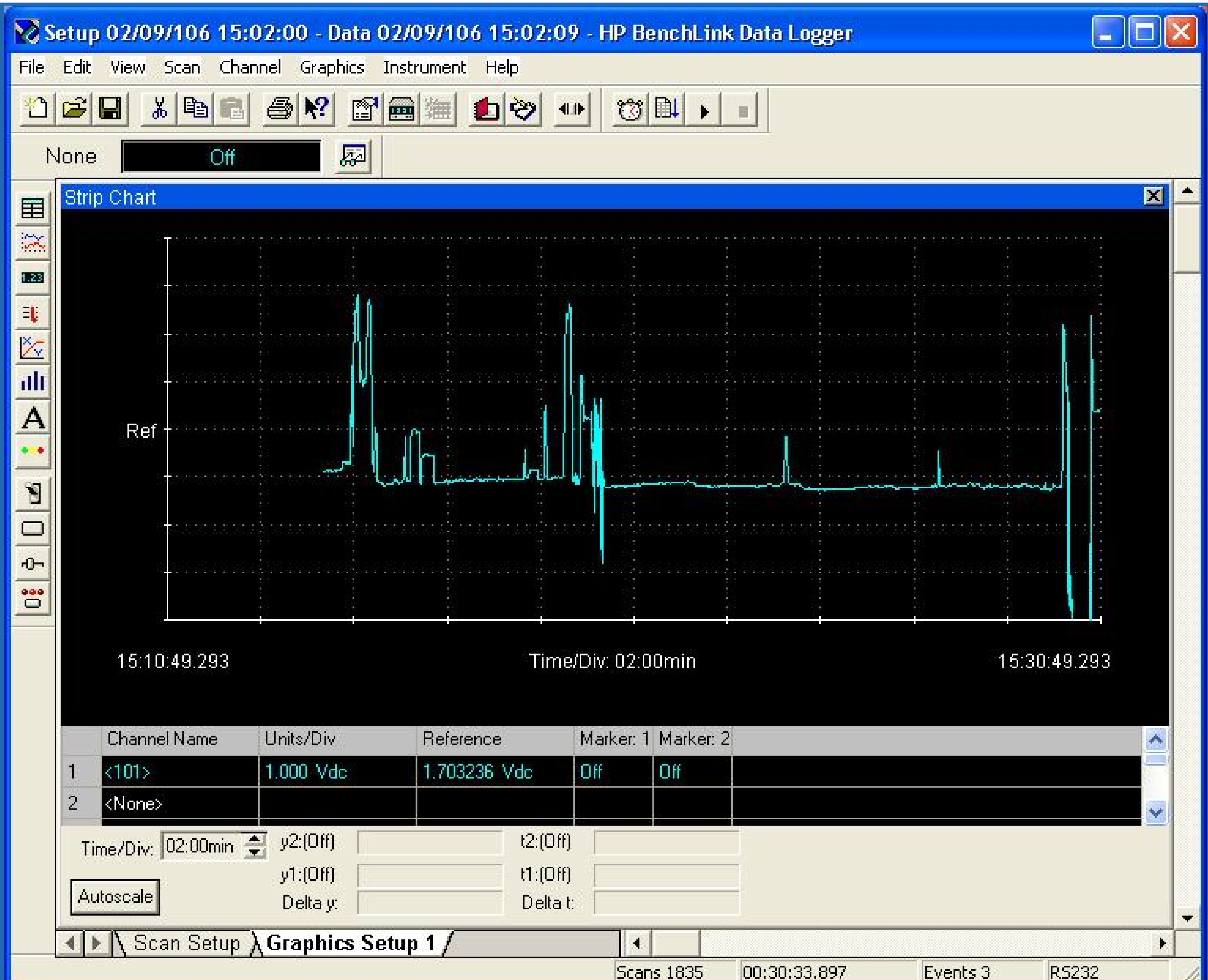
Water bucket, with observation window

Experimental facility

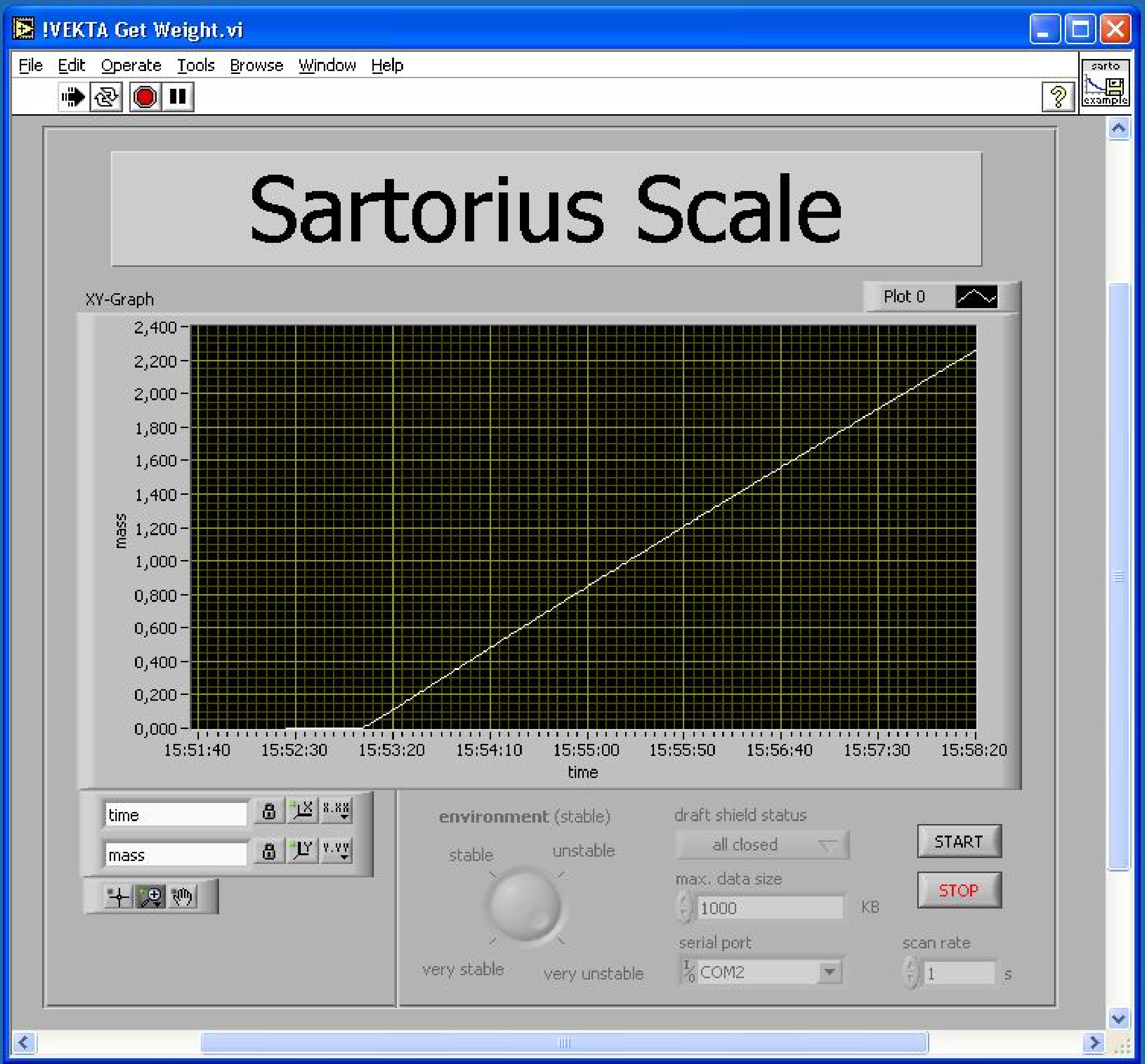
- Water tank, with floating oil
- Control valves
- Capacitance probe
- Outflow tank
- Electronic weight



Capacitance of out flowing liquid



Outflow rate measured by weight increase

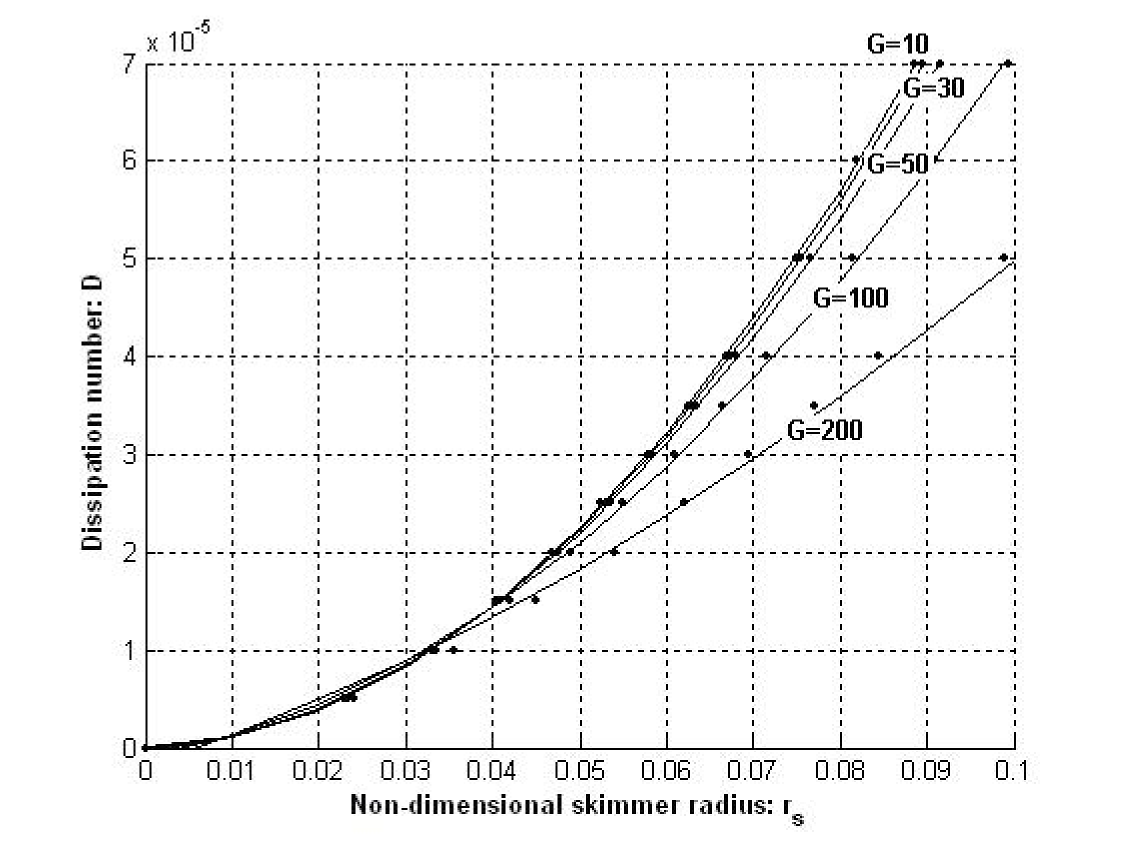


Theoretical results

- Skimmer capacity is governed by 4 dimensionless parameters
- For all viscosities, skimmer performance may be predicted numerically by the method developed
- The effect of viscosity is not quantified by the viscosity itself, but by a dimensionless number, called the: Goose Number
- For Goose Numbers below 50, skimmer performance is governed by viscous forces (viscid regime). An design formula has been developed, by analytical approximation .
- For Goose Numbers above 2000, skimmer performance is governed by inertial forces (inviscid regime). Traditional skimmer capacity formula apply

Viscid regime

low Goose Numbers

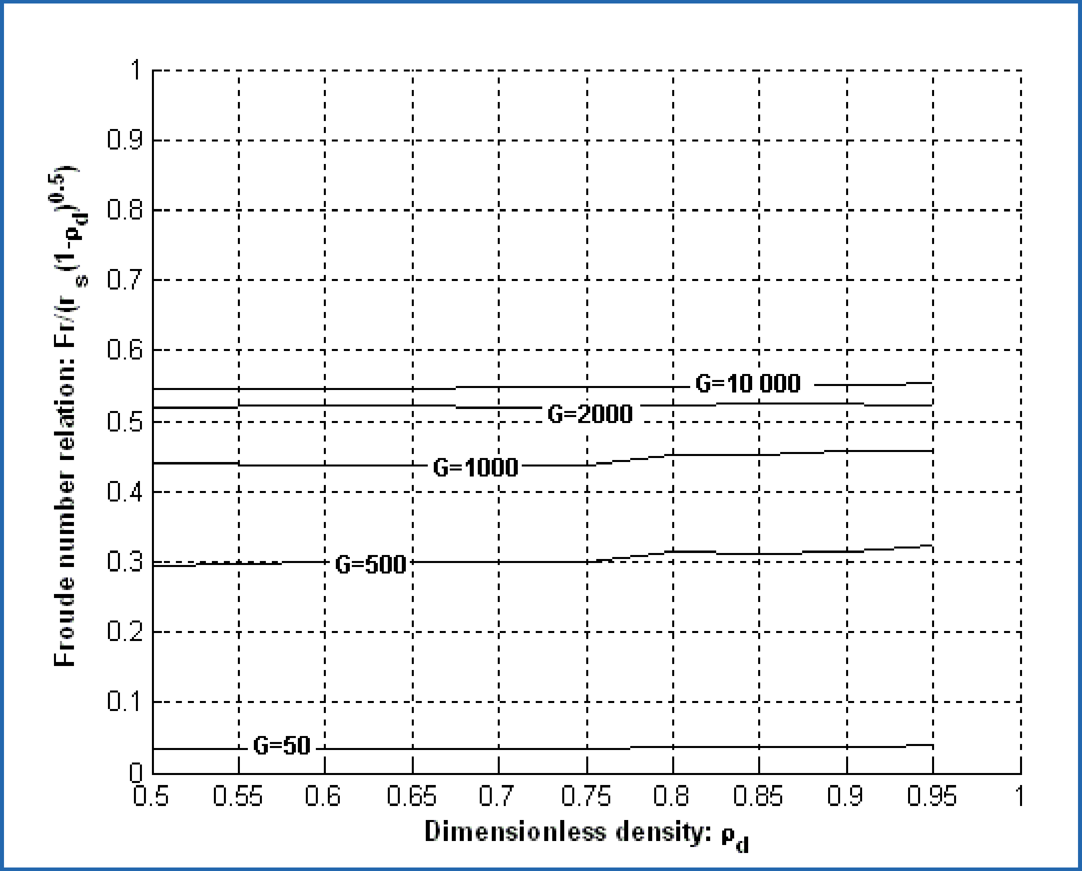


Skimmer design formula, for G<50

$$Q_o \approx \frac{\pi \rho_o g\ \tilde{r}_s^{\,2}\ h_e^{\,2}}{\mu_o}\left(\frac{1-\tilde{\rho}}{4-\tilde{\rho}}\right)$$

Inviscid regime

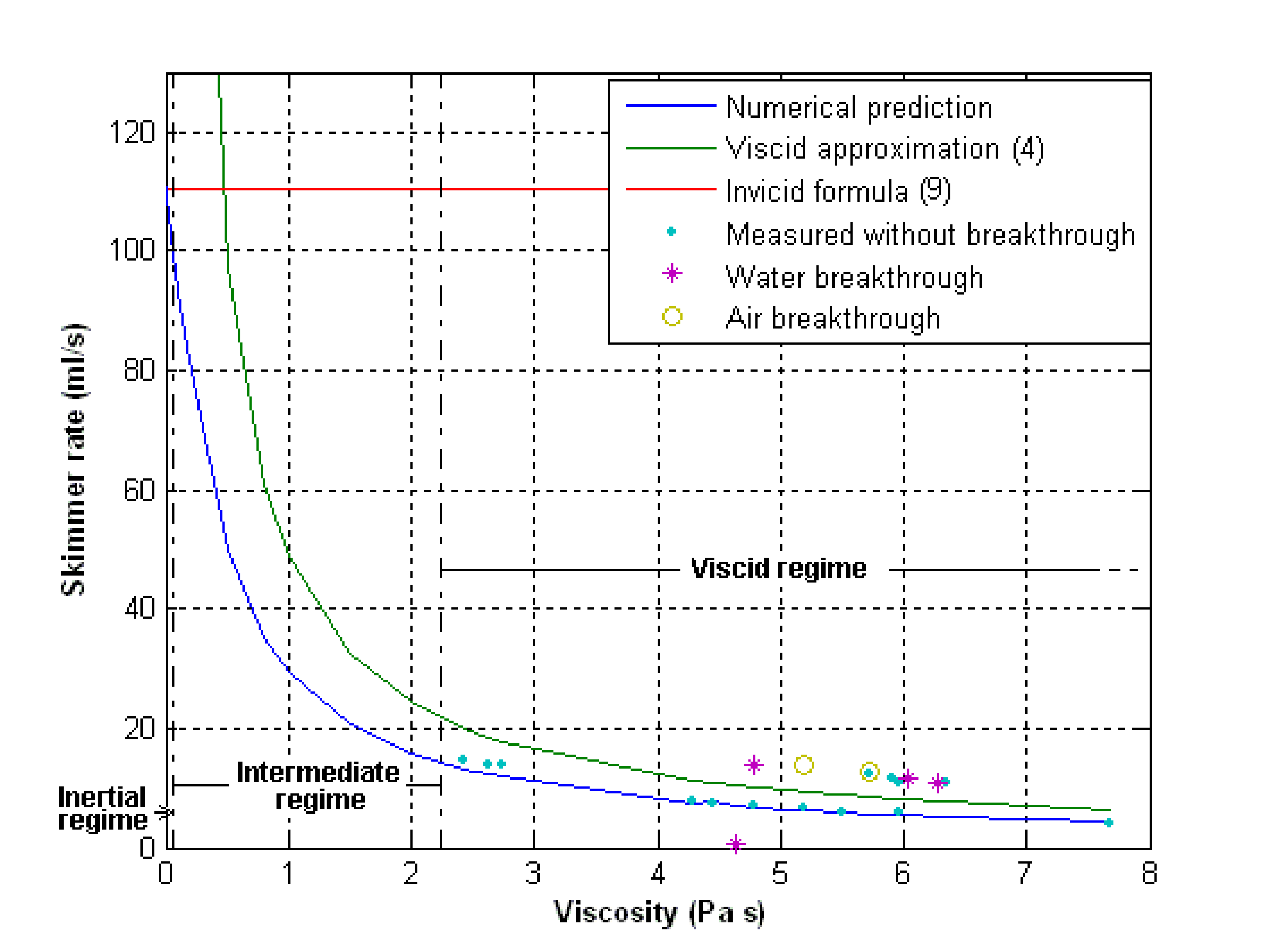
High Goose Numbers



Skimmer design formula, for G>2000

$$Q_o = 2\pi r_s \sqrt{\left(\frac{2h_e}{3}\right)^3 (1-\tilde{\rho})g}$$

Comparison of experiments and measurements



Conclusions- round up

- Traditional skimmer design formulae apply to the inviscid regime (Goose Number>2000),
- A new design formula has been developed for the viscid regime (Goose Number<50)
- Within the intermediate regime (50<G<2000), neither viscous nor inertial forces should be neglected . No design formula presented. Skimmer performance may be predicted by numerical solution
- The experiments support the theoretical results
- The current results assume newtonian fluid behavior
- Performance prediction enables optimization of skimmer design and operation