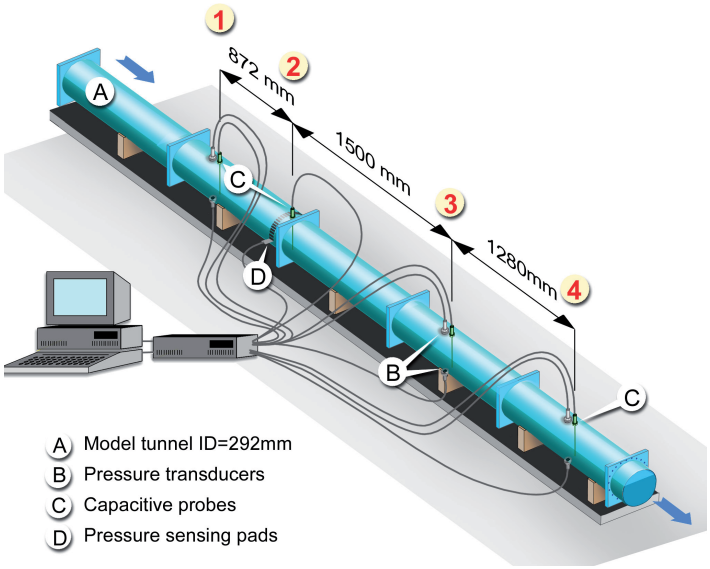
PhD - Air entrainment in Bottom Outlet Tailrace Tunnels (2006)

Common design criteria hydraulic structures such as bottom outlet tailrace tunnel, diversion tunnels etc, stipulate free surface flow within the structure as to avoid unpredictable conditions concerning air pressure and air discharges as well as pressure fluctuations in a possibly pressurized air-water discharge. Nevertheless, these criteria cannot always be attained for different reasons, e.g. supplementary heightening of dams. Another aspect possibly leading to flow conditions other than free surface mixture flow may be an unavoidable influence from the tail water.



Overview of the model test section. At four locations, level gauges and dynamic pressure measurments allow for complete description of the prevailing flow pattern.

This creates a need for more profound knowledge of the behaviour of these devices beyond the original design criteria. Special attention has to be paid to the several flow patterns that may occur in pressurized air-water flow.

In chemical and process engineering, various methods are common as to predict their presence and their characteristics in terms of head loss and pressure fluctuations. One example therefore is the Mandhane flow pattern map (1974) where the different possible flow patterns are categorized as a function of the so called superficial velocities of each phase (calculated as if each phase was flowing alone in the whole conduit). While this map is rather comprehensible, it suffers from the input parameters not being dimensionless. Direct applicability to hydraulic works scale is therefore not given.

A fully dimensionless approach was developed by Taitel&Dukler (1976) and is nowadays widely used in practice. Still, the theoretical description of the assumed transition mechanisms is partly simplified which hampers application to larger scale structures.

The goal of the present project is to close that gap between process and hydraulic engineering and to develop a predictive tool in terms of flow patterns and their characteristics including head loss and pressure fluctuations. Therefore, a model has been set-up consisting of a 34 m long pipe with an internal diameter of 0.292 m. A flow pattern map applicable to this pipe and larger conduits shall be developed and pressure fluctuations and head loss are measured and integrated into common approaches.

Keywords:	Multiphase flow, flow patterns, large conduits
Commissioned by:	Projekt- und Studienfonds der Schweizerischen Elektrizitätswirtschaft (PSEL)
Project status:	Completed 2006

Laboratory of Hydraulics, Hydrology and Glaziology
Versuchsanstalt für Wasserbau, Hydrologie und Glaziologie