CLAIMS

1. A method for estimating, for a water distribution network composed of a network of nodes and modeled as a graph, one or more water flow rates at boundaries of a sub-network of the water distribution network, said sub-network being a connected sub-graph of said graph, connected to the rest of the network by a finite set of arcs defining the boundaries, said method comprising:
   - Parameterizing a hydraulic model of the water distribution system with a set of values of control variables characterizing the network and its output at the nodes;
   - Using sensors on the water distribution network to acquire observations of a subset of state variables of the water distribution network at successive time references, said state variables comprising pressure and water flow rates;
   - Determining the set of values of control variables which minimize differences between predictions of state variables by the hydraulic model and observations of the subset of state variables by applying an optimization procedure;

   said method being characterized in that it further comprises:
   - Using said parameterized hydraulic model with the determined set of values of control variables, to calculate said one or more water flow rates at said finite set of arcs, for a period of time;
   - Summing said water flow rates at said finite set of arcs of the sub-network, for the period of time.

2. The method of claim 1, wherein the sensors on the network acquire measurements at least relative to water pressure at a subset of nodes of the network.

3. The method of claim 1, wherein the sub-network is predefined, and the sensors of the networks are iteratively placed in order to limit, at each iteration, one of

the maximum distance and the maximum pseudo-distance between any sensor and any node.

4. The method of any one of claims 1 to 3, wherein said optimization procedure comprises a stepwise adjustment of the set of values of control variables and a break criterion based on residue values of the state variables.

5. The method of claim 4, wherein the stepwise adjustment of the control variables comprises:
   - A) changing the set of values of the control variables;
   - B) using the hydraulic model to calculate predicted values of a set of state variables characterizing at least water velocity at the arcs and pressure at the nodes at the time references;
   - C) computing residue values of the set of state variables as a difference between predicted values and observed values at the time references;
   - D) changing the set of values of the control variables and going back to step B) if said difference does not satisfy a break criterion.

6. The method of claim 5, further comprising adding control variables in the set of control variables, and going back to step B, if said difference does not satisfy a refinement criterion.

7. The method of any one of claims 5 and 6, wherein computing residue values comprises calculating values of one of a least square, Bayesian objective function or absolute error function, and changing the set of values of control variables is determined by an iterative method comprising calculating one of a gradient, or a gradient and a Hessian.

8. The method of any one of claims 1 to 7, wherein the control variables comprise one or more of constant or time-based consumption profiles of users.

9. The method of claim 8, wherein consumption profiles of users are defined for a plurality of different categories of users.

10. The method of any one of claims 8 to 9, wherein control variables further comprise an estimation of water loss coefficient in the sub-network.

11. The method of any one of claims 8 to 10, wherein control variables further comprise an estimate of a water loss coefficient for at least one area, an area comprising at least a node based on a distance or a pseudo-distance to the sensors.

12. A system comprising a water distribution network composed of a network of nodes and modeled as a graph, the system being adapted to estimate one or more water flow rates at boundaries of a sub-network of the water distribution network, said sub-network being a connected sub-graph of said graph, connected to the rest of the network by a finite set of arcs defining the boundaries, said system further comprising:
    - Sensors of at least one of pressure, flow rate or water level of water tanks in the water distribution network;
    - a computing device comprising a processor;
    - communication links between sensors and one of the computing device or a measurement acquisition system;
    - a storage media;

    wherein the computing device is configured for:
    - Retrieving a set of values of control variables characterizing the network and its output at the nodes from the storage media and using it to parametrize a hydraulic model of the water distribution system;
    - Acquiring observations of a subset of state variables of said water distribution network, said state variables comprising pressure and water flow rates, said observations having time references, by either
        - using communication links between sensors and the computing device,
        - or retrieving observations in the measurement acquisition system;
    - Executing a method according to any one of claims 1 to 11.

13. A computer program product, stored on a non-transitory computer-readable medium, for estimating, for a water distribution network composed of a network

of nodes and modeled as a graph, one or more water flow rates at boundaries of a sub-network of the water distribution network, said sub-network being a connected sub-graph of said graph, connected to the rest of the network by a finite set of arcs defining the boundaries, said computer program product comprising code instructions for executing a method according to any one of claims 1 to 11.