Characterization of groundwater flow regimes in fractured bedrock aquifers on Southern Vancouver Island and the Gulf Islands of British Columbia are presently based on simple hydraulic testing methods and analytical models. Transmissivity, storativity and well capacity are derived from porous media (radial flow) analytical models that do not fully represent the more complex boundary conditions inherent to fractured bedrock aquifers. In this study, geological, horizontal loop electromagnetic (HLEM) and borehole geophysical surveys were used to characterize the lithology and structure of two fractured bedrock aquifers of low primary porosity (limestone/argillite and sandstone/mudstone), and to identify hydrostratigraphic and hydrostructural units and the associated boundary conditions. The applicability of constant-discharge aquifer testing and slug testing for determining hydraulic parameters of fractured aquifers was investigated by evaluating quantitatively each testing method and its associated analytical models (radial, linear, double porosity, unconfined). Pressure derivative analysis of the hydraulic test data aided in identifying boundary conditions and component flow regimes, thereby enhancing the analytical procedures.

Near-vertical, water-bearing fracture zones, identified using the geophysical techniques, were determined to be the most important unit for the transmission and storage of groundwater. These fracture zones are best represented in the conceptual hydrogeological models by vertical planar fractures or vertical dykes, and contribute to linear flow in the aquifer system, but approximate an equivalent porous medium (EPM). The surrounding bedrock aquifer (represented by a single hydrostratigraphic unit) is best represented in the conceptual hydrogeological models by an EPM, and is characterized by a radial flow regime. The calculated transmissivity and storativity values are subject to scale effects in that the values vary with the type of hydraulic test, the test duration, and the hydrostratigraphic or hydrostructural unit intersected by the well being tested. Transmissivity values range from $10^{-2}$ to $10^{1}$ m$^2$/day, and storativity values range from $10^{-9}$ to $10^{-3}$. Linear flow models provide the best fit to the data, and the radial flow models overestimate the transmissivity and storativity values by one half to one order of magnitude, respectively. An EPM/Discrete approach, which incorporates two superimposed EPMs as well as the fracture-related heterogeneity, is proposed to best represent the scale effects measured in the fractured bedrock aquifers in the two study areas.