

Introduction to the HKU Multi-Depth System (HKU-MDS) for Groundwater Monitoring

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1. Background

Groundwater systems exhibit complex 3D structures, with significant variations in water quality and hydraulic head across different depths. Conventional monitoring wells typically provide data from a single depth or a mixed signal from multiple depths, which fails to capture the vertical heterogeneity of the groundwater systems. Achieving accurate groundwater research, effective management, and sustainable protection requires substantially improved spatiotemporal resolution in monitoring.

Since the advent of the multi-depth monitoring systems in 1978, the widespread application has remained limited primarily due to design complexity, insufficient flexibility, and high costs. Most groundwater MDSs (e.g., CMT, PLUTE, Waterloo, and Westbay) rely on factory-preassembled, standardized configurations that are difficult to transport, expensive to procure, and inflexible for adaptation to specific project requirements or on-site conditions.

2. System Overview

The multi-depth system developed by The University of Hong Kong (HKU-MDS) is primarily constructed from standard PVC pipes and a small number of 3D-printed key components—including ports, connectors, and holders (Fig. 1). It is the most cost-effective system globally, as over 80% of its materials consist of locally available PVC pipes readily purchased from hardware stores. The system also features an inexpensive, practical water-activated swelling packer. Pre-wrapped around the system at designated depths prior to deployment, this innovative sealing unit ensures complete hydraulic isolation between monitoring intervals.

The core strength of HKU-MDS lies in its exceptional cost-efficiency throughout the entire workflow—from design and manufacturing to transportation and field installation. Its modular architecture enables on-site, segment-by-segment assembly, eliminating the high shipping costs and complex installation procedures associated with traditional systems. Typically, a 100-meter-deep monitoring system can be installed in just 2 hours.

Moreover, HKU-MDS offers exceptional customization flexibility: the number of monitoring intervals can be tailored to project-specific needs, and its outer diameter can be precisely matched to borehole dimensions, accommodating diverse geological and engineering conditions. For a given borehole diameter, HKU-MDS can accommodate far more monitoring zones than most existing commercial systems, thereby enabling higher-resolution profiling. Additionally, its reliable sealing technology replaces the labor-intensive conventional backfilling method using sand and bentonite.

3. Successful Applications and Further Information

HKU-MDS has already been successfully deployed in numerous projects: 5-depth systems in the Pearl River Delta to investigate groundwater dynamics and geochemical evolution; 6-depth systems in Mexico to track contaminant transport in groundwater; 18-depth systems in Taipei to support slope stability analysis.

As an open-source technology, HKU-MDS is now available worldwide and is applicable to a wide range of fields, including surface water–groundwater interaction studies, seawater intrusion monitoring, land subsidence assessment, investigations in karst and fractured rock aquifers, sponge city development, and mine groundwater management.

HKU-MDS is one of the eight technologies in HKU Depthwise HydrogeoSystem for high-resolution groundwater investigations, a joint project developed in collaboration with the Groundwater Project (gw-project.org). For more detailed information, technical documentation, or collaboration opportunities, please visit the official website: <https://hydrogeology.hku.hk/hku-dhs/>

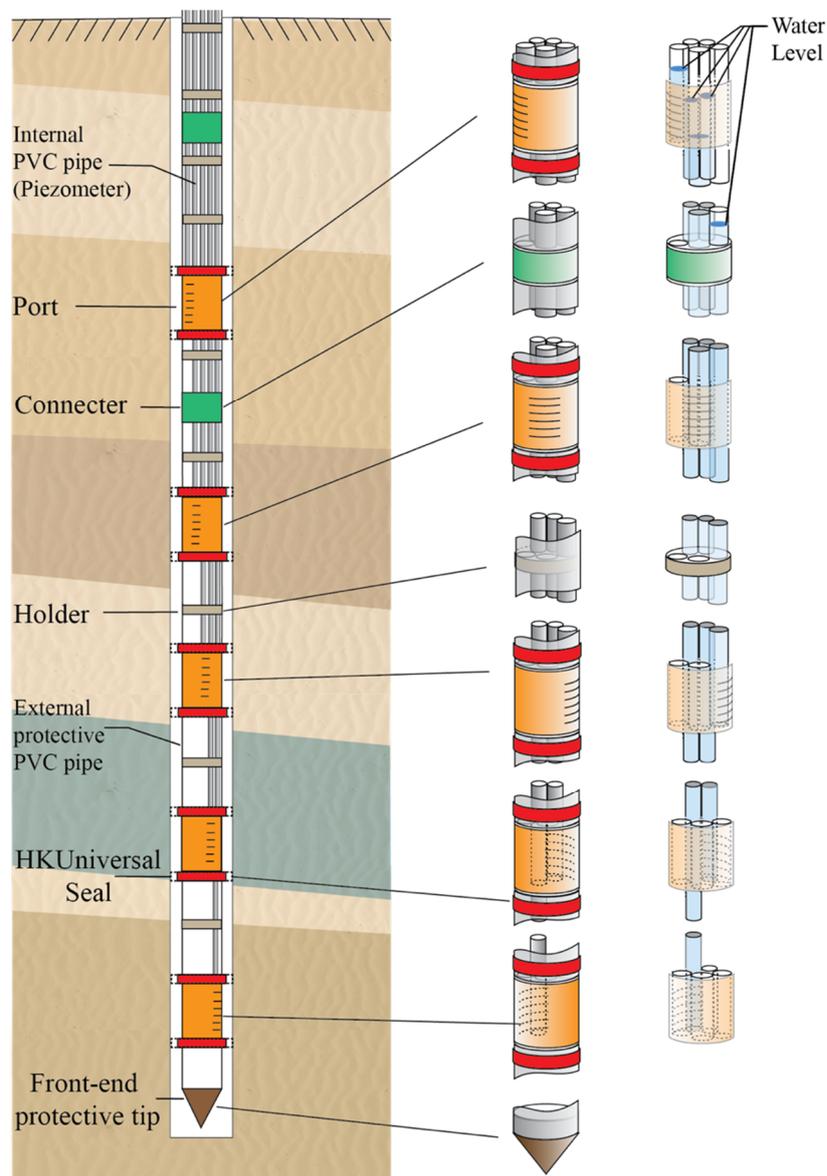


Figure 1. Schematic illustration of the HKU-MDS, exemplified with five piezometers.