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## **Water and Oil Do Mix! A Discussion on How Leading -Edge Oil Field Technologies are Applied to Groundwater Applications**

Schlumberger is the leading oilfield services provider for oil and gas companies around the world. Schlumberger Water Services (SWS), a division of Schlumberger is an international organization dedicated to groundwater management. The company has an array of integrated technologies and expertise for groundwater characterization and monitoring, advanced geophysical logging, software for seamless integration of data, from individual tests to large scale databases.

This presentation focuses on three leading-edge technologies used in Schlumberger's oil field services that are being used in integrated groundwater projects. These technologies include high-resolution borehole geophysics and image logging technologies, Petrel\* and ECLIPSE\* software and the management of data using wireless technologies.

During large-scale aquifer storage recovery (ASR) projects, high-resolution borehole geophysics and image logging technologies utilized in the oil field are used to provide the foundation for detailed aquifer characterization and valuable conceptual model development. These logs show portions of clay, dolomite, sand and free water in a multilayer aquifer with layers of confining clays and porous dolomites. The high resolution from these logs is capable of showing extremely detailed information whereby the clay is not pure clay, but a multilayer in itself with a high component of calcite. These logs also allow for an understanding of the formation dip of the strata, which is key to understanding preferential flow in some bedrock aquifers. Technologies utilized in this aquifer characterization are being used for a variety of groundwater projects around the world and will be discussed in brief.

Petrel\* and ECLIPSE\*, advanced modeling and visualization software from Schlumberger's oilfield services is used in large-scale aquifer storage and recovery projects. The integration of the necessary workflows surrounding simulation makes the dataflows transparent, thus reducing time and improving accuracy. Numerical models are generated using ECLIPSE\* software during the injection, storage and recovery phase of a pilot project. These models are vital in viewing the progression of the injection cycle creating a mound and the recovery cycle creating a depression. Petrel software is used for the optimization of well field efficiency to reduce the mixing that occurs between the injected water and the native groundwater in the aquifer. It is therefore desirable that the freshwater bubbles of each well in an ASR well field connect to create a single freshwater bubble at a prescribed depth. If a reasonable connection between the freshwater bubbles of each ASR well is not guaranteed, saline native water may be trapped between them, thereby having a negative impact on recovery efficiency.

InterACT can be used while drilling and performing geophysical logging. This software allows offsite hydrogeologists to visualize the logging in real time. Decisions regarding casing depths and screen placements can then be made based on information from the logs and interaction with the field crew can occur simultaneously. Additionally, once the wells are completed, data loggers can be installed to monitor water levels continuously. Well heads fitted with GSM telemetry can then be used to send the data via satellite to the office to be automatically uploaded to a central database.

\*Mark of Schlumberger

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Mr. Ken Campbell is a Senior Hydrogeologist at Schlumberger Water Services. Based in, Calgary, Alberta, Mr. Campbell has 35 years of professional experience in consulting and research in groundwater resource evaluation and development; hydrostratigraphy and regional hydrogeological mapping; solid waste management; mining hydrology; soil and ground-water remediation. In the course of his work, Ken has worked under provincial, state, EPA, and international environmental regulatory structures in Canada, United States, Asia, Middle East, Central and South America, and Europe. In addition to his consulting work, Mr. Campbell has participated as an instructor in drilling technology at the University of Wisconsin-Milwaukee. The author of several technical papers, Mr. Campbell was awarded the HSI Technical Excellence Award for Development of Innovative Techniques for Evaluating Dense Non-Aqueous Phase Liquids (DNAPL) sites.