Regional Characterization of Athabasca Oil Sands Area Groundwater Using Environmental Isotopes

Kathryn Pooley, Trevor Butterfield
Advisian, WorleyParsons Group, Edmonton, Alberta, Canada
Cynthia McClain
Environmental Monitoring and Science Division, Alberta Environment and Parks, Calgary, Alberta, Canada

ABSTRACT
Groundwater monitoring of Alberta Environment and Parks' North Athabasca Oil Sands (NAOS) and South Athabasca Oil Sands (SAOS) well network is a provincially-led groundwater management program, and is conducted under the mandate of the Groundwater Management Framework (GWMF) for the Lower Athabasca Region and the joint federal/provincial Oil Sands Monitoring Program. The 2016/2017 monitoring included sampling of select environmental isotopes in groundwater across the entire NAOS and SAOS networks.

Approximately fifty NAOS and SAOS groundwater wells were sampled and analyzed for a comprehensive set of both stable and radiogenic isotopic parameters (^{14}C, ^{13}C, ^{3}H, ^{18}O, ^{2}H) in 2016/2017. Previous monitoring of isotopic parameters included sampling in 2009 and 2012 in the NAOS network, but not in the SAOS monitoring network. The 2016/2017 isotopic data were used to estimate groundwater ages, evaluate aquifer and groundwater–surface water connectivity, and screen for monitoring well integrity. Six different age classifications (modern, mixing/modern, mixing, submodern, submodern [methanogenic] and submodern [high TDS]) were made throughout the networks.

An assessment of the results provided an indication of groundwater ages and flow dynamics at local- and regional-scales, insight into the hydrogeochemical conditions at some locations, and identification of potential integrity issues at individual monitoring wells within the network. In terms of local- and regional-scale groundwater flow dynamics, generally recharging conditions were observed for the area such that groundwater age generally increased with depth. The data also corroborated the subglacial hydrodynamic conditions previously interpreted by Grasby and Chen (2005) for the Western Canadian Sedimentary Basin. Based on groundwater and isotope chemistry of brine springs, Grasby and Chen (2005) suggested that there had been an influx of subglacial meltwater into pre-glacial formations during a reversal of the basin-scale flow system and proposed that this was caused by an overriding ice sheet. The radiogenic and stable isotope groundwater monitoring results from the fall 2016 and spring 2017 events supported this conceptual model by identifying isotope signatures indicative of glacially-derived groundwater in the Devonian and Cretaceous formations within the NAOS area. Results also provided insight into local hydrodynamic conditions, including: identification of potential locations of groundwater recharge from surface water, buried channels with potentially more direct hydraulic connection to surface, and areas where surficial sands were receiving groundwater discharge from stratigraphically deeper sources. An indication of hydrogeochemical conditions was provided by the ^{13}C isotope signature, with in-situ methanogenic conditions noted at some wells.

In addition to elucidating groundwater flow dynamics and hydrogeochemical conditions, the current isotopic data, both alone and in conjunction with observed shifts in primary indicator parameter concentrations, indicated potential integrity issues at up to about 20 monitoring wells. For example, tritium was detected in one of the deepest Beaverhill Lake wells, screened from 102 to 166 m below ground surface. The detection of tritium, combined with an observed shift between 2012 and 2016 in the ^{18}O-H_2O and ^{2}H-H_2O signatures, helped identify this well as potentially compromised. Overall, environmental isotope data have helped advance the understanding of groundwater flow dynamics and the status of monitoring well networks, as well as in-situ geochemical conditions, in the Athabasca Oil Sands Area.

REFERENCES:
Grasby, S.E. and Chen, Z. 2005. Subglacial recharge into the Western Canada Sedimentary Basin – Impact of Pleistocene glaciation on basin hydrodynamics. GSA Bulletin, March/April 2005. **117** (3/4): 500-514.