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Ecohydrological development of a reclaimed upland-wetland system constructed on soft tailings at an oil-sand mine, NE Alberta, Canada

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Oil-sand mine operators in north-east Alberta seek to demonstrate the viability of constructing wetlands that will develop into fen or bog peatlands on reclaimed mine landscapes. Syncrude Canada Ltd. constructed the 50 ha Sandhill Fen Research Watershed, a reclaimed area with uplands and lowlands designed for development of forestlands and wetlands. The experimental watershed was constructed on soft mine tailings deposited within a former open pit where the tailings water contains slightly elevated sodium concentrations from the ore and processing. The reclamation surface consists of mechanically placed sand hummocks and flat areas of various forms and elevations with a range of reclamation cover and vegetation prescriptions. The research objectives focus on evaluating the viability and efficacy of different choices for landform construction, reclamation cover materials and placement, and vegetation communities and densities. These objectives are met through field observations and modelling to quantify spatial and temporal variations in water budget components due to, for example, the sub-humid climate, the development of vegetation, and different substrates. Further analyses examine the migration and impact of solutes in process-affected water into and through the near-surface system.

Instrumentation and monitoring activities include: over 200 piezometers and wells with manual and continuous measurements of water level, electrical conductivity and temperature, plus water chemistry sampling; over 120 access tubes for manual measurement of soil-moisture content profiles; 32 automated sensors for measurement of soil-moisture content, tension, electrical conductivity and temperature at eight strategic soil-pit locations; over 100 upland vegetation plots, each with two automated soil-moisture tension sensors; three eddy-covariance stations to measure evapotranspiration and net carbon fluxes; and, three full meteorological stations and other hydrometeorological instrumentation. Forestland and wetland vegetation are regularly surveyed and inventoried, and saturated and flooded areas are mapped bi-weekly over the growing season. Up to six years of observations and data are available since reclamation material was placed, vegetation was planted and instruments were first installed. Interpretations are facilitated by using numerical models that couple water movement and changes in water storage in ponded surface water, groundwater and soil moisture to vegetation characteristics (e.g., roots and leaves) and atmospheric processes.

Shallow groundwater and surface water in the lowland area are highly responsive to precipitation events, including snowmelt, but demonstrate a limited catchment area and little direct input from deeper groundwater or adjacent hummocks. Recharge through hummocks appears to be limited by reclamation cover prescriptions and vegetation development. Similarly, vegetation development is sensitive to the capacity of the reclamation covers to store water available within the sub-humid climate. Near-surface occurrence of solutes from process-affected water appears to be associated with larger-scale flow paths and with precipitation input to shallow water tables.