



Final preparations for Alberta's biggest CO₂ Enhanced Oil Recovery in the Leduc Formation at Clive

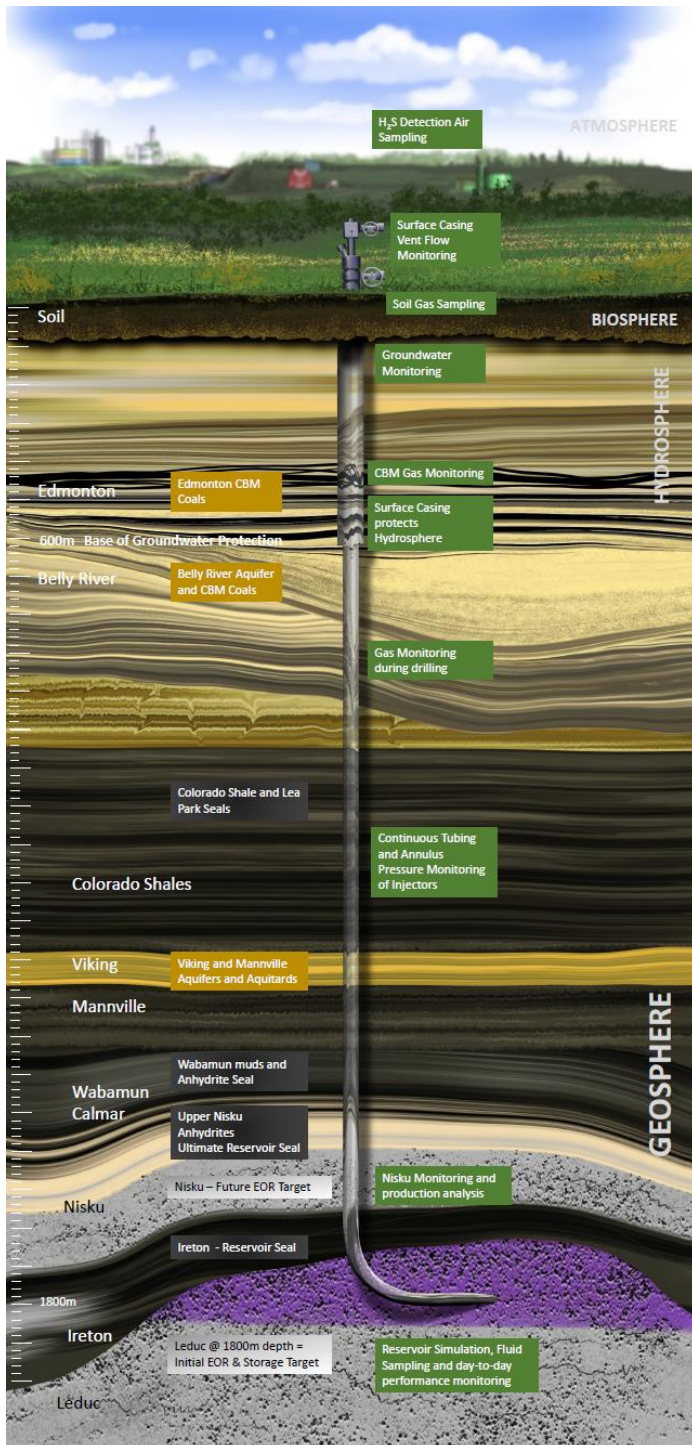
David Hills

Enhance Energy Inc. 2000, 500, 4th Ave SW, Calgary, Canada, T2P 2V6

In September of last year, Enhance Energy announced it had made arrangements for the financing and construction of the Alberta Carbon Trunk Line (ACTL). Under the agreement, Wolf Carbon Solutions will construct, own and operate the CO₂ capture and pipeline transportation assets, while Enhance will operate Alberta's first full scale CO₂ Enhanced Oil Recovery operation at its Clive Field. The ACTL has been designed to transport up to 14.6 million tonnes of CO₂ per year, which represents approximately 20% of all current oil sands emissions and equal to removing every car off of Alberta's roads. In this first stage of operation, due to begin in late 2019, the ACTL will transport 4,400 tonnes per day of high purity CO₂ from its partners at the recently opened Northwest Redwater (NWR) refinery, and Nutrien's Redwater Fertilizer facility at Fort Saskatchewan.

Among the many benefits that this program brings forward is the chance to add decades to the meaningful life of existing oil fields in Alberta. Clive is typical of the legacy oil fields throughout the province that have reached retirement age, where the costs of water management is closing oil revenue profit margins - yet vast oil reserves remain locked within these fields out of reach of the typical water flood. Clive's recovery of 47 million barrels represents between 40 and 50% of the total oil in place and typical EOR schemes have proven capable of recovering half of the remaining volume.

Environmental stewardship is paramount to Enhance's program at Clive, and it has built a rigorous environmental monitoring plan to ensure that CO₂ will reach its destination and remain there long after the program has completed operation. The first part of creating such assurance is the choice of geological target. In addition to having a size that allows for a feasible EOR program, the Leduc Pool at Clive also has the benefit of multiple geological seals between storage location and the base of groundwater protection. The Ireton carbonate shales provide the first level of protection between the Nisku and Leduc that as maintained hydrodynamic separation between the two pools. The ultimate seal, however, is provided by multiple anhydrite and shale layers between the Upper Nisku and Wabamun formations. Further protection is offered from the Joli Fou and Upper Mannville shales, followed by the Lea Park and McKay and Bearpaw shales. Careful management of the flood and iterative simulation work will protect from lateral movement of the CO₂ beyond the pool spill point.



The monitoring component of the project will encompass every geological level, from the reservoir to the surface, and include a variety of techniques. Prior to injection, a baseline of carbon isotope samples will be taken to serve as a carbon fingerprint database. These samples will then be compared to both injected gas samples and future samples of unknown origin, should the need arise. Reservoir monitoring and simulation will ensure the Leduc responds within expected parameters to the introduction of CO₂. Furthermore, Nisku Formation production monitoring will verify Ireton seal containment. Shallow production monitoring in the Cretaceous CBM zones will monitor CO₂ at the Base of Groundwater Protection (BGWP). Sampling domestic potable water wells will ensure public safety and confidence in containment. Soil gas sampling will take place throughout the CCLA as to give full public assurance. Due to inherent risk, wellbores will be the main focus of monitoring efforts; all wellheads will be monitored for surface casing vent flow events, as this is the most likely outcome of downhole failure. At surface, Supervisory Control and Data Acquisition (SCADA) systems will monitor and shut down injection wells, should a failure be detected. Air quality and safety systems designed to alert and prevent an escape of H₂S, which is present in Leduc and Nisku production, will inherently monitor for CO₂ leakage.

In addition to its environmental benefits, injecting CO₂ into the Clive field will profoundly increase oil recovery. In terms of expected EOR results, the project will extend the Clive unit operational life for more than 20 additional years. Using CO₂ to produce oil will create a new revenue stream for

the Alberta Government of up to \$15 billion in royalties, based on up to one billion barrels of CO₂ EOR potential along the first leg of the ACTL pipeline system for which Clive is the anchor project. All Albertans will benefit from the royalties and taxes the ACTL EOR projects will generate, in the form of education, essential services, health care, infrastructure, social programs and transportation.