

Hydrochemistry and Isotope Systematics of Regional Drift Aquifer Systems, Athabasca Oil-Sands (*in situ*) Area

Tony Lemay* and Sheila Stewart
Alberta Geological Survey, Alberta Energy and Utilities Board
4th Floor, 4999-50th Street, Edmonton, Alberta
Tony.Lemay@gov.ab.ca Sheila.Stewart@gov.ab.ca

ABSTRACT

The extensive regional Quaternary drift aquifers and Quaternary/Tertiary buried valley complexes in the Athabasca Oil Sands (*in situ*) Area south of Fort McMurray, Alberta (Figure 1), have long been assumed to contain vast quantities of groundwater. The oil sands industry will need water of suitable chemistry for successful development of *in situ* projects. Where sufficient volumes of treatable brackish water from deep formations are limited or unavailable, potable to near-potable groundwater from drift aquifers may be used as a source of make-up water. Major questions remain as to the sustainable yields of these drift aquifers and the chemical nature of the groundwater therein.

INTRODUCTION

Ongoing work at the Alberta Geological Survey seeks to determine the sustainable yields of the drift aquifers, understand the controls on groundwater chemistry, and document baseline hydrogeological conditions prior to intensive energy development. This poster provides an update of ongoing efforts towards understanding the geochemistry of the drift aquifers.

A field program was conducted during the summers of 1999 to 2001 to collect high quality groundwater samples. The program had three components:

- 1 Sampling of water from domestic water wells, existing observation wells, and springs discharging from drift aquifers;
- 2 Sampling of produced water from oil and gas wells;
- 3 Sampling of new piezometers installed as part of this program.

This poster will present preliminary results for the first two points.

SAMPLING METHODS AND ANALYTICAL PROGRAM

An extensive list of analytes was constructed (Table 1) in order to arrive at the best possible baseline characterization and geochemical understanding of the drift aquifers in the study area. The groundwater sampling protocols used in this program were developed from the combined practices of the United States Geological Survey, the United States Environmental Protection Agency, and geochemical specialists at the University of Calgary, the University of Alberta and the University of Saskatchewan.

Sampled wells were carefully chosen based on location, completion depth, and quality of well construction based on drillers' reports. High quality water samples from these wells, AGS piezometers, and samples from a spring discharging from an exposed section of a Quaternary/Tertiary buried channel were collected along with quality control samples. The samples were analyzed for major, minor and trace constituents, organic acids, naturally occurring radioactive materials, stable isotopes and radiogenic isotopes. Additional historical chemical information was gathered from analyses performed by the Alberta Research Council and Alberta Environment as well as produced water analyses collected by the Alberta Energy and Utilities

Board. The additional sample points were selected based on well completion quality and charge balance criteria.

INITIAL RESULTS

Initial interpretation of the collected data suggests a number of hydrogeological and geochemical processes are causing substantial regional variability in groundwater chemistry. These processes include mixing of waters of meteoric, and possibly glacial origin, with basinal waters emanating from deeper formations, as well as water-rock interactions. The piezometric surface developed for the Quaternary aquifers suggests that flow is dominated by topography, flowing from recharge in the Moostoos Uplands and other highlands towards the Christina, Horse, Wandering and Athabasca River basins. Flow within the major Quaternary/Tertiary buried channel in the study area is towards the Athabasca River.

ONGOING ACTIVITIES

Work continues on better defining the nature of the water-rock and water-water interactions. Statistical analyses of the data along with geochemical and GIS analyses will help explain not only point by point chemical characteristics, but also will place the data and results of analyses in a spatial context from which the regional chemical system can be examined and defined.

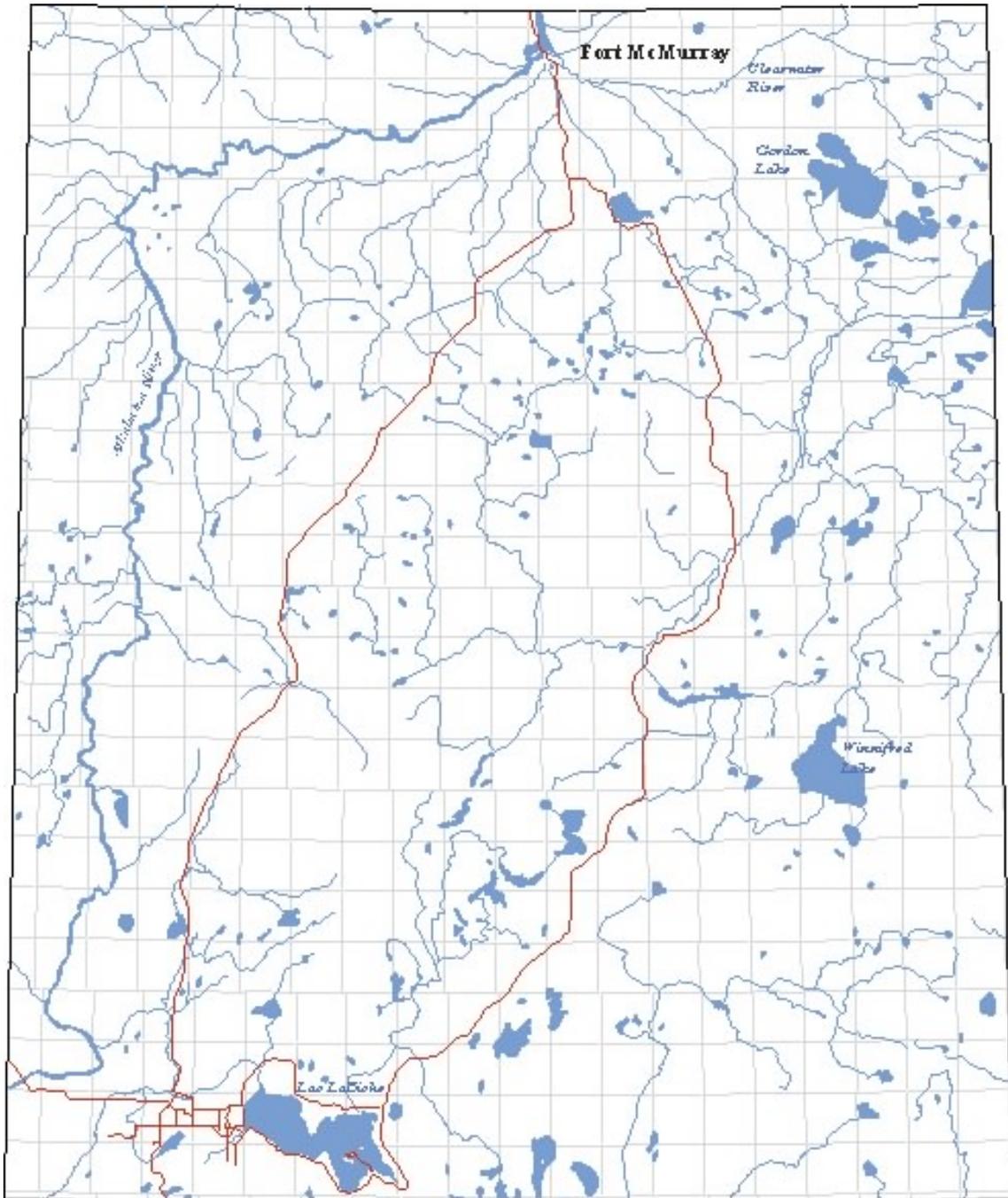


Figure 1 - Study Area

Chemical parameter	Reason for analysis
Major, minor and trace elements	Process identification (i) water rock interaction (ii) mixing of different waters (iii) mineral dissolution and precipitation Health concerns Geothermometry and age dating Oil and gas, and mineral exploration tool
Organic Acids	Many are water-soluble and naturally occurring. The potential exists for complexation between organic acids and metals, facilitating transport of the metals.
$\delta^{18}\text{O}$ and $\delta^2\text{H}$	Water Source Paleohydrogeology Renewability of the resource
$\delta^{13}\text{C}$	Process identification (i) dissolution of carbonate minerals (ii) dissolution of organic carbon (ii) solution of atmospheric or soil CO_2 (iii) rates of decomposition and burial of organic matter (iv) mixing of waters Tracing pathways by which C enters or leaves groundwater
$\delta^{34}\text{S}$	Process identification (i) dissolution of evaporite gypsum (ii) dissolution of organic matter (coal or peat) (iii) dissolution of sulphide minerals (ii) sulphate reduction Tracing pathways by which S enters or leaves groundwater
$\delta^{11}\text{B}$	Process identification (i) mixing of waters (ii) water rock interaction (iii) anthropogenic input
$\delta^{87}\text{Sr}$	Process identification (i) mixing of waters (ii) dissolution of carbonates (iii) weathering of continental crust (iv) weathering of volcanic rocks Water source
Naturally Occurring Radioactive Materials (NORMs)	Health concerns Process identification (i) mixing of waters

Table 1 - Chemical parameters and reasons for analysis.