Introduction

- Hydraulic fracturing in Northeast British Columbia (NEBC) produces large quantities of saline wastewater that must be managed responsibly.
- Most commonly, waste is injected via disposal well into deep, permeable geologic units known as aquifers (Fig. 1).
- These aquifers are host to natural waters that are much less dense than the waste being injected into them. The difference in density between the two fluid types affects how the wastewater migrates through the subsurface.

\[ V = \pi r^2 h \theta \]

There is little to no monitoring of wastewater once it enters the subsurface. Industry instead calculates the lateral extent of wastewater extent using simple volumetric calculations. The accuracy of these calculations is suspect, as they do not take into account mass transport processes or the effect of varying fluid density.

- There is potential for wastewater to contaminate shallow groundwater by migrating upwards through preferential pathways such as improperly cemented or damaged well casings.

Research Objectives

1. Characterize the shape and extent of wastewater plumes created in the subsurface by disposal wells due to varying conditions in the subsurface.
2. Model historic disposal of wastewater and extraction of source water from the Paddy-Cadotte Formation in NEBC.

Meeting these objectives will allow for a better understanding of the potential for shallow groundwater contamination by wastewater. The groundwater modelling code PEFLOW is used to simulate disposal.

Study Area

- Group of disposal and source wells 20 km to the west of Dawson Creek (Fig. 3).
- Wells have been operating for ~5 years and target the Paddy-Cadotte formation (Fig. 4), which is 1 km below surface.
- Paddy-Cadotte is bounded above and below by low permeability shales, which help confine the waste.

Model Setup and Results

- A simple, axisymmetric box model (Fig. 5) was constructed in which 100 m³/day of saline wastewater (200 g/L NaCl) was injected into a formation host to fresh water (0 g/L NaCl). Disposal was simulated for one year, after which time injection was stopped and the model was allowed to recover for 20 years.

- Model results (Fig. 6) show that the shape and extent of the wastewater plume vary greatly from that estimated using industry calculation. During pumping, mass transport processes cause the plume to spread twice as far as initially estimated by industry. Density differences between fluid types causes the plume to extend further at its base relative to its top. During the recovery period, density effects become significant, resulting in the plume flattening out and spreading along the bottom of the aquifer. After 20 years of recovery, the plume extends over four times further than it would based on industry calculations alone.

Conclusions and Future Work

- Volumetric calculations used by industry to estimate plume extent are inaccurate, as they do not take into account mass transport processes or density effects.
- Potential for contamination of shallow groundwater is very low due to the overlying low permeability shale and the tendency for dense waste to sink to the bottom of the disposal formation.

- These results will be used to help construct a regional model of the Paddy-Cadotte in which historic injection/extraction of water for all disposal/source wells in Fig. 3 will be simulated. This will allow for delineation of plume extent up to present.

Acknowledgements

This project is being carried out in association with the British Columbia Oil and Gas Commission and the Encana Corporation. Funding is provided by the Pacific Institute for Climate Solutions.