

Report as of FY2007 for 2006FL143B: "Investigating arsenic mobilization during aquifer storage recovery (ASR)"

Publications

- Dissertations:
 - Norton, S. Quantifying the Near-Borehole Geochemical Response During ASR. Masters Thesis. University of Florida. May, 2007.

Report Follows

Status Update

Investigating Arsenic Mobilization During Aquifer Storage Recovery (ASR)

Project Background

Due the growing demand on water resources within the State of Florida, alternative water supply and water storage technologies are becoming increasingly attractive to municipalities. Aquifer Storage Recovery (ASR) has the potential to provide much of the seasonal storage need for many municipalities within areas of increased water demand. However, as with any engineered water supply process, ASR must meet stringent Federal and State regulations to insure the protection of human health and the health of the environment.

Recently, facilities in southwest Florida utilizing the Suwannee Limestone of the Upper Floridan Aquifer for ASR have reported arsenic concentrations in recovered water at levels greater than 112 µg/L (Arthur et al., 2002). On January 23, 2006 the Maximum Contaminant Level for arsenic was lowered from 50 µg/L to 10 µg/L (FDEP: Chapter 62-550 F.A.C., Table 1).

Research has been conducted to determine the abundance and mineralogical association of arsenic within the Suwannee Limestone (Pichler, et al., 2006). This research suggests that the bulk matrix of the Suwannee Limestone generally contains low concentrations of arsenic. However, according to this research, arsenic is concentrated within the Suwannee Limestone in arsenic bearing minerals such as pyrite.

The potential mechanisms by which arsenic may be mobilized during ASR have been investigated (Arthur, et al., 2002) and suggested by others (Pichler, et al., 2006). The conclusions of this research suggest that the introduction of the injectate containing oxidants, such as oxygen and chlorine, into a highly reduced groundwater environment produces a geochemical response that releases arsenic from the aquifer matrix.

Several ASR projects are under testing in southwest Florida. Of these, the recently constructed Bradenton Potable ASR facility presents several benefits for further research including the following:

- Only a few small volume recharge and recovery cycles have been performed at the facility. Therefore, the aquifer matrix has not been repeatedly exposed to water with high levels of oxidizers.
- One large volume cycle was recently completed (Cycle 6) with recharge being initiated immediately at the end of the recharge event. Because no storage occurred during this cycle it may be possible to determine the rate at which the oxidizers are consumed in the matrix.
- The data sets collected to date at this facility are fairly extensive.
- The City of Bradenton has authorized the use of the data set in this study.
- Site access has been granted by the City of Bradenton.

Work Scope

Based on the research completed to date, it appears that one of the primary mechanisms by which arsenic is mobilized during ASR is by the introduction of oxidizers into the aquifer. Therefore, the following work scope was developed to further evaluate the role of oxygen and other oxidizers in the mobilization of arsenic during ASR:

- Compile and evaluate in-situ measurements collected at the Bradenton ASR site during recovery for Cycle 6 to include field measurements (pH, temperature, dissolved oxygen,

- conductivity, and ORP) and laboratory measurements (sulfate, sulfide, hydrogen sulfide, carbonate, bicarbonate, total chlorine, total phosphorous, and ortho-phosphate).
- Review the data being collected per the FDEP temporary operations (cycle testing) permit for this facility and additional data being collected by FGS.
 - Employ Istok's approach to data analysis and compare Istok's push pull test method to the current method of Cycle Testing regulated by FDEP.
 - Utilize the existing Bradenton ASR data to:
 - Attempt to quantify the consumption rates (reaction rates) of oxygen and other oxidizers (i.e. chlorine) during ASR.
 - Investigate the applicability of solute transport models to predict the behavior of arsenic during ASR to suggest future studies.
 - Make suggestions for further studies.

Schedule and Deliverables

The timeline to complete this research and submit a paper for publication will be as follows:

- In-Situ data collection occurs January 2006.
- FGS grant awarded by end of February 2006.
- WRC funding awarded by end of March 2006.
- Funds dispersed over three semesters; Summer 2006, Fall 2006, and Spring 2007.
- Thesis defense Spring 2007.
- Thesis submitted for publication Spring 2007.

Project Status

Funding was awarded from the FGS and WRC, through the State Water Resources Research Institute (WRRRI) Program and the following research components are underway.

In-Situ data collection and review was extended through March 2006 to include Cycle 6a conducted at the Bradenton ASR facility. The available field data and laboratory analytical data have been reviewed. Istok's push-pull analytical model has been employed to quantify DO consumption rates. Results are similar for three of the four cycle tests completed to date. The results indicate that DO undergoes first order decay during ASR. Variability in the measured decay rates appears to be due to a reaction rate dependence on temperature (Prommer, 2005). While recharge water temperatures were similar for three of the four cycle test, one of the test was conducted during the summer with recharge water temperatures exceeding 30°C. Therefore, additional computations are underway to correlate the decay rate at varying temperatures.

A review of potential reactive transport (geochemical transport) models is nearly complete. The reactive transport model PHT3D appears best suited for modeling arsenic mobilization during ASR. PHT3D couples the geochemical model PHREEQC-2 with the multi-component transport model MT3DMS. The model is being maintained by Henning Prommer at the University of Western Australia. Future studies may include the application of PHT3D to the Bradenton dataset, or others.

A project status update was presented, in power-point format, to the graduate committee (Dr. Mike Annable and Dr. Kirk Hatfield) and Dr. Jon Arthur of FGS on November 9, 2006. Two committee members, Dr. Mark Newman and Dr. Jean-Claude Bonzongo could not attend the presentation. Therefore, separate review meetings will be held with these members in the near future. Comments received by the committee members and FGS will be incorporated into the draft thesis due April 2007.

Dr. Arthur has expressed his interest in providing funding support for continuing the project during the following year. A prospectus will be drafted for review by the graduate committee and subsequent submittal to FGS for approval.

References

Arthur, Jonathan D., Dabous, Adel A., and Cowart, James B., 2002, Mobilization of arsenic and other trace elements during aquifer storage and recovery, southwest Florida: USGS Open-File Report 02-89

Price, Roy E., and Pichler, Thomas, 2006, Abundance and mineralogical association of arsenic in the Suwannee Limestone (Florida): Implications for arsenic release during water-rock interaction: *Chemical Geology*, Vol. 228, pp. 44-56

Prommer, Henning, and Stuyfzand, Pieter J., 2005, Identification of temperature-dependent water quality changes during a deep well injection experiment in a pyritic aquifer: *Environmental Science and Technology*, Vol. 39, pp. 2200-2209