United States Department of the Interior

U. S. GEOLOGICAL SURVEY
Arizona Water Science Center
520 N Park Ave Ste. 221
Tucson, AZ 85711
Office: (520) 670-6671 Fax: (520) 670-5592

March 17, 2015

MEMORANDUM

SUBJECT: Opportunities to understand the inherent uncertainty of potential changes to riparian areas in response to the Rosemont Copper Project

On March 9, 2015, the U.S. Geological Survey (USGS) presented their results from Task 4: USGS Review of Boundary Condition Test Documentation during a meeting with the Coronado National Forest (CNF), U.S. Fish and Wildlife Service (FWS), and SWCA Consultants. The purpose of Task 4 was to perform a peer review of the documentation of a series of tests on the possible effects of selected boundary conditions in two numerical groundwater models for the Rosemont Copper project. In evaluating the test results, the USGS identified three topical areas that would substantively improve the groundwater models' capacity to simulate inherent uncertainty in the groundwater system:

Topic Item 1: Increase range of storage parameter values in uncertainty analyses

In transient groundwater flow systems, the timing and magnitude of changes in drawdown and flow are highly sensitive to storage parameters. The documentations of the models include a range of drawdown from varying storage values by a factor of 1.5. In many aquifer systems, however, research shows storage properties can range by several orders of magnitude with strong effects on groundwater model response (Anderson and Freethey, 1996). To improve the models' ability to explain system uncertainty, specific yield could be varied by an order of magnitude and specific storage by three orders of magnitude.

Topic Item 2: Employ Monte Carlo approach to improve prediction uncertainty

The range of possible effects on surface features is unknown, or uncertain, because of limited knowledge of the hydrologic system. Monte Carlo approaches are widely adopted for evaluating groundwater-model uncertainty in environmental decisions (*e.g.*, Wagner and Gorelick, 1987; Leake and others, 2005; Refsgaard and others, 2007; Brakefield and others, 2013; Sepúlveda and Doherty, 2014). A Monte Carlo approach generates a range of potential predictions that effectively identifies uncertainty in the groundwater system. A Monte Carlo approach applied to the Rosemont project groundwater models, varying key variables of hydraulic conductivity and

storage parameters (specific yield and specific storage) with constant head and no-flow boundary conditions, would improve the models' ability to characterize system uncertainty.

Topic Item 3: Use water-budget approach to evaluate effects to riparian areas

To better understand the project effects on the discharge of water to springs and streams, a water-budget approach, in addition to the current drawdown analysis, could be employed. Some springs and streams that have been identified as important for ecosystems are not explicitly simulated in the models. The potential change in discharge can be examined by adding appropriate boundaries that represent these features in the models.

References cited:

Anderson, T. W., and G. W. Freethey, 1996, Simulation of ground-water flow in alluvial basins in south-central Arizona and parts of adjacent states, U.S. Geol. Surv. Prof. Pap., 1406-D, http://pubs.usgs.gov/pp/1406d/report.pdf.

Brakefield, L., Hughes, J.D., Langevin, C.D., and Chartier, K., 2013, Estimation of capture zones and drawdown at the Northwest and West Well Fields, Miami-Dade County, Florida, using an unconstrained Monte Carlo analysis: recent (2004) and proposed conditions: U.S. Geological Survey Open-File Report 2013–1086, 124 p., http://pubs.usgs.gov/of/2013/1086.

Leake,S.A., J.P.Hoffmann, and J.E.Dickinson, 2005, Numerical ground-water change model of the C aquifer and effects of ground-water withdrawals on stream depletion in selected reaches of Clear Creek, Chevelon Creek, and the Little Colorado River, northeastern Arizona, U.S. Geological Survey Scientific Investigations Report 2005-5277, 39 p., http://pubs.er.usgs.gov/usgspubs/sir/sir20055277

Refsgaard, Jens Christian, et al, 2007 "Uncertainty in the environmental modelling process–a framework and guidance." Environmental modelling & software 22.11 (2007): 1543-1556.

Sepúlveda, N. and Doherty, J., 2014, Uncertainty Analysis of a Groundwater Flow Model in East-Central Florida. Groundwater. doi: 10.1111/gwat.12232

Wagner, B. J., and S. M. Gorelick, 1987, Optimal groundwater quality management under parameter uncertainty, Water Resour. Res., 23(7), 1162–1174, doi:10.1029/WR023i007p01162.