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United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Reston, VA 20192

TAKE PRIDE IN AMERICA

In Reply Refer To:
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200990-DO

NOV 13 2008

Mr. Neal McAliley
White & Case, LLP
Wachovia Financial Center, Suite 4900
200 South Biscayne Boulevard
Miami, Florida 33131-2352

Dear Mr. McAliley:

This letter is written in response to your complaint of September 11, 2008, regarding four technical publications related to water supply and water quality in the Miami-Dade County, Florida. USGS Office of Ground Water senior scientists evaluated the technical issues raised in the Information Quality Act (IQA) complaint. These senior scientists were not previously involved with the Miami-Dade Project in question. The senior scientists read the complaint, read the four journal articles that are the subject of the complaint, and reviewed the response of the authors to the technical issues raised on pages 11-15 of the IQA complaint. The questions raised about the press release were not evaluated, as press releases are outside the scope of the IQA. It is our judgment that the four journal articles do not contain false statements and technical errors in violation of Office of Management and Budget and USGS guidelines as alleged by the complainant. Attached are detailed responses to the technical comments.

Cordially,

Matthew C. Larsen

Matthew C. Larsen
Associate Director for Water

Attachment

Response to the Complaint About Information Quality in the following technical articles:

Renken, R. A., Cunningham, K. J., Shapiro, A. M., Harvey, R. W., Zygnerski, M. R., Metge, D. W., and Wacker, M. A., 2008, Pathogen and chemical transport in the karst limestone of the Biscayne aquifer, 1: Revised conceptualization of ground water flow, *Water Resources Research*, doi: 10.1029/2007WR006058.

Shapiro, A. M., Renken, R. A., Harvey, R. W., Zygnerski, M. R., and Metge, D. W., 2008, Pathogen and chemical transport in the karst limestone of the Biscayne aquifer, 2: Chemical retention from diffusion and slow advection, *Water Resources Research*, doi: 10.1029/2007WR006059.

Harvey, R W., Metge, D. W., Shapiro, A. M., Renken, R. A., Osborn, C. L., Ryan, J. N., Cunningham, K. J., and Landkamer, L., 2008, Pathogen and chemical transport in the karst limestone of the Biscayne aquifer, 3: Use of microspheres to estimate the transport potential of cryptosporidium parvum oocysts, *Water Resources Research*, doi: 10.1029/2007WR006060.

Renken, R. A., Cunningham, K. J., Zygnerski, M. R., Wacker, M. A., Shapiro, A. M., Harvey, R. W., Metge, D. W., Osborn, C. L., Ryan, J. N., 2005, Assessing the vulnerability of a municipal well field to contamination in a karst aquifer, *Environmental and Engineering Geoscience,* v. 11, 319-331.

In the following discussion, the ***Page*** and ***Item*** refer to the page and item in the letter of complaint dated September 11, 2008.

Page 11, Item A. The Results of the Field and Laboratory Tests Described in Paper 3 Were Biased Due to Flaws in the Study Design

The complaint claims that excessive quantities of microspheres were used in the laboratory and field tests, which results in a bias in the results reported in Harvey et al. (2008). In response, the comments regarding the laboratory tests and the field tests are addressed separately.

<u>Laboratory Column Test</u>. The claim of excessive quantities of microspheres added to the limestone core may be the result of a misunderstanding of the experimental design. As indicated in Figure 1 of Harvey et al. (2008), the microspheres were added as a short-term pulse by an injection loop, rather than addition in the carrier fluid (artificial groundwater) that provided the long-term water flux through the column. Consequently, the initial concentration of microspheres added to the column was immediately diluted by the carrier fluid and decreased rapidly. Because of dilution with the much larger volume of carrier fluid and because of the short-term nature of the "pulse" introduction, a substantial concentration of oocysts and microspheres in the injection loop had to be added to the column to allow accurate quantification of the tailing portion of breakthrough after almost two log units of removal. This setup allowed a much more modest addition of colloids and tracer to the column than would have been the case if the injectate was added by continuous feed. Evidence provided by the breakthrough curves

indicated that the column was far from saturation. Also, any substantive plugging of the column porosity by colloids would have resulted in an increased pressure required by the piston pump to deliver the same volumetric flow rate (water flux) through the column. This was not observed. The column test indicated that any transport through the matrix porosity should result in good removal of *Cryptosporidium parvum* oocysts. The column tests also indicated that the microspheres would be better removed in the aquifer than the oocysts. The later observation was also consistent with the measured differences in surface charge (zeta potential) between the two types of colloids. The comparative transport behavior of the oocysts versus the microsphere surrogates depends upon their surface properties and would be valid regardless of a higher or lower input concentration.

Field Test. In the design of the field experiment there was a need to measure concentrations of microspheres after many log units of dilution that occurred at the pumping well. This is because the injectate, which traveled along a horizontal highly permeable flow zone, experienced many log units of dilution at the high-capacity municipal supply well that collects groundwater from many directions; a large volume of the 8-12 million gallons per day pumped from the production well comes from orientations that are not aligned along the orientation between the injection well and the production well. If lower concentrations of the 3- and 5-micron microspheres in the field test were used, the concentrations of the microspheres could not have been quantified in the sampled well water. A larger concentration of the smaller microspheres was needed because they had to be enumerated under higher magnification and a correspondingly smaller field of view. The results of the field test showed that a log unit lower concentration for the 2 micron microspheres could have been used in the field test and the results could still have been quantified. The choice of the concentrations of the microspheres was based upon the best information that was available at the time. A rough idea of the dilution the colloids would experience at the pumping well was available from the tracer test that was conducted in 2003. However, no estimate was available for the degree of sorptive filtration on the field scale that the colloids would experience in the horizontal flow zone. The column test, which focused on matrix porosity, could not provide this information. The objectives in the field test were to measure the transport time relative to a conservative tracer, and to assess the degree of removal within the aquifer. The field test successfully provided both types of information. Using higher or lower concentrations of microspheres would not have made them travel any faster or slower in the aquifer, although as indicated above, using a much lower concentration of the larger microspheres would have made it difficult to quantify them. The comment that the number of microspheres would have substantively reduced or saturated the sorption sites is not correct. It should be noted that the total surface area of the limestone over the 97 m distance between the injection and pumping well is enormous relative to the amount (tens of grams) of polystyrene spheres that were added to the aquifer. Also, the total number of fluorescent beads added to the aquifer was small compared to the long-term flux of other reactive colloids (e.g., bacteria) going through the same pathways in the limestone.

Page 12, Item B. The Conclusions in Paper 3 Regarding the Removal Capacity of the Aquifer Are Inconsistent With the Data

The complaint alleges that the technical conclusions in Harvey et al. (2008) are not supported by the data. In particular, the complaint focuses on the following statement in Harvey et al. (2008):

> "[t]he field and laboratory results collectively suggested that it may take 200-300 meters of transport to ensure even a 1-log unit removal of oocysts."

This is a phrase extracted from a sentence in the abstract. In the actual text of Harvey et al. (2008), the period that has been inserted in the above quotation noted in the complaint is supposed to be a comma followed by the rest of the sentence that has been omitted from the quotation. The complete sentence upon which the above statement in the abstract is based may be found on p. 10 of Harvey et al. (2008) and reads

> "Assuming our laboratory observation that oocysts have lower propensities for attachment to limestone than microspheres is applicable to the field, it may take 200–300 m of travel to safely reduce by one log unit the concentration of 3 to 5 μm *C. parvum* oocysts from a hypothetical introduction into the aquifer, depending upon local-scale heterogeneity."

This statement follows from the observations of microsphere removal that occurred during the 97 meters of subsurface transport in the 2004 field test and from the laboratory-based correction that needed to be applied because of the microspheres' greater propensities for attachment to limestone surfaces relative to those of similar sized oocysts. From comparisons of breakthrough for coincident injection of microspheres and oocysts, fractional recoveries of oocysts were considerably (4-6 fold) higher than the more reactive microspheres, depending upon colloidal size. From the broad range given (200-300 m), the qualifying clauses regarding the effects of local-scale heterogeneity and applicability of laboratory observations, and other cautionary statements in the paper (e.g., variability in oocyst surface charge), it should be clear to the reader that this is only an estimate, not an absolute number. Furthermore, the estimate of 200-300 meters for 1 log unit removal matches reasonably well with the CH2M-HILL (2001) estimate of 1.5 log unit removal per 300 m of transport. Although there is uncertainty in either estimate, both support the notion that filtration of pathogens within karst-limestone characterized by horizontal flow zones requires travel distances that can be quite long relative to most granular aquifers.

Page 12, Item C. Papers 1 & 4 Fail to Acknowledge Errors in the 2003 Dye Tracing Test

Comments in the complaint attempt to cast doubt on the results of the tracer testing conducted in 2003 in the Northwest Well Field (NWWF) by stressing the fact that the recovery concentration was greater than anticipated and resulted in the discoloration of the water pumped from the public supply well in the NWWF. The complaint fails to note that the significant results of that test would not have changed if the mass of the tracer injected was less than that used. The results of the 2003 tracer test showed that the travel time of ground water in the Biscayne aquifer is dramatically faster than previously acknowledged. The travel times of ground water, as seen from that tracer test, are not consistent with the ground water travel times used to define the set back distances for mining operations in the vicinity of the NWWF. If less tracer mass was added, the concentration at the production well would have been smaller, but the time of travel would have been the same. This result was confirmed in our 2004 tracer experiment, which used dissolved gases as conservative tracers. Accounting for differences in the pumping rates between the 2003 and 2004 tracer tests, the arrival of the conservative tracers at the production well was consistent between the two tests.

In raising the complaint about the procedures used in conducting the 2003 tracer test, the complaint fails to the note that there were multiple motivations for conducting the tracer test between the injection well and the production well in the NWWF. The first motivation was to gain insight into the chemical dilution and travel time between the injection well and the production well. This information was critical in designing and implementing the tracer test in 2004 using microspheres to mimic the behavior of *Cryptosporidium parvum* oocysts. Secondly, the tracer test was designed to provide insight into the physical and chemical mechanisms that affect the transport of dissolved chemical constituents in complex geologic settings that have preferential flow paths that may interact with a fluid in a matrix porosity, where the ground water in the matrix porosity may be stagnant or moving at a much slower rate than the ground water in the preferential flow paths. This objective was pointed out in Shapiro et al. (2008). To extract useful information from a tracer test, the experiment must be conducted in a quantitative fashion where the time-varying concentration of the tracer must be measured at the abstraction well. In addition, to obtain useful information about the mechanisms that are controlled by the matrix porosity, it is necessary to monitor the concentration of the declining limb of a break through curve. In general, to extract robust information about the matrix porosity, it is necessary to observe a change in concentration in the declining limb of the breakthrough curve over several orders of magnitude. Thus, designing the injected mass of the tracer experiment to look only at the first detection and the peak of the tracer arrival (as is frequently done in the qualitative tracer experiments that are often conducted in karst terrain) would not be sufficient in attempting to identify the physical and chemical processes that are influenced by the matrix porosity. In designing the tracer test in the NWWF, a sufficient amount of the tracer mass had to be added so that the peak concentration would be at least 2 orders of magnitude greater than the detection limit of the tracer.

Existing information was considered in designing the mass of the tracer to be injected in the 2003 tracer test to meet the objectives noted above. The results of previously conducted tracer experiments in the vicinity of the NWWF in the Biscayne aquifer were reviewed prior to designing the 2003 tracer experiment. However, tracing conducted in 1998 and 1999 by Miami-Dade County was conducted prior to the robust delineation of a conceptual hydrogeologic framework and before a realization that porosity and permeability in the Biscayne aquifer are related to lithofacies that have a predictable vertical distribution, unique spatial distributions, and unique hydraulic characteristics. Of most importance was the delineation of aerially-extensive stratiform flow zones that dominate ground water flow. In addition, previous tracer tests were conducted using wells that lacked installation and construction data and had well screens that did not necessarily allow injected tracers to interrogate the macroporous sections of the aquifer. In the case of the tests conducted in 1998, 3 of 4 wells used for tracer injection are open to a section of the aquifer dominated by matrix porosity. The results of such tests can not be compared with the results obtained in which a borehole is open to a preferential flow zone. The Miami-Dade tracer tests conducted in 1998 show that tracers will move much more slowly if introduced into limestone characterized by matrix porosity. In addition, there have been several tracer tests conducted by Miami-Dade County that failed to yield detections, and other tests were conducted during periods of excessive rainfall, where results of the tracer test may have been impacted by the dilution caused by rainfall events. Tracer tests in the vicinity of the NWWF could also be influenced by the operation of the gated structures on the canals that surround the NWWF; changes in elevation of the canal stages can greatly influence ground-water levels and flow directions.

Taken as a whole, the tracer tests conducted in the vicinity of the NWWF prior to 2003 were conducted without clearly delineating and identifying the hydrogeologic, hydraulic, and climatic factors that affected the tracer recovery and the resulting concentrations in each tracer test. Without such information and explanations, it was difficult to clearly identify the factors that would go into designing the injected mass to meet the objectives associated with the USGS project.

The tracer tests conducted in this investigation were designed to limit the number of confounding factors. In particular, the aerially continuous stratigraphic features that were responsible for the majority of fluid movement in the aquifer were clearly defined. The injection wells in the 2003 and 2004 tracer experiments were designed to interrogate the aerially continuous preferential flow zones in the Biscayne aquifer that are also intersected by the production well used to recover the injected tracer mass. In addition, the tracer tests in 2003 and 2004 were planned so as not to be impacted by the excessive rainfalls during the summer months. Furthermore, the water level responses in over 20 observation wells in and around the NWWF were carefully monitored to identify the influence of canal stages and minor rainfall events prior to and during the tracer experiments. This type of attention to detail was not exhibited in tracer experiments conducted prior to the USGS investigations.

Furthermore, the original plan for conducting the 2003 tracer test in the NWWF was to conduct the experiment in an incremental manner by first adding a small amount of a particular tracer and then monitoring for its arrival at the production well. In the event that the tracer was not observed in the production well in a reasonable period of time, a larger mass of a different tracer was to be injected at a later time. This approach had to be abandoned and one tracer experiment had to be designed because of limits in project funding, time constraints, and concerns about the conducting tests during excessive rainfall events during the summer months. Prevailing hypotheses of aquifer conditions prior to the 2003 tracer test indicated that each tracer test would take at least weeks or months to observe the rising and falling limbs of the breakthrough curve at the production well; conducting multiple tests of such duration was not feasible under project constraints.

Because of the lack of clarity in factors governing the tracer responses from previous tracer experiments, the 2003 tracer experiment was designed with the use of the prevailing information about aquifer properties. In particular, the preferential flow zones over the entire depth of the aquifer were assumed to contribute to the ground water flow and tracer migration. In addition, the tracer migration was assumed to be governed by the presumed large porosity of the preferential flow zones. These assumptions gave rise to the presumed ground water travel times that have been used to define the set back distances for mining operations around the NWWF.

Models of ground water flow and chemical transport based on these assumptions yielded significant dilutions in the tracer concentration at the production well for modeled tracer experiments. The significant dilutions as predicted from these assumptions indicated that a large amount of tracer mass was needed to meet project objectives.

The intention of the 2003 tracer experiment was not to alarm the public or disrupt the operation of the Miami-Dade Water and Sewer Department (WASD). Prior to the start of the 2003 tracer test, the USGS suggested to the Miami-Dade Department of Environmental Resource Management (DERM) and WASD that a press release be distributed to explain the test that was to be conducted; WASD and DERM decided against distributing this press release. It is unfortunate that more tracer mass was injected than was needed in conducting the 2003 tracer test. However, from the results of the 2003 tracer test, the 2004 tracer test using microspheres and dissolved gases as conservative tracers was successfully designed. In addition, the results of the 2003 tracer test clearly identified the flaws in the prevailing hypotheses of ground water flow and chemical transport in the Biscayne aquifer.

Page 13, Item D. Paper 3 Fails to Provide Context to Statements Regarding Presence of Cryptosporidia

The complaint alleges that two sentences in the second paragraph of the Introduction of Harvey et al. (2008) are inappropriate in their context. These sentences are: "C. parvum oocysts are ubiquitous in surface waters throughout much of North America [e.g., LeChevallier et al., 1991]" and "Consequently, shallow, karst limestone aquifers hydraulically connected to surface waters, such as the Biscayne aquifer in southeastern Florida, may be particularly vulnerable to contamination by oocysts." In discussing these sentences, however, the complaint has removed them from their context in the paper. If put back into the context of the entire introduction, it would be clear to the reader that the sentences quoted above were used to discuss the reasons why oocyst contamination is a concern for shallow, drinking-water aquifers, particularly limestone aquifers that are hydraulically connected to surface water. The word "Consequently" in the second sentence draws not only upon the fact that oocysts are widespread in surface waters, but upon the facts stated earlier in the introduction, e.g., the documented ability of karst aquifers to transport a wide spectrum of particle sizes and types.

Although the complaint correctly states that the reference to LeChevalier et al. (1991) does not deal specifically with *Cryptosporidium parvum* oocysts in surface waters of Florida, there is ample evidence that this pathogen is present in a variety of surface water environments in South Florida, including canals, streams, storm ponds, reuse water, etc. For example, concentrations of *Cryptosporidium parvum* oocysts >150/100 mL have been observed in urban streams in the Sarasota area in studies conducted by the University of South Florida and reported by authors from Florida Departments of Health and Environmental Protection (e.g., York et al., 2003). Also, studies conducted by Solo-Gabriele et al. (1998) report *Cryptosporidium parvum* oocyst concentrations in water samples taken from canals in Miami-Dade County that range from 25-175 oocysts/100 mL.

The complaint also alleges (on page 13) that oocysts do not survive as long in warm waters of South Florida. Although there is ample evidence to suggest a temperature dependency for die-off rates of *Cryptosporidium parvum* oocysts suspended in water, studies by Ives et al. (2007) showed that it took more than 200 days to achieve a two-log die off of *Cryptosporidium parvum* oocysts that were incubated at 22 degrees (Centigrade) in Florida groundwater (Avon Park well). Waterborne Cryptosporidiosis in which *C. parvum* was implicated as the causative agent and contaminated water as the likely vehicle of transmission has been documented in the state of Florida by the Centers for Disease Control (1996).

Page 13, Item E. Paper 3 Identifies a Protection Factor Which is Unsupported by Law or Policy

The complaint alleges that the following sentence in Harvey et al. (2008) is making a statement of policy:

> "[f]or C. parvum oocysts, which are capable of causing disease in very low numbers, it is desirable to have 4-5 log(10) units of removal between contaminant source and well."

Clearly, the above sentence is not a policy statement, nor was it meant to be. Harvey et al. (2008) use the word "desirable", not "required". Given the small numbers of oocysts required to cause disease and their high resistance to chlorine disinfection, higher log unit removals of this pathogen are indeed "desirable", particularly during substantive contamination events. The complaint refers to EPA regulation 40 CFR parts 9, 141-142 that requires removal of 3 to 5.5 log unit removals from surface waters, where Cryptosporidium is present in abundance of more than 3 oocysts per liter; the regulation clearly brackets the 4-5 log units in the quoted sentence.

Page 14, Item F. Paper 3 Contains Incorrect Information Regarding Ongoing Mining Activities

The complaint alleges that the following statement from Harvey et al. (2008) provides false and misleading information concerning the effect on water quality from future borrow-pit lakes that will be farther away from the NWWF than existing borrow-pit lakes:

> "[t]he proposed expansion of extractive limestone-mining activities in the immediate vicinity of the Northwest well field (NWWF) has attracted widespread attention [Renken et al, 2005] because the resulting borrow pit lakes bring potentially contaminated surface waters within close proximity of Florida's largest municipal well field, in some cases within a few hundred meters."

The complaint has taken this statement out of context of the article. If this statement is put back into the context of the whole introduction, it is clear that the existing and proposed lakes are considered collectively. The statement in Harvey et al. (2008) refers to the fact that there are lakes in close proximity to the NWWF. In fact there is an existing borrow-pit lake approximately 247 meters from one of the production wells of the NWWF. A map of the NWWF area that shows the approximate distances of the borrow-pit lakes to the NWWF was provided in Renken et al. (2008), which was the first article of the three-part series that was published in *Water Resources Research.* A version of this map was also published earlier (Figure 1, Renken et al., 2005). There is nothing stated or implied in Harvey et al. (2008) or Renken et al. (2005) to indicate that limestone companies are seeking to excavate new borrow-pit lakes within a few hundred meters of the NWWF.

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