U.S. Geological Survey Proposal

C: Ground Water Near Deer Trail, Colorado

C-2: Bedrock Hydrology and Ground-Water Quality

Question:

Are biosolids applications on the Metro properties near Deer Trail adversely affecting the quality of the bedrock aquifers in the vicinity?

Concerns:

The Metro properties near Deer Trail are located at the eastern edge of the Denver Basin. The Laramie-Fox Hills aquifer is part of the Denver Basin aquifers and is the bedrock aquifer used as a water supply in this area. The Fox Hills formation crops out on and adjacent to the Metro properties, which indicates that this area could have both recharge and discharge zones for this aquifer. Biosolids applied to the land surface could therefore affect the quality of the bedrock ground water directly through 1) recharge from water infiltrating through contaminated soils or sediments (remobilization), 2) recharge from contaminated surface water, or 3) recharge from contaminated alluvial ground water. Biosolids can also affect the quality of bedrock ground water indirectly through 1) plowing that mobilizes or changes subsurface constituents, or 2) contributions to natural processes such as nitrification.

Discharge from contaminated bedrock ground water could contaminate 1) surface water (ponds or streams), 2) alluvial aquifers, or 3) water-supply wells.

Objectives:

To determine the hydrology of the Laramie-Fox Hills aquifer in the vicinity of the Metro biosolids properties.

To determine the hydrologic interaction of the Laramie-Fox Hills aquifer with the alluvial aquifers in the vicinity of the Metro biosolids properties.

To determine whether concentrations of nitrate, arsenic, cadmium, copper, chromium, lead, mercury, molybdenum, nickel, selenium, zinc, plutonium, and gross alpha and beta radioactivity in the bedrock aquifer are significantly greater than regulatory limits.

To determine whether concentrations of nitrate, arsenic, cadmium, copper, chromium, lead, mercury, molybdenum, nickel, selenium, zinc, plutonium, and gross alpha and beta radioactivity are increasing with time in bedrock ground water in the vicinity of biosolids-application properties.

Approach:

A structure map of the base of the Fox Hills (sandstone) formation will be compiled for the area of interest (including the Muddy Creek drainage near the Metro properties and as far north as Highway 36) using existing information such as geophysical logs from oil and gas exploration and other data. Field verification will be used to match geology inferred from other data with actual rock outcrops. The structure map will show the altitude of the base of the Laramie-Fox Hills aquifer, and when used with a topographic map, will indicate the depth to the bottom of the Laramie-Fox Hills aquifer at any point where the aquifer is present. This structure map would then be used to select sites for installing monitoring wells in the Laramie-Fox Hills aquifer.

After completion of the structure map, two new monitoring wells will be installed in the bedrock aquifer in the Muddy Creek drainage; additional wells can be installed on or near the Metro properties at a later time, depending on the extent of the bedrock aquifer in this area. Complete borehole geophysical logging (including gamma, neutron porosity, short-normal resistivity, and flowmeter data) will be done when the wells are drilled to evaluate lithology and aquifer properties. Two new monitoring wells also will be installed in the corresponding alluvial aquifer (Muddy Creek), one in close proximity to each of the new bedrock wells. These well pairs will enable evaluation of the hydrologic connection between the bedrock and alluvial aquifers (including possible recharge zones) in the vicinity of the Metro properties. Wells will be installed by USGS drillers. Water levels will be measured monthly. Aquifer tests will be made to estimate hydraulic conductivity and transmissivity.

The two new bedrock wells and an existing bedrock monitoring well (D29) will be sampled approximately quarterly for total and dissolved nutrients, dissolved major ions and trace elements, and physical properties. These three wells will be sampled annually for radionuclides. Analyses will include nitrate and ammonia nitrogen, arsenic, cadmium, copper, chromium, lead, mercury, molybdenum, nickel, plutonium, selenium, zinc, and gross alpha and beta radioactivity, as well as full nutrient, trace-element, major-element, and anion chemistry. Samples will be collected using appropriate USGS protocols. Water levels and field parameters will be measured with each sample collected to provide context for the chemical analyses. Sufficient field blanks will be analyzed to enable sample bias (laboratory plus field) to be evaluated with at least 90 percent confidence after 5 years of monitoring. Sufficient field replicates will be analyzed to enable sample variability (laboratory plus field) to be evaluated with at least 90 percent confidence after 5 years of monitoring. Bias and variability for bedrock-aquifer monitoring also will be evaluated from the alluvial-aquifer monitoring data because sampling methods, personnel, and some equipment will be the same.

Water-quality data will be maintained in a USGS data base and reviewed within one month of receipt from the laboratory. A newsletter will be distributed quarterly (every 3 months) to all stakeholders and interested parties; monitoring progress will be described every quarter, and reviewed hydrologic and chemical data will be included in the newsletter every other quarter. Reviewed data will also be available in electronic format. Data will be compiled into annual summaries and distributed with preliminary, reviewed interpretations at annual stakeholder meetings. Progress and scope of work will be reviewed at the annual meetings, at which time the scope of work and budget for the next year can be revised.

Water-quality data will be statistically analyzed each year and after about 5 years to determine if 1) concentrations are significantly greater than regulatory limits and 2) any

constituents of interest are increasing significantly over time. All results of the statistical tests will have full technical review before release, and will be released with the alpha, beta, and theta levels used for the testing. Data and interpretations will be published in a report following 5 years of monitoring.

Monitoring sites:

Any sites of interest to the stakeholders can be monitored, although bedrock-aquifer-monitoring sites would be most useful if selected according to the structure map. In general, paired alluvial and bedrock wells located in the drainage valleys near Metro properties where both alluvial and bedrock aquifers are likely to exist will result in the most information about hydrologic interactions between alluvial aquifers and the Laramie-Fox Hills aquifer. The USGS study on the Metro Central property indicates that the Laramie-Fox Hills aquifer does not underly the entire property, but is present mainly in limited areas of the north and west. Therefore, two alluvial-bedrock well pairs will be installed in the Muddy Creek drainage after completion of the structure map. These two new bedrock wells and the existing USGS bedrock monitoring well in section 16 (SE1/4, S16, T5S, R58W) will be sampled approximately quarterly. Additional bedrock wells on or near the Metro properties could be installed and monitored to provide additional chemical and hydrologic information.

Benefits:

This approach will yield data useful for objectively evaluating hydrology and water quality of the bedrock aquifer, as well as changes in water-quality parameters over time. Hydrologic and geochemical processes can be evaluated because extensive hydrologic and water-quality information will be collected.

The structure map and the geophysical tests also will be useful to landowners and county officials in considering planning issues and future use and development of the limited water resources in this area.

Limitations:

This approach will not yield sufficient water-quality information to definitively prove that biosolids applications are causing the changes in water quality (analyses of natural isotopes or wastewater tracers, in addition to age dating, are needed to determine sources). “Background” (pre-biosolids or even pre-farming) water quality can not be determined because biosolids have been applied in this area for several years, and parts of the area have been farmed since the 1970’s. Trends and statistical tests, as well as sampling and laboratory bias and variability, can be calculated each year but can not be effectively evaluated until the end of about 5 years because of the number of samples needed for a viable statistical evaluation.

Hydrologic characteristics of the Laramie-Fox Hills aquifer are variable. Unless many monitoring wells and well pairs are installed in the major drainage valleys containing both bedrock and alluvial aquifers (such as the Muddy Creek drainage valley), every recharge and discharge area of the Laramie-Fox Hills aquifer can not be identified. However, mapping the base of the Fox Hills formation and locating several bedrock-alluvial well pairs in the major drainage valley known to have Fox Hills outcrops provides a reasonable approach that should result in information about general recharge-discharge

characteristics in this area. Installation of the bedrock wells without the corresponding new alluvial wells will enable the first, third, and fourth objectives of this option to be met, but will enable only generalized evaluation of the second objective.

Chemical characteristics of the Laramie-Fox Hills aquifer also are variable. Sampling only three bedrock wells will not fully evaluate the water quality of this aquifer, but will provide information about bedrock water quality and changes at specific areas of interest. Sampling only the bedrock wells (and not the two new paired alluvial wells) will satisfy the objectives of this program, but will not enable changes in bedrock water quality to be directly linked to alluvial water quality at these sites.

The USGS study on the Metro Central property indicates that nitrate concentrations in alluvial ground water in this area can fluctuate at least 19 milligrams per liter within 3 months. If nutrient concentrations in the Laramie-Fox Hills aquifer fluctuate similarly, sampling the bedrock wells quarterly for nutrients might not document all nutrient concentrations and may result in underestimated maximum nitrate concentrations. If maximum nitrate concentrations are of concern, then wells will need to be sampled more frequently than quarterly until nutrient variability of this aquifer has been established.

Schedule of initial monitoring:

Monitoring bedrock ground water in the vicinity of the Metro properties can begin within one month after the contract is finalized with a signed funding agreement. Much of the equipment is already available because it was obtained for the USGS monitoring of the Metro Central property (1993-98). One of the three bedrock monitoring wells is already installed, and the USGS drilling team is available to install additional bedrock and alluvial wells as early as November 1998, weather permitting. Well sampling can commence at any time for the existing wells, or as soon as one week after new wells are installed. New wells can be installed as soon as about two weeks after completion of the structure map, weather permitting. The structure map can be completed as soon as about eight weeks after a funding agreement is signed, weather permitting. The schedule for signing the funding agreements precludes a full four quarters of sampling in the first monitoring year (October 1, 1998 through September 30, 1999) at all the bedrock monitoring wells, but three sampling trips to all three bedrock monitoring wells on an approximately quarterly schedule should be possible in 1999 if the funding agreements are signed by the end of December 1998.