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April 4, 2010

The Honorable Congressman Raul Grijalva
Chairman of the US House of Representatives
Subcommittee on National Parks, Forests, and Public Lands
1440 Longworth HOB
Washington, DC 20515

Dear Congressman Grijalva,

This is my written testimony provided to the Subcommittee on National Parks, Forests, and Public Lands of the U.S. House of Representatives Natural Resources Committee for the hearing on April 8, 2010 at the Shrine of the Ages at Grand Canyon National Park. I am a Professor of Hydrogeology at Northern Arizona University (NAU) where I have been studying the aquifers and springs of Northern Arizona and the Grand Canyon region since I arrived in Flagstaff in 1994. Also, I am currently serving as the Director of the School of Earth Sciences and Environmental Sustainability at NAU. The comments in this letter do not represent the opinions of NAU, but my own personal observations and interpretations as being a hydrogeologist for over 20 years. I have supervised numerous student research projects on the groundwater flow of the aquifers, have developed numerical groundwater flow models to describe flow through the aquifers, have been involved in numerous management and planning decision processes for the region, and have extensively studied the springs ecosystems and groundwater flow regimes of the Grand Canyon and surrounding regions.

Despite my varied background in ecology, policy, management, and planning, my comments are restricted to my academic specialties in geology and hydrogeology. They are targeted to the issues of 1) recharge to the aquifers, 2) natural discharge from the aquifers through springs, 3) properties of flow within the aquifers, 4) potential impacts from uranium mining on natural recharge and discharge and flow through the aquifers.

Recharge

Although there are multiple and very deep (over 3,000 foot deep) aquifers in the vicinity of the Grand Canyon, recharge to these aquifers tends to be mostly focused and very rapid through faults, fractures, and sinkholes (Figure 2). Recharge to these deep aquifers can be on the order of hours and days, not weeks or years. The faults, fractures, and sinkholes can be pervasive and any enhancement of them can lead to enhanced recharge to the aquifer. Mining activity has the potential to expand and enhance the fracturing of the aquifer and enhance recharge through the mine sites.

Discharge

Except for a small amount of pumping of water through a few wells, most of the water in the aquifers to the North and South of the Grand Canyon discharge naturally through springs. Recent studies by the USGS and others give us reasonably good estimates of how much water is discharging from these aquifers. These springs, in the middle of a very dry landscape, support a diverse and rich abundance of plants, insects, birds and animals. They also provide important sources of water for many local tribes and backcountry recreation activities. These aquifers serve as the *sole source supply* for surrounding tribes, communities, and ecosystems. As a sole source supply, the aquifers should be considered for special protections under EPA.

Aquifer flow

Just as recharge tends to be largely focused along faults, fractures, and conduits, so does flow of groundwater within the aquifers. The rocks surrounding the faults, fractures, and conduits also contain water which drains more slowly. So the aquifer behaves as a "dual flow" system, with part of the flow system being rapid flow with short residence times (days to 10s years) and part being very slow with long residence times (100s to 1000s years). In the fast flow system, recharge may move from rain/snow on the land surface, through over 2000 feet vertical feet of rock, through 1000s of feet of horizontal flow in the aquifer, to discharge at a spring within a few days to weeks. The springs flow the rest of the year after the rain/snow ends, because of the surrounding unfractured rocks draining water. South of the Grand Canyon, most of the Coconino Plateau sub-basin contributes groundwater flow to Havasu Springs, the largest spring discharging from the Coconino Plateau sub-basin (Figure 1). In between Havasu Springs and Blue Springs, the springs of the Grand Canyon discharge from smaller groundwater contribution areas that are located close to the Rim.

The USGS report (ed. Alpine, 2010) indicates the following future study that would improve the understanding of mine related effects.
"Development of geochemical and aqueous transport models for transport to deep groundwater of any contaminants mobilized from mined waste rock located in back-filled mine openings."

Despite all of the recent hydrological, geological, and biological site characterization of the aquifers underlying the uranium mine segregation areas, there still does not exist an accurate understanding of the directions and magnitudes of flow of water in the aquifers underlying these areas. Because groundwater flow likely follows the major faults and fractures, it may flow in uncertain directions when under pressure (not perpendicular to regional dip) and unknown velocities. A regional groundwater flow model should be built specifically for the breccia pipe uranium mining areas of Northern Arizona and should be used to simulate the directions and magnitudes of flow from each breccias pipe. A separate, coupled contaminant transport model should be built to simulate the potential transport of chemicals introduced by mining activities.

The best model we currently have of the regional groundwater flow system of the South Segregation area was published in Crossey and others (2009) and was from the M.S. thesis of Kessler (2002) (Figure 1). This model shows that most of groundwater within the region of the

South Segregation area flows towards and discharges to Havasu Springs, but the remainder flows towards smaller springs along the South Rim directly to the north of the South Segregation Area. Because groundwater flow models do not exist for the North and East Segregation areas, it is difficult to predict the directions and magnitudes groundwater flows.

Uranium mining impacts on aquifers

Uranium mining in the Grand Canyon region is from breccias pipes which formed due to collapse of paleocaverns in the rocks which now comprise the deep regional aquifer (Huntoon 1996). Uranium is just one of many mineral elements which have been enriched in these deposits (Weinrich and others 1996). If mining or related mining activities were to cause these elements (and uranium) to become mobile and to enter the surface water, or groundwater flow system, they would move toward springs or wells which drain the regional aquifer. Surface water flow is generally focused in the faults and fracture zones as is aquifer recharge and groundwater flow. Some of the watersheds of the region are internally drained, meaning that all surface water flow is focused to a sinkhole that recharges the aquifer, and no surface water flow leaves the watershed as surface flow. Once these elements became mobile through mining activities, they would continue to be mobile through the aquifer and eventually discharge at springs impacting the human and ecosystem uses of water of these springs.

Summary

Although there is uncertainty in our understanding of the directions and magnitudes of groundwater flow in the regional aquifers and how it is connected to mineralization in these breccias pipes, what we do know should lead us to exercise the precautionary principle of doing no additional harm. Because there is potential to harm the aquifer feeding the springs of one of the most important natural wonders of the world, and to tribes which count on the water from the aquifers as a *sole source* of water, it makes good sense to exercise the precautionary principle.

There may be the potential for developing mitigation strategies and solutions for potential introduction of contaminants from a few mining and mining related activities, but it is likely that they would be cost prohibitive for the marginal value of the resource. If there are 100s to 1000s of mining related sites, the mining activity becomes not a point source of potential contamination, but a large, areally distributed source, making mitigation next to impossible to mitigate.

I would recommend that Congress encourage investment and develop incentives for developing the abundant renewable wind and solar resources for Arizona which would have positive long-term impacts on the region. If there is contamination from uranium mining activities, the effects could last for 100s to 1000s of years in these deep aquifers.

Sincerely,
Abe Springer, PhD, Professor and Director

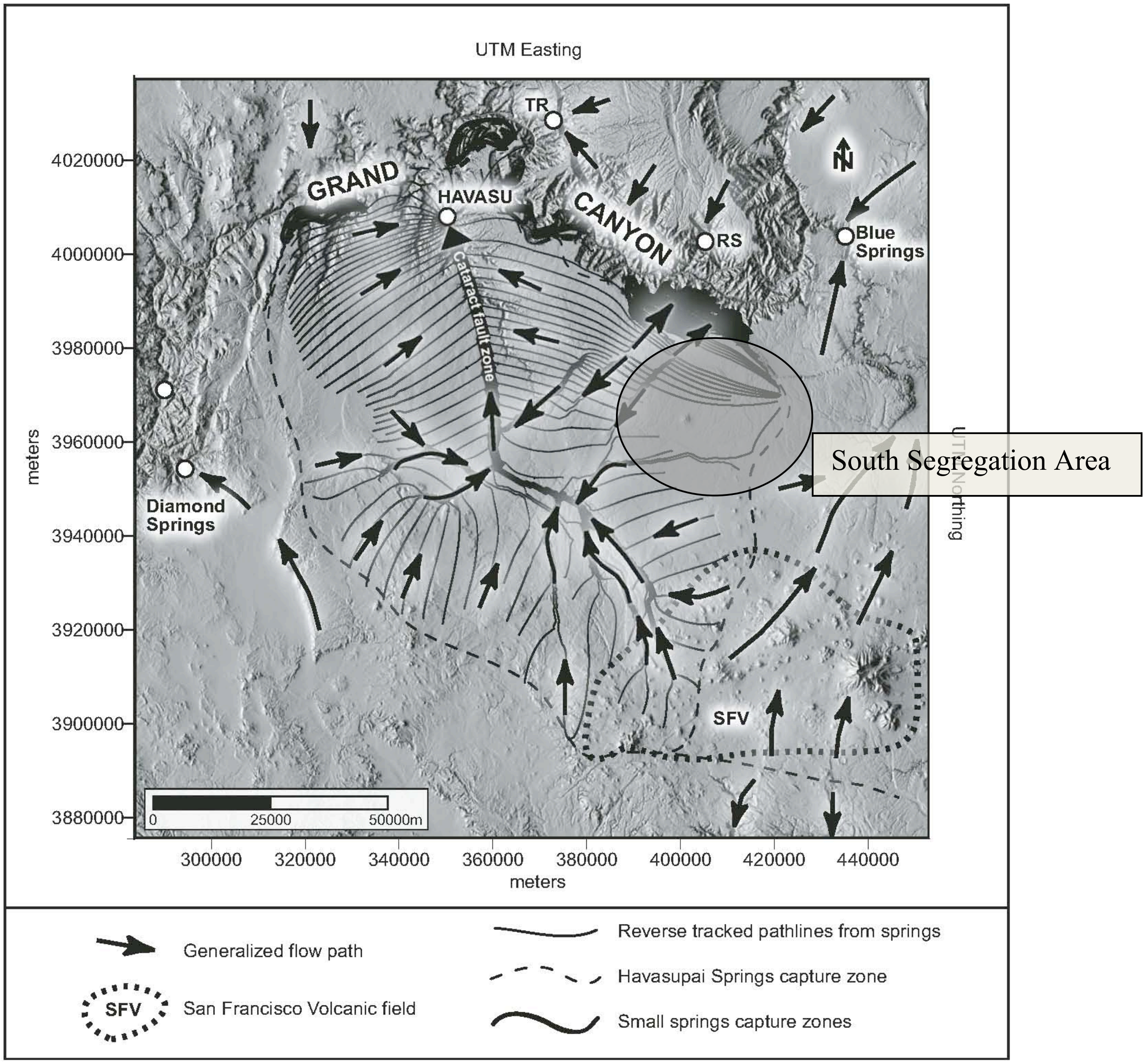

Figure 4. **Hydrologic model for Coconino Plateau subbasin (Kessler, 2002) showing San Francisco volcanic field (SFV) recharge area and major high-volume springs: Blue Springs, Diamond Springs, Havasu Springs, RS—Roaring Spring, TR—Trunder River. Fine lines are reverse-tracked particle paths from the model; arrows indicate generalized groundwater flow paths; heavy line shows Cataract fault zone as a fast pathway for groundwater movement.**

Figure 1. Pathlines and capture zones for Havasu Springs and small springs of the Coconino Plateau Sub-basin (Crossey and others 2009).

Figure 2. Recharge through sinkhole near the North Rim entrance gate on the Kaibab Plateau.