WELL AND SPRING VULNERABILITY TO CONTAMINATION IN THE MOUNTAINS AND INNER PIEDMONT OF SOUTH CAROLINA: A TRITIUM SURVEY TESTING LOCAL RECHARGING

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INTRODUCTION

South Carolina shares a portion of the Appalachian mountains and broad piedmont with the remainder of southeastern United States. These geologic provinces are underlain by hard crystalline mostly metamorphic rocks but the rock is capped by a thick (often 10-20 m) earthy regolith of saprolite that was produced by prolonged in-place chemical weathering of the rock. The mountains and bordering transition to the innermost piedmont (basically foothills) have special ground-water hydrologic conditions compared to the rest of the state This is due both to the different nature of the fractured-bedrock/saprolite-regolith geology, compared to the sedimentary deposits of the coastal plain, and to the higher relief compared to both the coastal plain and the rest of the piedmont. Furthermore, the mountains and foothills are now being subject to considerable development pressure for various purposes—widely at lower intensity (both residential or recreational) but in places as denser suburbs, especially nearer the several cities. Thus simultaneously the local ground-water resource has become much more important, by its greater use, while potential threats to ground-water quality have increased markedly by the many human uses of the land just above it. Presently wells in both public systems and at private homes supply many residences, schools, and businesses in this area. Small springs are also relatively common and well known locally, with several springs in the mountains and elsewhere used by the public for special drinking water or used commercially for bottling water (Mitchell, 2004). Still other springs are garnering interest for bottling water. In summary, in this area of special or different hydrologic conditions the ground-water resource is important, becoming more so, and at the same time potential threats to its quality are multiplying.

AQUIFER VULNERABILITY

Circumstantial evidence derived from known geologic conditions and hydrogeologic principles, plus extrapolation of findings from the broader piedmont (e.g., Stone et al., 1992), suggested that ground water in the mountains and innermost piedmont should be very vulnerable to rapid and ready contamination by chemical contaminants that are applied or leaked at the surface in nearby locations (e.g., gasoline, pesticide, fertilizer). This would be no matter whether the ground water was derived from wells or from springs. This conceptual assessment is based mainly on the lack of any thick areally extensive layer of tight clay in the regolith to confine or isolate the ground water in the fractured rock below it. The nature of saprolite in the regolith controls this. Water can thus recharge readily through the regolith near the wells, as there is no strong geological impediment. Secondly, vulnerability is interpreted to be higher because of the minimal volume of saturated regolith, the water that eventually recharges into fractures at the top of the bedrock. With sometimes only a few meters of saturated thickness, the regolith simply does not contain many years of infiltrated rainwater “stacked up” above the recharging fractures, to delay entry of any contaminant to the fractures. After recharge reaches the fractures, the small volume but relatively open nature of these bedrock fractures comes into play, allowing rapid velocities of ground water, especially under pumped conditions or other imposition of high hydraulic gradients. Finally, high natural (unpumped) hydraulic gradients can be predicted due to the great local relief in the mountains and foothills. Recharging and subsequent ground-water flow is predicted to be relatively rapid and this can carry and introduce any dissolved contaminants that are present at or near the ground surface.

VULNERABILITY TESTING

An important resource such as this, if truly vulnerable, would deserve a high degree of purposeful protection (higher, say, compared to that required by many naturally protected confined aquifers on the coastal plain). A brief initial survey was used at a convenient selection of sites to test this interpretation of high vulnerability due to predicted rapid nearby recharging. Tritium already emplaced by natural rainfall was used as a tracer or indicator of recent recharge water.

Aboveground nuclear weapons testing from the mid-1950s to mid-1960s has contaminated all rainfall since then with tritium (radioactive hydrogen, ^3H) as part of the water molecules. This "labeled" rainfall water with tritium subsequently traveled naturally as infiltrating recharge water and then ground water. Detectable tritium found in well or spring discharge shows that the ground water there is very young, having been rainfall no earlier than about the mid-1950s. This in turn shows, by strong inference, that the recharge area lies close by and the tested well or spring could readily and rapidly be contaminated chemically, i.e., it is highly vulnerable.

RESULTS AND CONCLUSION

Nearly all wells and springs tested in this brief survey had confidently detected tritium (>8 ±8 Tritium Units, TU being a concentration). Tables 1 and 2. This is similar to the findings elsewhere in the lower-relief piedmont in South Carolina (Stone et al., 1992) and in various piedmont settings in Georgia (Rose, 1992). In this survey, even high-water-table wells in valley bottoms and springs in lower parts of broad lower areas showed this indication of high vulnerability, these settings being plausibly those with longer flowlines and longer flow times from more distant upland recharge areas, and thus were possibly of lower vulnerability. But they too mostly showed the recent recharge tritium. We assume that in the case of the valley-bottom wells at least, the high relief on the nearby mountain slopes with attendant high hydraulic gradients caused the more rapid ground-water flow to explain this.

We conclude that wells and springs in this region used for such critical purposes as public supply (including bottled), home drinking water, sensitive manufacturing or agriculture, or in the case of some springs, supporting endangered species, all deserve special attention to the land use practices surrounding them and especially upslope of them. For public supply wells this special attention will be part of source-water protection plans.

LITERATURE CITED

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Stone, P.A., W.R. Chapman, and R.W. Oldham, 1992. Aquifer and wellhead vulnerability to contamination in the piedmont: conceptual evaluation and tritium testing in South Carolina, in Daniel, C.C., R.K. White, and P.A. Stone (eds.), *Ground water in the piedmont*: Clemson University, p. 377-394.

Table 1. Tritium Presence in Springs

Spring / Province	Tritium Concentration (TU Tritium Units)
Moody	19 ± 8
Mountain	
Routine public use	
Williamston	<6 ± 8*
Piedmont	6 ± 8* (duplicate)
Substantial public use	
*Possibly low vulnerability	
Boiling (Spartanburg Co.)	27 ± 8
Piedmont	
Waddy Thompson	33 ± 8
Piedmont	
Cedar	21 ± 8
Piedmont	23 ± 8 (duplicate)
Unnamed (Greenville Co.)	16 ± 8
Piedmont	
Important to an endangered species	

Table 2. Tritium Presence in Public-Supply Wells in Mountains and Foothills

Site / Well	Tritium Concentration (TU Tritium Units)
Cliffs at Glassy Mountain	
Well 4	14 ± 8
	11 ± 8 (duplicate)
Well 8	10 ± 8
Well 11	<6 ± 8*
*Possibly low vulnerability	
Caesars Head	
Well 1	11 ± 8
Well 2	14 ± 8
Table Rock State Park	
White Oak well	12 ± 8
Devils Fork State Park	
Laural Ridge well	9 ± 8
	15 ± 8 (duplicate)
Oconee State Park	
Campground well	16 ± 8