The Bluff Point Water Supply Plan Is Bad Science

A Pernicious Idea

According to overwhelming evidence, the Bluff Point water supply plan is founded on bad science. This plan is based on an obsolete and flawed hydrostratigraphic interpretation of the Potomac aquifer, which subdivides the Potomac into three regionally continuous and hydraulically isolated aquifers—lower, middle, and upper. This over simplified scheme is particularly grievous because, without discrete aquifers that are separated by regionally extensive, impermeable confining layers, the developer's proposal to inject saline wastewater into the Potomac aquifer is unsubstantiated by geology and stands little chance of approval by the USEPA.

Convenient Inventions Not Real Geologic Units

The picture of three separate Potomac aquifers is a sad illusion. The obsolete scheme was developed in the 1980s by staff of the U.S. Geological Survey as part of an attempt to produce a hydrostratigraphic framework of Coastal Plain aquifers (called the *Regional Aquifer-System Analysis*, or RASA), which could be used as a foundation for a computer model of the groundwater system of the Virginia Coastal Plain (see Figure 1). Because of the peculiar design of the computer model, it was necessary to create discrete and

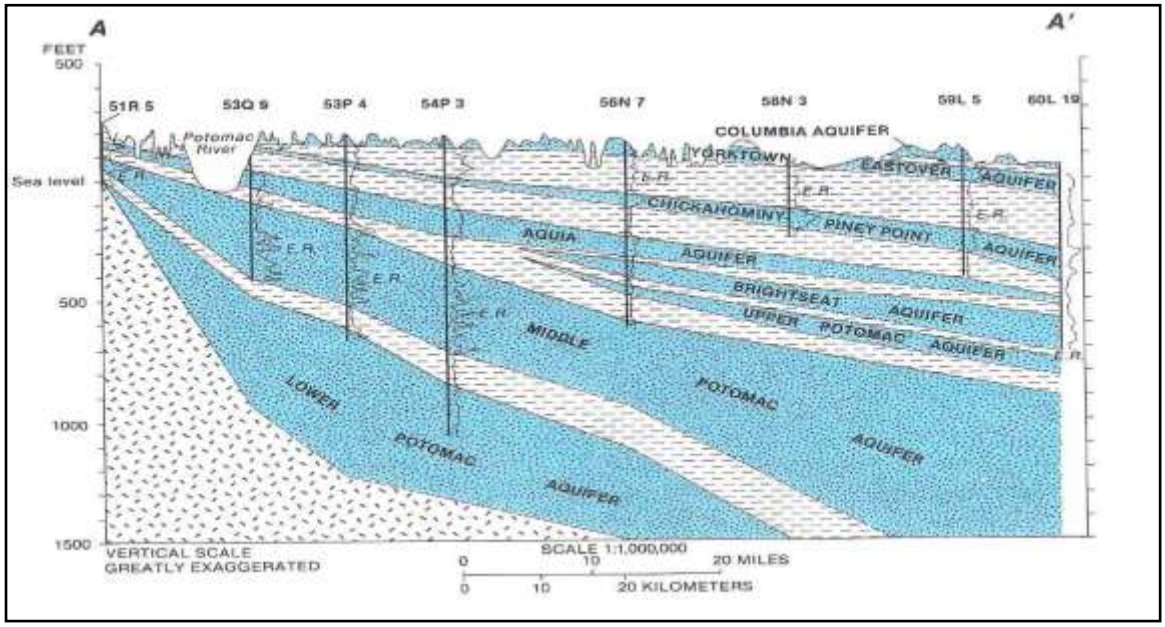

Figure 1. A generalized hydrogeologic cross-section of Virginia Coastal Plain based on the now-obsolete RASA model, showing three Potomac aquifers (USGS PP 1404-F).

regionally continuous aquifers as model layers (Figure 2, Conceptual Representation) and then reconstruct these layers into a vertical stack (Figure 2, Model Representation). "The quasi-three-dimensional modeling techniques required the designation of separate aquifers to enable the representation of separate model layers needed to simulate vertical [groundwater] flow" (McFarland and Bruce, 2006, USGS PP 1731, p. 32). Thus, despite a paucity of control points and subsurface data, particularly in the Potomac aquifer of the

eastern region of the Northern Neck,[1] the requirements of the computer model dictated the creation of three discrete and continuous hydrologic layers, AQ1, AQ2, and AQ3 (called the Lower, Middle, and Upper Potomac aquifers). Unfortunately, these three so-called aquifers and the interbedded confining units are, in reality, simply artifices to facilitate computer modeling and not actual rock units. The actual hydro-stratigraphy of the Potomac is far more complex. This distinction is important to understand if one is to recognize the fundamental error in the Bluff Point water plan.

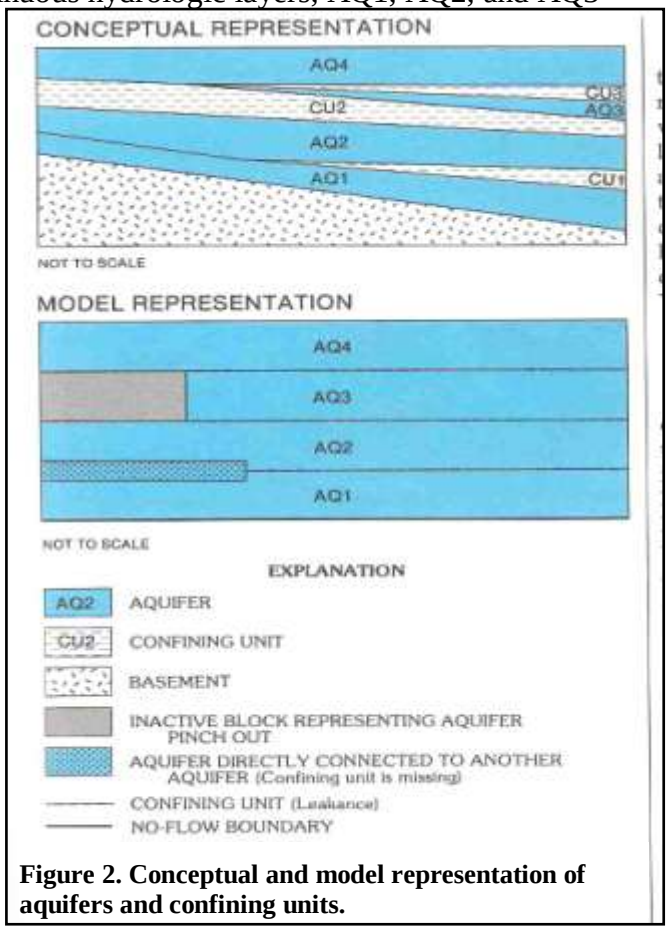

Figure 2. Conceptual and model representation of aquifers and confining units.

The most recent and thorough study of the aquifers of the Virginia Coastal Plain, USGS Professional Paper 1731, carefully documents the geologic reasons why the RASA tri-partite division of the Potomac is incorrect and should not be employed to characterize this unit. Instead of being composed of a thick sequence of homogeneous and regionally continuous layers, the Potomac is an example of a *heterogeneous aquifer*. McFarland and Bruce explain,

> . . . heterogeneous aquifers [see Figure 3] *exhibit sharp contrasts in sediment texture across small distances in the form of discontinuous and locally variable fine-grained sediments that are interbedded with coarse-grained sediments* [emphasis added]. Some interbeds have thicknesses as great as several tens of feet and lateral extents of less than one mile. Across some larger areas, interbeds can be densely spaced and partly coalesced, whereas in other areas they can be sparse or absent. Water flows mostly through the coarse-grained sediments, moving around and between relatively stagnant fine-grained interbeds. Thus, heterogeneous aquifers generally are hydraulically continuous at the regional scale but discontinuous locally where flow is impeded by fine-grained interbeds (p. 25).

[1] *Because no control wells penetrate the Potomac aquifer in Northumberland and Lancaster County more than 450 feet below the top of the aquifer (the total aquifer thickness is roughly 2,000 feet), there is no direct knowledge of the hydrostratigraphy of the deeper three-quarters of the aquifer beneath Bluff Point. Any characterization of these rocks is largely speculation.*

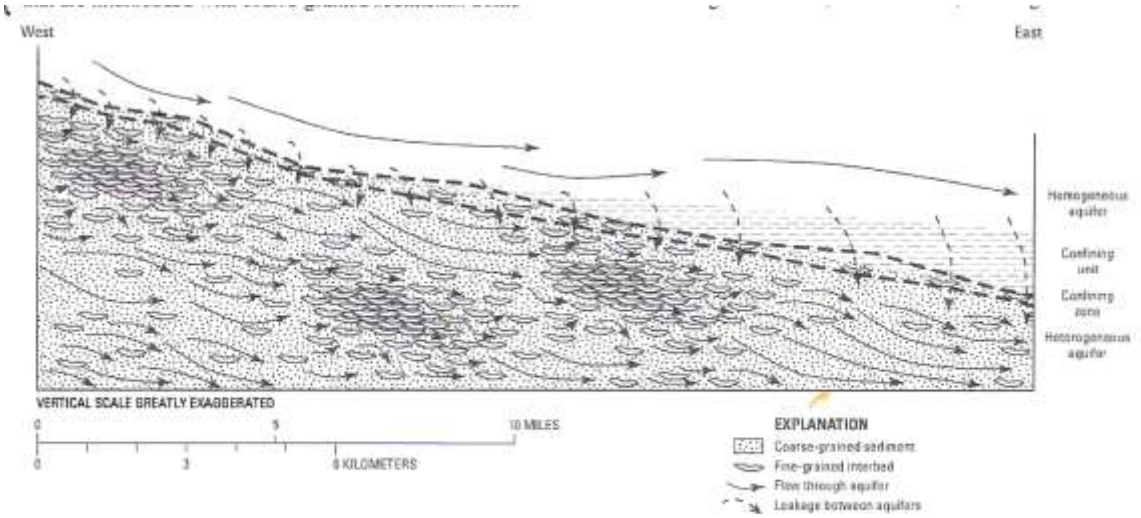

Figure 3. Illustration of the complex stratigraphy of a heterogeneous aquifer. Notice the absence of discrete, regionally-continuous layers (USGS PP 1731).

This same variability characterizes the confining units, which the developer of Bluff Point is counting on to provide barriers against the migration of the injected saline wastewaters.

> Examination of stratigraphic relations among fine-grained borehole intervals in Potomac Formation sediments during this investigation indicates that the *confining units as previously described probably are not present* [emphasis added]. Correlated intervals extend across volumes of Potomac Formation sediments in which fine-grained interbeds are either thin and isolated or absent. Concentrations of fine-grained interbeds appear to be primarily of local extent, as indicated in some areas extending across as much as several miles where boreholes exhibit fine-grained intervals of similar thickness and altitude. *Continuity across even local distances remains uncertain* [emphasis added], however, considering the inherent discontinuity of the sediments resulting from their fluvial-deltaic origin (see "Cretaceous Period"). Additionally, potentiometric surfaces mapped for the three separate Potomac aquifers (Hammond and others, 1994a, b, c) are broadly similar and do not indicate widespread vertical hydraulic gradients that would result from regionally continuous confining units (p. 32).

The heterogeneity of the Potomac aquifer is the product of its depositional history. McFarland and Bruce explain:

> Potomac Formation sediments, deposited by braided streams, meandering streams, and deltas exhibit sharp contrasts in texture across small distances as a result of the highly variable and frequently changing depositional environments (see "Cretaceous Period"). Thus, the Potomac aquifer is hydraulically continuous on a regional scale, but locally exhibits discontinuities where flow is impeded by fine-grained interbeds (p. 31).

Figure 4 illustrates the depositional environment of the Potomac Formation. This figure demonstrates that the unique hydrostratigraphy of the Potomac sediments is the result of the conditions of their origin. These geologic conditions produce complex sequences of localized gravel, sand, and clay lenses, not homogeneous layers that spread over broad areas of depositional basin.

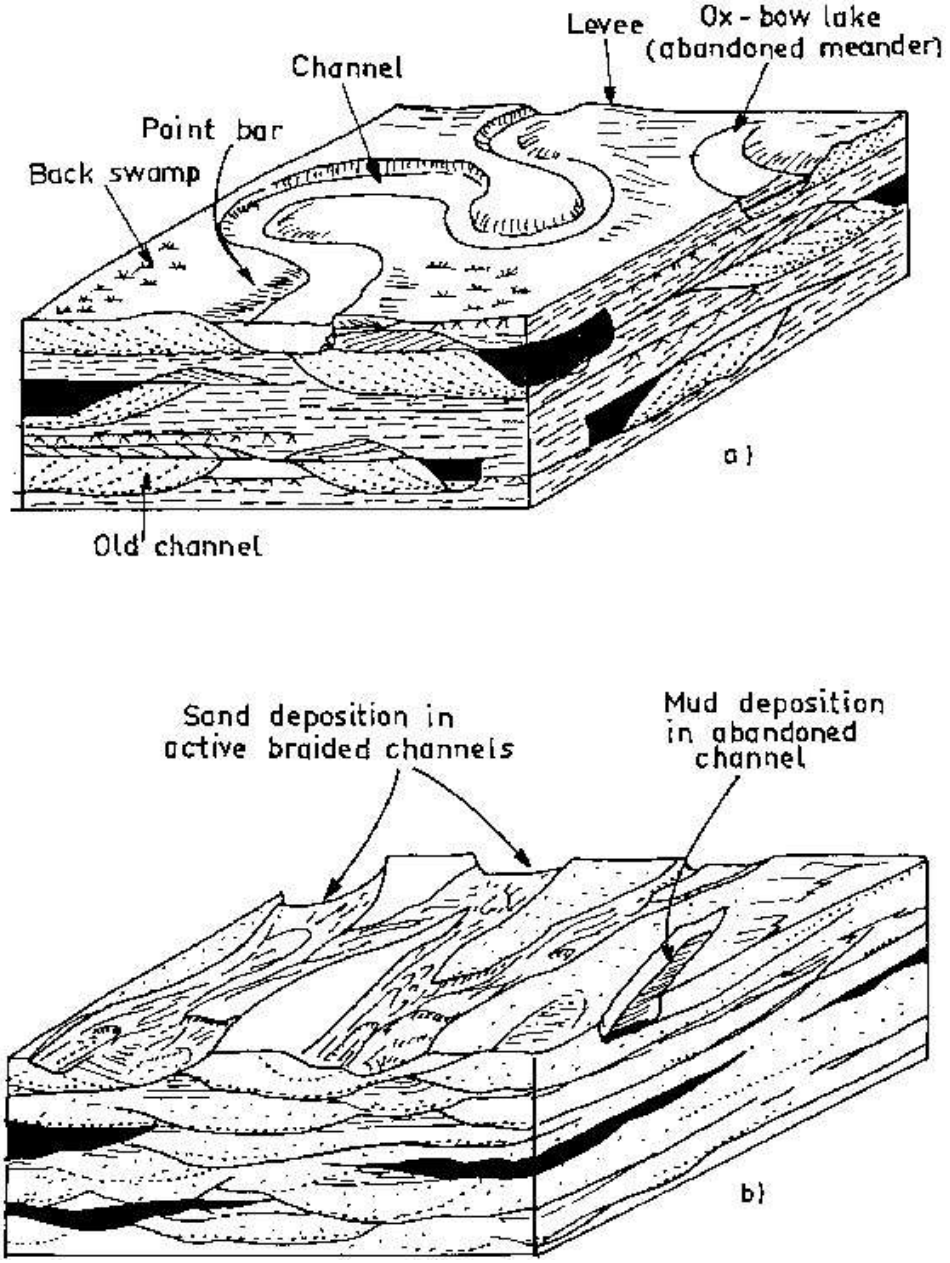

Figure 4. Models of the depositional environment of the Potomac Formation. Note the heterogeneity of the sedimentary pattern and the absence of continuous layers.

A Lack of Direct Geologic Information

The previous analysis demonstrates the scientific reasons why the so-called Upper, Middle, and Lower Potomac aquifers are not real geologic units but, instead, are artificial constructs created for a computer model of the groundwater flow system. But this flaw is not the only one of the water plan of Bluff Point. A particularly troublesome fact is that there is absolutely no direct geologic evidence concerning the character of the rock that is

to be drilled into at Bluff Point. The developer's submittal states that the water supply wells will tap groundwater at altitudes of roughly 1,000 to 1,200 feet below sea level. No well in Northumberland or Lancaster County has ever penetrated this deep. (The State Observation Well at Surprise Hill [Northumberland County], the nearest control well, reached a depth of approximately 977 feet below sea level.) What is worse, there are no bore holes or observation wells within 50 miles or so that penetrate the Potomac Formation to the level of Bluff Point's intended groundwater withdrawals (see the well logs on Figure 5). Moreover, in light of the absence of rock core samples beneath the site of Bluff Point and the adjacent region, together with the absence of hydraulic testing of Potomac sediments in the vicinity of Bluff Point, continued advancement of the flawed water supply plan demonstrates a reckless disregard for the facts

Conclusion

The matters described raise create serious doubts about the merit of the characterizations of the groundwater environment by the Bluff Point proposals. The fact is that the developer's proposal and the statements by his consultant offer little confidence that groundwater withdrawals by Bluff Point can be effected without damage to the local and regional groundwater system or harm to citizens of Northumberland and Lancaster Counties.

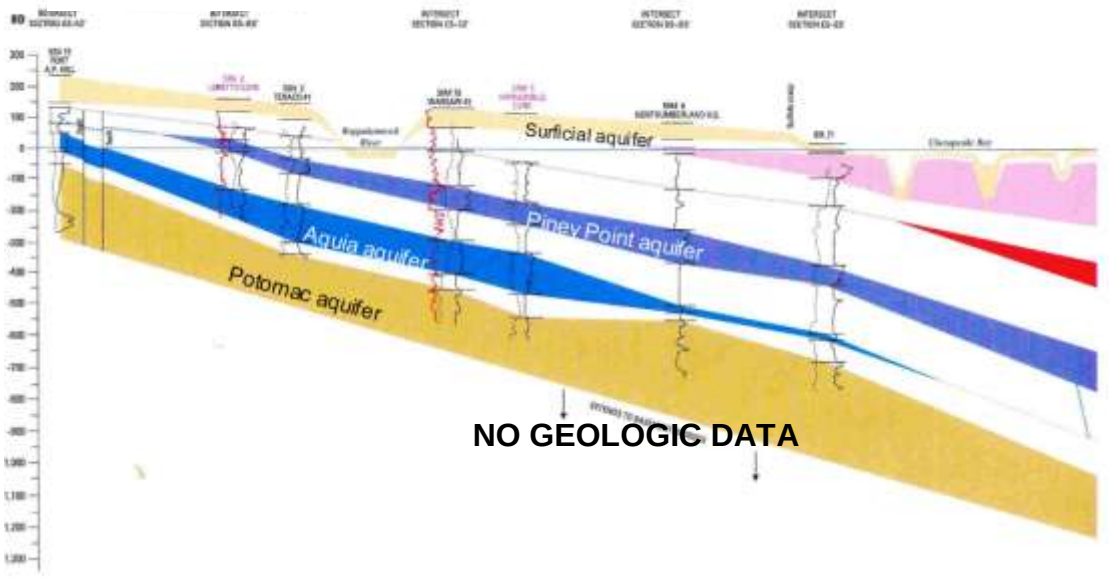

Figure 5. Hydrogeologic cross-section of aquifers of the Virginia Coastal Plain. Note that the well logs provide geologic information about the upper few hundred feet of the Potomac aquifer only (modified from USGS PP 1731).

Frank W. Fletcher, Ph.D., P.G.