

Section 1

Introduction

This Hydrogeologic Investigation and Groundwater Modeling Report has been prepared by Camp Dresser & McKee Inc. (CDM) for Huff, Poole & Mahoney, P.C. (HPM), Attorneys for the City of Chesapeake, Virginia (City). This report presents the results of investigation activities completed by CDM for the Battlefield Golf Club (site) located in Chesapeake, Virginia (**Figure 1-1**). The hydrogeologic investigation was performed to assess water quality at the site and to support the development of a groundwater model. The groundwater model was developed to assess the potential migration of constituents derived from fly ash that was deposited as fill beneath the golf course.

The general data needs for the groundwater modeling effort were identified in a previously prepared *Preliminary Site Assessment Work Plan* (CDM, September 2008). Efforts to fulfill the data needs identified in the work plan were performed by CDM and included groundwater and surface water monitoring, an aquifer performance test (APT), and fly ash sample collection and laboratory analyses.

Additional onsite work was completed by MACTEC Engineering and Consulting, Inc. (MACTEC) for Dominion Generation (Dominion) that included monitoring well installation, groundwater and surface water monitoring, characterization of the golf course cover and fly ash, and characterization of the hydrogeologic conditions. MACTEC previously submitted a Sampling and Analysis Plan (MACTEC, October 16, 2008) that detailed the work to be performed by MACTEC. The results of the MACTEC work were reported in the *Post-Construction Ash Fill, Soil Cover and Groundwater Evaluation Report* (MACTEC, December 17, 2009).

Work was also completed by URS Corporation (URS). The work performed by URS consisted of offsite monitoring well installation, groundwater and surface water monitoring, and collection of hydrogeologic data. This work was reported in the *Water Supply Feasibility Study* (URS, April 10, 2009).

The U.S. Environmental Protection Agency (EPA) completed several studies of the site that were performed by Tetra Tech, Inc. (Tetra Tech). These studies included the *Draft Site Inspection for the Battlefield Golf Club Site* (Tetra Tech, 2009) and the *Final Site Inspection for the Battlefield Golf Club Site* (Tetra Tech, 2010).

The remainder of this introduction section provides a brief project background and describes the site environmental setting. Section 2 describes CDM's data collection and Section 3 presents the investigation results. Sections 4, 5, 6, and 7 present the groundwater modeling effort and results. CDM's conclusions are provided in Section 8 and references are included in Section 9. Laboratory reports are included in the Appendices along with a water quality database and APT data.

1.1 Site Location

The site is located at 1001 Centerville Turnpike South on the east side of the road, south of Whittamore Road, and north of Murray Drive in the City of Chesapeake, Virginia (**Figure 1-2**). The site is bounded by residential properties to the south along Murray Drive. Additional residential properties are located to the east-northeast on Whittamore Road and to west beyond Centerville Turnpike. Agricultural properties exist to the north and east of the site and beyond the residential properties to the south.

The Battlefield Golf Club covers approximately 217 acres and opened to the public on October 13, 2007. Prior to the construction of the golf course, fly ash derived from the burning of coal was used as fill material. The fly ash was then covered with soil for the construction of the golf course. Groundwater wells have historically been used by residents in the vicinity of the golf course but these residents are now served by the City's municipal supply. Environmental concerns over the potential degradation of groundwater and surface water quality associated with the fly ash fill are the subject of CDM's investigation and modeling work.

1.2 Environmental Setting

1.2.1 Climate

Chesapeake is located within the Tidewater climate region of Virginia (University of Virginia Climatology Office). The area averages approximately 51 inches of precipitation annually and the average temperature is approximately 57 degrees Fahrenheit. The monthly average values are included on **Figure 1-3**.

1.2.2 Topography and Drainage

The topography of the site vicinity is very flat, with a gradual slope to the east toward the Atlantic Ocean. The west border of the site is at an elevation of approximately 20 feet above mean sea level (msl) and the east border is at an elevation of approximately 10 feet above msl. Prior to ash fill placement, the area of the golf course ranged in elevation from approximately 10 to 15 feet above msl. Fly ash fill and a soil cover were emplaced that reportedly created elevations on the golf course as high as 40 feet. Therefore, CDM assumes that the depth to the fly ash base is approximately 25 below land surface (bls) at the areas that have the highest elevations. The current topography of the golf course has not been surveyed but proposed topographic plans were prepared prior to the construction.

The site vicinity has a network of surface water drainage ditches (**Figure 1-1**). The topographic map in **Figure 1-1** was prepared in 2003. Since that time, many smaller drainage ditches have been filled from agricultural practices. Drainage in the ditches is generally from west to east. A portion of the drainage on the golf course is into the ponds that are used as water hazards and as source water for irrigation (**Figure 1-2**). Otherwise, the general runoff direction on the golf course is to the south into a

drainage ditch that merges east of the site with the headwaters of a tributary, referred to in this report as the North Tributary to the Pocaty River. A second tributary to the Pocaty River is located further south and is referred to as the South Tributary in this report. The Intracoastal Waterway/Albemarle Canal is located approximately 2.5 miles north of the site.

1.2.3 Hydrogeology

The site is located within the Coastal Plain physiographic province of southeast Virginia. This area is underlain by an alternating sequence of aquifers and confining zones. The aquifers of interest to this report include the surficial aquifer, also referred to as the Columbia aquifer, and the underlying Yorktown-Eastover (Yorktown) aquifer. A generalized hydrogeologic section is shown on **Figure 1-4**.

The surficial aquifer is a heterogeneous aquifer, consisting of sand and gravel (Pope, 2008), that is locally interbedded with fine-grained sediments (McFarland, 2006). The top of the aquifer is at land surface and extends to an estimated depth of approximately 60 feet (McFarland, 2006) in the site vicinity. The surficial aquifer is unconfined and under water table conditions. The depth to groundwater in the site vicinity is generally less than 5 feet. The estimated transmissivity (T) of the surficial aquifer in the site vicinity ranges from 1,000 to 1,500 feet² per day (ft²/d) (McFarland, 1998). The surficial aquifer is underlain by the Yorktown confining zone.

The Yorktown confining zone separates the underlying Yorktown aquifer from the overlying surficial aquifer and exhibits characteristics of both units (Pope, 2008). This is a heterogeneous zone generally defined as the uppermost silt/clay that is interbedded with glauconitic, phosphatic, and fossiliferous quartz sand. The Yorktown confining zone does not represent a distinct contact surface, but rather approximates a transition from the Yorktown aquifer to the surficial aquifer. The zone is approximately 20 to 30 feet thick in the site vicinity (McFarland, 2006). Because of the heterogeneity of this zone, the Yorktown confining zone may act as a semi-confining zone or may allow hydraulic communication between the surficial and the Yorktown aquifers on a localized basis. The estimated vertical leakance of the Yorktown confining zone is from 0.0001 to 0.001 inches per day (in/d) (McFarland, 1998).

The Yorktown aquifer is a heterogeneous unit composed of glauconitic, phosphatic, and fossiliferous quartz sand with interbedded silt/clay. The lower part consists of abundantly fossiliferous sands. The Yorktown aquifer is commonly used for domestic water supplies. This aquifer is present at an estimated depth of approximately 80 to 90 feet in the site vicinity. The T of the Yorktown aquifer in the site vicinity ranges from 1,000 to 2,000 ft²/d (McFarland, 1998). The Yorktown aquifer is underlain by the Saint Mary's confining zone at an estimated depth of 130 feet to 140 feet and the estimated vertical leakance is from 0.00001 to 0.0001 in/d (McFarland, 2006).

Both the surficial aquifer and the Yorktown aquifer are used locally for residential water supplies. The average residential water supply well depth in Chesapeake is approximately 80 feet BLS (Pope, 2008). There are approximately 200 residential supply wells in the site vicinity. All of the residences in the immediate site vicinity, including those along Murray Drive and Whittamore Road, are currently supplied by the municipal provider.

1.3 Project Scope

The scope of the investigation completed by CDM included groundwater and surface water monitoring, an APT, fly ash sample collection, and laboratory analyses. **Table 1-1** includes a summary of the monitoring locations utilized by CDM and summarizes the sampling performed by others as well. For the purposes of this report, CDM has established a location code index that provides each location with a unique code. The unique codes used in this report are included in Table 1-1 along with corresponding alias codes used by others. This systematic approach to location codes is beneficial because non-unique location codes exist from the previous work and can be a source of confusion. These locations are mapped on **Figure 1-5**.

In addition to the monitoring, CDM also completed an APT that consisted of pumping a test well (TW-1) for a period of 72 hours while recording aquifer response in two piezometers (PZ-1 and PZ-2) and select monitoring wells. Additional hydrogeologic data were collected by URS and MACTEC by performing slug tests on select monitoring wells.

In an attempt to collect leachate samples from the fly ash, CDM constructed boreholes into the fly ash at three locations (LW-1, LW-2, and LW-3). Fly ash samples were collected from these locations. A field decision was then made at each location as to whether leachate was present in sufficient quantities to allow sample collection from a temporary well point. One leachate well was installed (LW-1) but did not provide sufficient recharge to allow sample collection.