HYDROGEOLOGIC CALCULATIONS
WILLIAM C. MEREDITH COMPANY
EAST POINT, GEORGIA
PERMIT NO. HW-062(D)

The following hydrogeologic calculations are provided as a supplement to the text for annual reports. The hydrogeological calculations were performed using values calculated using the April 2023 groundwater elevation data, calculated hydraulic conductivity data, and estimated values derived from published sources referenced. Supplemental vertical groundwater flow velocities were also calculated using newly installed monitoring wells MW-8A, MW-8B, and MW-8B2.

***Horizontal Groundwater Flow Velocity (Vh)*:**

The average horizontal groundwater flow was calculated using data collected during the April 2023 sampling event. Calculations were performed using the following formula taken from Darcy's equation for fluid flow through a porous medium:

$$Vh = \left[\frac{K \frac{dh}{dl}}{n} \right]$$

Where:

K = the average hydraulic conductivity of 3.565 x 10^{-6} centimeters per second (cm/sec) or 0.010 feet per day (ft/day), calculated using data evaluated from wells PW-1, MW-5R, MW-6R, and MW-7 from May 1990 recovery tests;

dh/dl = the hydraulic gradient measured as the hydraulic head distance between up-gradient well MW-6R and down-gradient well MW-12 (April 2023 data), divided by the measured distance between the wells, equaling 0.036 ft/ft; and

n = an estimated effective porosity for a silty-sand saprolite of 20% or 0.20 (taken from *Fetter, C. W., 1988, Applied Hydrogeology, 2nd Edition, Macmillan Publishing Company, New York, 592 p*.).

Using this formula, an average horizontal groundwater flow velocity of **0.0018** ft/day or **0.657** feet per year (ft/year) was calculated.

This calculated value assumes groundwater flow occurs through a homogeneous, isotropic, porous medium. Since groundwater flow in the Piedmont is commonly influenced by secondary fracture pathways caused by soil heterogeneities and other structural features not accounted for in this equation, this calculated value should be considered an estimate only of the actual horizontal groundwater flow velocity.

Vertical Groundwater Flow Velocity:

Vertical groundwater flow dynamics have not been evaluated through actual field testing. Comparative observations have been made based on differences in groundwater elevation readings taken from “nested” well locations. Based on these observations, there does not appear to be a hydraulic separation between shallow residuum (saprolite) and weathered rock/top-of-rock (PWR) zones. However, calculations were performed for a vertical groundwater flow or seepage velocity using MW-7/MW-8 and MW-7A/MW-8A (Vv), MW-7A/MW-8A and MW-7B/MW-8B (Vvv), and MW-7B/MW-8B and MW-7B2/MW-8B2 (Vvv).

Vertical Groundwater Flow Velocity (Vv) between Residuum and PWR Zones:

MW-7 and MW-7A

A review of the boring log and well schematic for MW-7A indicates the well is screened from 48-53 feet below ground surface (ft-bgs) in a weathered mica schist while MW-7 is screened from 28-38 ft-bgs in shallow residual soils. Vertical groundwater flow/seepage between MW-7 and MW-7A likely involves a combination of porous flow through soil and flow through secondary pathways caused by foliation or preferential pathways in the weathered bedrock (saprolite). The vertical groundwater flow (Vv) was calculated using Darcy's equation:

$$Vv = \left[\frac{Kv \frac{dh}{dl}}{n} \right]$$

Where:

Kv = the average hydraulic conductivity of 3.565×10^{-6} cm/sec or 0.010 ft/day, similar to published values for a weathered mica schist as described in *Batu, Vedat, 1998, Aquifer Hydraulics, John Wiley & Sons, Inc., New York, 727p*.;

dh/dl = the vertical hydraulic gradient measured using the head difference between MW-7 and MW-7A (April 2023 data) divided by the midpoint of each screened interval as the travel length. The calculated gradient is 0.034 ft/ft; and

n = an estimated porosity of 18% or 0.18, assuming a combination of porous and fracture flow for a schist (taken from *Batu, Vedat, 1998, Aquifer Hydraulics, John Wiley & Sons, Inc., New York, 727p*.).

Using these values, the calculated Vv = **0.0019** ft/day or **0.663** ft/year was calculated.

MW-8 and MW-8A

A review of the boring log and well schematic for MW-8A indicates the well is screened from 45-50 ft-bgs in a weathered mica schist while MW-8 is screened from 27-37 ft-bgs in shallow residual soils. As noted above, vertical groundwater flow/seepage between these wells likely involves a combination of porous flow through soil and flow through secondary pathways caused by foliation or preferential pathways in the weathered bedrock (saprolite). The vertical groundwater flow (Vv) was calculated using Darcy's equation:

$$Vv = \left[\frac{Kv \frac{dh}{dl}}{n} \right]$$

Where:

Kv = the average hydraulic conductivity of 3.565 x 10^{-6} cm/sec or 0.010 ft/day, similar to published values for a weathered mica schist as described in *Batu, Vedat, 1998, Aquifer Hydraulics, John Wiley & Sons, Inc., New York, 727p*.;

dh/dl = the vertical hydraulic gradient measured using the head difference between MW-8 and MW-8A (April 2023 data) divided by the midpoint of each screened interval as the travel length. The calculated gradient is 0.043 ft/ft; and

n = an estimated porosity of 18% or 0.18, assuming a combination of porous and fracture flow for a schist (taken from *Batu, Vedat, 1998, Aquifer Hydraulics, John Wiley & Sons, Inc., New York, 727p*.).

Using these values, the calculated Vv = **0.0024** ft/day or **0.876** ft/year was calculated.

Vertical Groundwater Flow Velocity between PWR and Bedrock Zones (Vvv):

<u>MW-7A and MW-7B</u>

Vertical groundwater flow/seepage between MW-7A and MW-7B is assumed to occur along secondary pathways caused by foliation, jointing, or fracturing in the PWR and bedrock. A review of the boring log for MW-7B indicates the presence of competent biotite-muscovite-gneiss bedrock beginning at a depth of 65 ft-bgs. Possible water-bearing fractures were identified during drilling at depths of 87 ft-bgs, 107 ft-bgs, 110 ft-bgs, 115 ft-bgs, and 118 ft-bgs. The aperture size, orientation, and connectivity of these fractures is unknown. The screened interval for MW-7B is 111-121 ft-bgs.

Vertical groundwater flow (Vvv) was calculated using Darcy's equation with the following values:

$$Vvv = \left[\frac{Kv\,\frac{dh}{dl}}{n}\right]$$

Where:

Kv = an estimate of the vertical hydraulic conductivity for fractured gneiss of 1 x 10^{-7} cm/sec or 0.0003 ft/day (taken from *Batu, Vedat, 1998, <u>Aquifer Hydraulics,</u> John Wiley & Sons, Inc., New York, 727p*.);

dh/dl = the vertical hydraulic gradient determined using the head difference between MW-7A and MW-7B (April 2023 data) divided by the midpoint of each screened interval as the travel length and equaling 0.024 ft/ft; and,

n = an estimated fracture porosity of 2% or 0.02 was used (taken from *Freeze, R.A., and Cherry, J.A., 1979, <u>Groundwater:</u> New Jersey, Prentice Hall, Inc., 604 p*.).

Using these values, the calculated Vvv = **0.00036** ft/day or **0.13** ft/year.

<u>MW-8A and MW-8B</u>

Similar to MW-7A and MW-7B, vertical groundwater flow/seepage between MW-8A and MW-8B is assumed to occur along secondary pathways caused by foliation, jointing, or fracturing in the PWR and bedrock. A review of the boring log for MW-8B indicates the presence of competent biotite-muscovite-gneiss bedrock beginning at a depth of approximately 55 ft-bgs.

Possible water-bearing fractures were identified during drilling at depths of 53-58 ft-bgs, 61-66 ft-bgs, 66-71 ft-bgs, 71-76 ft-bgs, 91-96 ft-bgs, and 148-153 ft-bgs. The aperture size, orientation, and connectivity of these fractures is unknown. MW-8B was set as an open borehole from 55-80 ft-bgs.

Vertical groundwater flow (Vvv) was calculated using Darcy's equation with the following values:

$$Vvv = \left[\frac{Kv \frac{dh}{dl}}{n} \right]$$

Where:

Kv = an estimate of the vertical hydraulic conductivity for fractured gneiss of 1 x 10^{-7} cm/sec or 0.0003 ft/day (taken from *Batu, Vedat, 1998, Aquifer Hydraulics, John Wiley & Sons, Inc., New York, 727p*.);

dh/dl = the vertical hydraulic gradient determined using the head difference between MW-8A and MW-8B (April 2023 data) divided by the midpoint of each screened interval as the travel length and equaling 0.008 ft/ft; and,

n = an estimated fracture porosity of 2% or 0.02 was used (taken from *Freeze, R.A., and Cherry, J.A., 1979, Groundwater: New Jersey, Prentice Hall, Inc., 604 p*.).

Using these values, the calculated Vvv = **0.00012** ft/day or **0.044** ft/year

Vertical Groundwater Flow Velocity between Intermediate and Deep Bedrock Zones (Vvvv):

<u>MW-7B and MW-7B2</u>

Vertical groundwater flow/seepage between MW-7B (screened 111-121 ft-bgs) and MW-7B2 (screened 195-200 ft-bgs) is assumed to occur along secondary pathways caused by foliation, jointing, or fracturing in the bedrock. The extent and orientation of water-bearing fractures encountered in these two wells is unknown. Dissolved VOC and SVOC contaminant impact has been observed in MW-7B and in discrete water samples collected at intervals of 148-150 ft-bgs and 173-175 ft-bgs, during the drilling of MW-7B2. Detectable VOC/SVOC concentrations were not observed in MW-7B2 suggesting some hydraulic separation between fracture zones.

Vertical groundwater flow (Vvvv) was calculated using Darcy's equation with the following values:

$$Vvv = \left[\frac{Kv\,\frac{dh}{dl}}{n}\right]$$

Where:

Kv = an estimate of the vertical hydraulic conductivity for fractured gneiss of 1×10^{-9} cm/sec or 0.000003 ft/day (taken from *Batu, Vedat, 1998, <u>Aquifer Hydraulics,</u> John Wiley & Sons, Inc., New York, 727p*.);

dh/dl = the vertical hydraulic gradient determined using the head difference between MW-7B and MW-7B2 (April 2023 data) divided by the midpoint of each screened interval as the travel length and equaling 0.033 ft/ft; and,

n = an estimated fracture porosity of 1% or 0.01 was used (taken from *Freeze, R.A., and Cherry, J.A., 1979, <u>Groundwater:</u> New Jersey, Prentice Hall, Inc., 604 p*.).

Using these values, the calculated Vvvv = **0.0000099** ft/day or **0.0036** ft/year.

<u>MW-8B and MW-8B2</u>

Vertical groundwater flow/seepage between MW-8B (open borehole 55-80 ft-bgs) and MW-8B2 (screened 148-153 ft-bgs) is assumed to occur along secondary pathways caused by foliation, jointing, or fracturing in the bedrock. Fractures were observed at MW-8B, most evidenced by moderate to slight rock weathering, iron oxide (rust colored) mineralization, and oil contaminant odor.

In addition, during well installation activities, MW-8B contained oil product residue in fracture zones encountered in the 66-71 ft-bgs interval. Dissolved VOC and SVOC contaminant impact has been observed in both MW-8B and MW-8B2 suggesting hydraulic connection between fracture zones.

Vertical groundwater flow (Vvvv) was calculated using Darcy's equation with the following values:

$$Vvv = \left[\frac{Kv\,\frac{dh}{dl}}{n}\right]$$

Where:

Kv = an estimate of the vertical hydraulic conductivity for fractured gneiss of 1 x 10^{-9} cm/sec or 0.000003 ft/day (taken from *Batu, Vedat, 1998, Aquifer Hydraulics, John Wiley & Sons, Inc., New York, 727p*.);

dh/dl = the vertical hydraulic gradient determined using the head difference between MW-8B and MW-8B2 (April 2023 data) divided by the midpoint of each screened interval as the travel length and equaling 0.0068 ft/ft; and,

n = an estimated fracture porosity of 1% or 0.01 was used (taken from *Freeze, R.A., and Cherry, J.A., 1979, Groundwater: New Jersey, Prentice Hall, Inc., 604 p*.).

Using these values, the calculated Vvvv = **0.0000020** ft/day or **0.00073** ft/year.