Numerical Simulation of Groundwater Flow at Kori Nuclear Power Plant Site

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1. Introduction

Recently, the understanding of hydrogeological characteristics of nuclear power sites is getting more importance with increasing public concerns over the environment since such understanding is essential for an environmentally friendly operation of plants. For such understanding, the prediction of groundwater flow pattern onsite plays the most critical role since it is the most dynamic of the factors to be considered. In this study, the groundwater flow at the Kori Plant 1 site has been simulated numerically with aim of providing fundamental information needed for improving the understanding of the hydrogeological characteristics of the site.

2. Modeling and Results

2.1 Outline of Kori Nuclear Power Plant 1 Site

The site of Kori nuclear power plant, which was originally a part of Bongwha Mountain reaching the seashore with the sea level (EL) of over 10 m, has been excavated to EL 5.8 m during the construction with the western and southern border areas being backfilled. The ground on which most plant structures are located has been excavated below the sea level. The containment building and the auxiliary building are located on the bed rock at approximately EL -20 m and EL -17 m, respectively, and the other structures and underground pipes are positioned at EL -1 m and back-filled later.

It is noted that, for forced drainage of groundwater, a permeable layer has been laid beneath the basement of the containment building and the auxiliary building, and dewatering sump and pump has been installed at the southern tip of the containment. The most area around the major buildings has been paved while the west-southern site boundary area, the switch yard and the northern slop-sided area have not been paved.

The geological survey shows that sedimentary rocks of the Mesozoic Era-Cretaceous Period such as sandy limestone, siltstone, conglomerate and coarse sandstone are distributed with strike of about N30°E and slope direction of NW.

2.2 Study Area and Geological Model for Simulation

The simulation was performed by using MODFLOW software. The area of 1,300 m × 900 m including the Kori Plant 1 site and a part of Bongwha Mountain was selected for modeling. The whole area was divided by 10 m × 10 m mesh except for the area around Units 1 and 2 which was divided by 5 m × 5 m mesh. Based on the hydraulic conductivity data [1], the geological model for the area was assumed to be composed of five geologic units as shown in Fig. 1: an unconsolidated back-filled layer (Layer 1: silty sandstone with conductivity of 1.0×10^{-3} cm/sec), a porous aquifer (Layer 2: sandstone with conductivity of 1.0×10^{-4} cm/sec), an aquitard (Layer 3: mud-stone and siltstone with conductivity of 1.0×10^{-6} cm/ sec) and an upper bed rock (Layer 4: conductivity of 1.0×10^{-3} cm/sec) and a lower bed rock (Layer 5: conductivity of 1.0×10^{-3} cm/sec) in increasing depth order with the plant structures assumed to be laid on the upper base rocks. The hydraulic conductivity of the plant structures was set to 1.4×10^{-6} cm/sec a little higher than that of Layer 3, the aquitard layer.

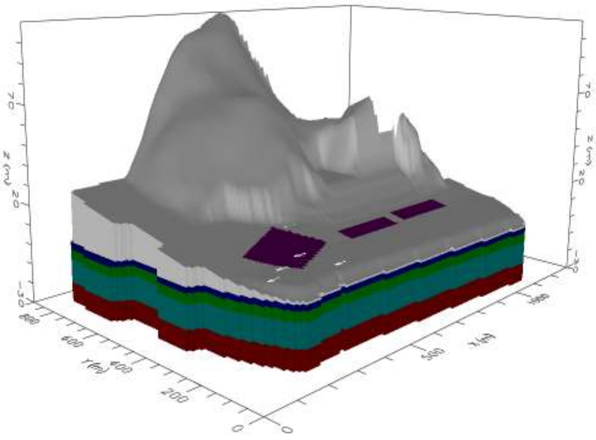

Fig. 1. Three-dimensional schematic diagram for layers with different hydraulic conductivity values in Kori nuclear power plant site.

2.3 Boundary Condition and Dewatering Effect

Since the site is located on the seashore, a constant head boundary of EL 0 m has been delineated for all layers along the shoreline. Based on the precipitation data for the area, a groundwater discharge rate of 125 mm/yr has been applied to Bongwha Mountain, and a smaller rate of 10 mm/yr to the rest of the area which is paved with impermeable materials such as asphalt and artificial structures.

To simulate the dewatering effect which was observed at the well installed near the refueling water storage tank of Unit 2, groundwater flowing into Layers 1 to 4 around the dewatering sump was assumed to be drained to the sump located at EL -20 m.

2.4 Results of Groundwater Simulation

The groundwater flow in each layer of the study area has been numerically simulated by means of Particle Tracking function of the software. For this, equi-potential groundwater lines have been portrayed for each layer based on the hydraulic conductivity data and recharges rates etc., and then virtual particles dropped along the northern boundary of the site in order to visualize groundwater flow in each layer [2]. Fig 2. shows the simulation result of groundwater flow in Layer 3.

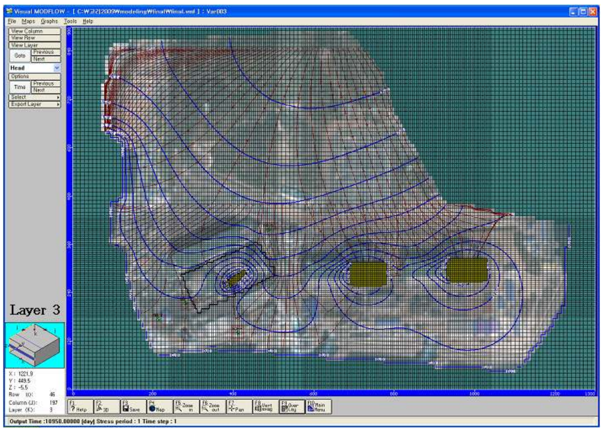

Fig. 2. Equi-potental groundwater lines and groundwater flow in Layer 3.

Although the simulated groundwater flows in all layers are different in detailed aspects, they have two features in common. First, all of the groundwater flowing out of the site in all of the layers is headed only for the western and the southern boundaries facing the sea but not for the northwestern boundary adjoining the resident area. Second, the groundwater flows in the area around the plant buildings are affected by the dewatering effect so strongly that almost of them are removed by the dewatering pump on their way to the sea thereby reducing a fraction of the groundwater reaching the sea to an insignificant level.

2.5 Simulation of Contaminant Behavior

To predict the long term behavior of a contaminant which can be produced in a nuclear power plant, an imaginary contaminant was modeled to have been released at a constant rate of 10 mg/L for 10 years from six points located in the area around Units 1 and 2.

As can be seen from Fig. 3 showing the results of simulation for the imaginary contaminant, a noticeable migration of contaminant was able to be observed at only two of six points. This can be explained by the dewatering effect which prevents the groundwater containing the contaminant from spreading out of its release point. The results also indicate that it took as long as 10 years for the contaminant to arrive at the sea.

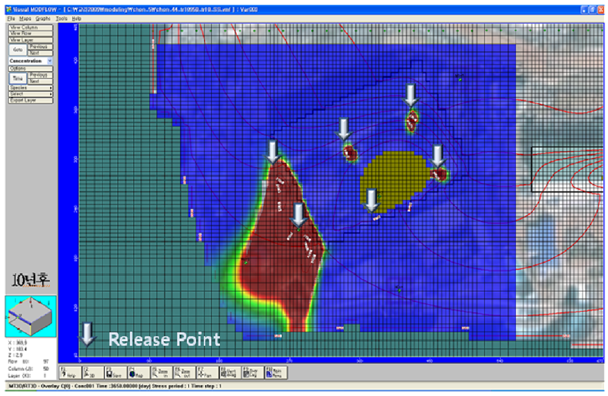

Fig. 3.Results of simulation for contaminant behavior for 10 years.

3. Conclusions

The results of this study provided several implications which is important for the environmentally-friendly operation of the Kori nuclear power plant. First, since the groundwater does not migrate into the resident area, undesirable effects, which a contaminated groundwater may cause, are negligible. In addition, most of the groundwater entering the site is eliminated halfway due to the dewatering effect, which prevents the groundwater with a contaminant passing a dewatering pump from spreading further. Finally, it takes as long as 10 years for the contaminant released from area with little dewatering effect to arrive at the sea. Therefore it can be said that the Kori nuclear power plant site has a condition favorable for minimization of contaminant spreading and its undesirable effects.

REFERENCES

[1] Korea Hydro and Nuclear Corporation, Report on Installation of Groundwater Lever Measurement Equipment and Evaluation of Groundwater Distribution/Hydrological Characteristics at Kori Unit 1, 2008 (in Korean).

[2] Davis, S.N, Campbell, D.J., Bentley, H.W, and Flynn, T.J., Ground Water Tracers, National Water Well Association, 2003.