Richard Martin Groundwater LLC

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Xinghua Groups

RE: Construction Dewatering Evaluation and Design Recommendations, Mercer Island Mixed Use, Mercer Island, Washington

This letter presents our evaluation and recommendations for preliminary temporary construction dewatering for the Mercer Island Mixed Use project being developed by Xinghua Groups in Mercer Island, Washington. The proposed project includes construction of a below grade stormwater detention vault underneath the parking structure foundation slab. The detention vault excavation subgrade will be below the water table and will require a dewatering system to control groundwater inflow to the excavation. In addition to the detention vault excavation, several smaller excavations may require groundwater control, including elevator pits and a utility room. As part of the evaluation, a numerical groundwater flow model was constructed to evaluate potential temporary construction dewatering approaches to control potential groundwater seepage into the excavation. The numerical model inputs, assumptions, and results of the dewatering evaluation are provided in this letter. These services were performed in general accordance with our proposal dated September 9, 2023.

The Mercer Island Mixed Use project is located at 2885 78th Avenue SE in the north central portion of Mercer Island just south of Interstate I-90. It is our understanding that the project consists of a 4-story mixed-use building with one basement level of parking and support services. Most of the base of the floor slab excavation will be above the selected design groundwater elevation of 75 feet with the exception of a small area at the southern portion of the excavation and the elevator pits. Stormwater detention vaults will be installed below the floor slab and will require construction dewatering. Because the observed groundwater elevation ranges from approximately elevation 74 to 79 feet, localized dewatering will likely be required during excavation activities. Most of the upper soils are likely susceptible to dewatering induced settlement and care will be needed to reduce the risk of settlement outside the excavation footprint. Because of the settlement risk, the City of Mercer Island requires a dewatering plan as part of the design review.

The groundwater flow model is generally based on the soil and groundwater exploration and testing program performed by Hart Crowser, a division of Haley & Aldrich for the site; refer to the Hart Crowser 2023 Geotechnical Engineering and Design Report for additional details. The profiles developed by Hart Crowser provide the subsurface framework for the model. Hydraulic inputs were estimated based on slug tests performed on monitoring wells installed at the site and our experience in the King County area with similar types of subsurface conditions.

Soil Conditions

Soil conditions below the site are described by Hart Crowser in their geotechnical report based on explorations performed for the site and on other explorations performed by others. Hart Crowser divided the observed soil conditions into four soil units:

- **Unit 1.** Loose to medium dense silty granular FILL, soft SILT, and PEAT.
- **Unit 2.** Medium stiff to hard SILT and silty CLAY.
- **Unit 3.** Medium dense to dense SAND and silty SAND.
- **Unit 4.** Hard SILT.

For additional information on the soil units, refer to the Hart Crowser geotechnical report.

The depth and presence of each soil unit is variable at the site but the sequence of units generally increases with depth, i.e. Unit 1 is the shallowest soil unit and Unit 4 is the deepest unit. Units 1, 2, and 4 would be anticipated to have a relatively low permeability with Unit 3 as the primary unit that requires dewatering. However it is likely that the other units may contain layers of sand that could contribute to groundwater inflow into excavations. Rather than attempt to simulate the complicated interlaying, depths, and thicknesses of each soil unit, the soil units are lumped together in the dewatering evaluation. The variability in soil properties with respect to dewatering in this evaluated by performing parametric analyses over the expected range of permeability for the soil units. The exception is Unit 4, which based on the nature of the soil in not anticipated to require dewatering.

Groundwater Conditions

Several monitoring well have been installed on the site by Hart Crowser and others, which indicates a groundwater elevation ranging from approximately 74 to 79 feet. We understand for civil and structural engineering purposes, a design groundwater elevation of 75 feet was selected. For the dewatering evaluation, a groundwater elevation of 78 feet was assumed.

Based on the observed soil types and groundwater elevations, groundwater is anticipated to generally flow under unconfined conditions.

Aquifer Parameters

For the dewatering evaluation, aquifer parameters including hydraulic conductivity and storage coefficient are required. Most of the base of the excavation will be in the fine-grained soil of Units 1 and 4, with the northwest corner potentially in Unit 3. Hart Crowser performed slug tests in four of the on-site monitoring wells to estimate the hydraulic conductivity of on-site soil. Two of the four monitoring wells are screened in Unit 3 but at a depth of 7+ feet below the base of the detention vault excavation. One of the wells is screened above the base of the excavation in mostly silt (Units 2 and 4) with the bottom two feet in Unit 3. The fourth well is screened a just below the base of the excavation in Unit 4, and is likely the only well screened at an elevation representative of soil to be dewatered.

Because the excavation is likely to be in variable soil conditions, including Units 1, 3, and 4, the range of hydraulic conductivity values from the slug tests were used for the dewatering evaluation. The results of the slug test analyses indicate the horizontal hydraulic conductivity ranges from approximately $5x10^{-5}$ to $1x10^{-3}$ centimeters per second (cm/sec).

As noted above, groundwater is flowing under unconfined conditions and a storage coefficient of 0.2 was assumed based on our experience in the types of soil observed

Temporary Construction Dewatering Approach

It is our understanding that the bottom elevation of the detention vault mat is 70.5 feet. For the dewatering evaluation the target elevation for dewatering is 1 foot below vault mat to elevation 69.5 feet. With an assumed static groundwater elevation of 78 feet, the total assumed drawdown for the dewatering evaluation is 8.5 feet.

In general, it is anticipated that most of the detention vault excavation will be in fine-grained soil with the exception of potentially areas of silty sand (Unit 3). Because of the risk of dewatering-induced consolidation of the soft Unit 1 soils and the relatively low hydraulic conductivity of the soils, the use of deep dewatering wells is not recommended. In our opinion, the use of a vacuum well point system to control groundwater flowing into the excavation is likely to be effective. Sumps within the excavation footprint will likely be needed to control residual groundwater. For planning purposes, we recommend installing the well points on approximately 5- to 10-foot centers and approximately 5 feet outside the perimeter of the excavation. If residual groundwater between well points causes the excavation sidewalls to become unstable, additional well points may be needed.

It is our understanding the vacuum well point system will be installed once the excavation has reached approximately floor grade of the garage. The well points should be installed approximately 4 to 5 feet below the base of the detention vault excavation. We recommend operating the vacuum well point system approximately 2 weeks prior start of the detention vault excavation.

Dewatering Evaluation

The dewatering evaluation was performed using MODFLOW as part of the Groundwater Vistas Version 6 (Environmental Simulations, 2011) groundwater modeling program. MODFLOW was developed by the United States Geological Survey (McDonald and Harbaugh, 1998), and is the most widely used groundwater modeling program in the industry.

Model Grid and Boundaries

A 5,000-foot by 5,000-foot model domain was constructed and roughly centered on the site. The model includes 159 columns and 208 rows with spacing ranging from 2 feet around and within the excavation footprint to 175 feet near the edges of the model domain. The model consists of one layer representing the soil units; variability in the soil properties is evaluated by varying the soil hydraulic conductivity over the range described above.

Model boundary conditions consisted of constant-head boundaries on the north and south sides of the model set at an elevation of 78 feet. Given the lack of groundwater data in the vicinity of the property, the water table is assumed to be flat.

The vacuum well points were simulated as general head boundaries with an elevation of 69.5 feet. The drain boundaries were set just outside the edge of the excavation footprint.

The following assumptions were incorporated into the model:

- Hydraulic conductivity: $5x10^{-5}$ to $1x10^{-3}$ centimeters per second (based on the results of slug testing).
- Specific yield: 0.2 dimensionless (based on experience with similar soil conditions).
- Saturated thickness of water bearing zone: 18 feet (assumed based on a review of soil logs near the detention vault excavation and assuming that groundwater flow is predominately horizontal).
- Pumping period: 100 days.
- Approximate dimensions of the excavation: 64 feet by 120 feet.

The results of evaluation indicate that total discharge from the vacuum well points ranges from approximately 4 to 16 gallons per minute (gpm) after 7 days, and decreasing to relatively steady-state flow rate of approximately 1 to 6 gpm after 100 days. The range is a result of performing model runs for the range of hydraulic conductivity values listed above. During excavation some residual water will flow into the excavation from between the well points. We recommend the use of perimeter drains and sumps, as needed, to manage the residual water.

Because of the concern of dewatering-induced consolidation of the Unit 1 soil, which could lead to ground settlements, the approximate drawdown was estimated a the property line for the range of hydraulic conductivity values:

- North property line – 3 to 5 feet
- West property line – <1 to 2 feet
- East property line – 1 to 3 feet
- South property line – <1 to 2 feet
- Corner of the church property – 3 to 5 feet

Note that drawdowns could be higher depending on the variability of hydraulic conductivity within each soil unit and the distribution of soil units.

CONSTRUCTION DEWATERING RECOMMENDATIONS

This section provides recommendations for construction dewatering and groundwater control during excavation activities for the below slab detention vault. Based on the anticipated soil conditions that will be encountered during excavation for the detention vault, it is our opinion that a perimeter vacuum well point system is the preferred approach for groundwater control. Because the performance and operation of dewatering systems is closely tied to the contractor's excavation means and methods, sequencing, and schedule, we recommend the actual design, installation, operation, and maintenance of the dewatering system be the responsibility of the contractor.

Vacuum Well Points

Vacuum well points use a surface vacuum pump to suction groundwater into the well points, with a single vacuum pump working on multiple well points connected to a single header pipe. They also have the advantage of potentially reducing the radius of influence of drawdown because they are typically more closely spaced resulting in less drawdown away from the excavation. In theory, a vacuum system can lift water approximately 32 feet; in practice the lift is limited to approximately 17 to 20 feet because of system and pump inefficiencies and head loss through the system.

Typical well point spacing for silty soils is 5 to 10 feet. Well point construction could consist of 1- to 2-inch diameter PVC with a minimum 3-foot, machine-slotted screen (10-slot) at the bottom of the well point. A drop tube consisting of smaller diameter PVC should be installed to base of the well screen and connected to the vacuum head pipe. We recommend pre-packing the well screens with 10-20 Colorado silica sand to facilitate proper installation of the well points. Recommended drilling methods for well points include hollow stem auger methods.

Engineered Sumps

Residual groundwater may be observed at the base of the excavation. We recommend the contractor be prepared to manage groundwater with engineered sumps, as needed. The sumps should be engineered with a machine-slotted screen (10-slot) and surrounded by an appropriate filter pack to reduce migration of soil particles. The installation method should be the responsibility of the excavation contractor.

The Washington State Department of Ecology defines sumps as shallow wells and will require a licensed well driller for installation.

Dewatering System Performance Monitoring and Operation

To evaluate the performance of the dewatering system in meeting the drawdown requirements for excavation activities and to evaluate the potential impact of dewatering on adjacent properties, we recommend installing additional monitoring wells as close as feasible to the north, west, south and east property lines and the detention vault excavation, as wells as the inner corner adjacent to the church property to observe changes in groundwater levels. If drawdown exceeds the values described above,

work should be stopped and additional evaluation of the drawdown and risk of ground settlement should be performed.

Discharge should be to the sanitary sewer in accordance with the project King County Wastewater Discharge Permit and local, state, and federal regulations.

All dewatering well, vacuum well points, monitoring wells, and sumps should be drilled and constructed in accordance with Washington Administrative Code (WAC) 173-160. Following completion of dewatering activities, the dewatering wells, vacuum well points, monitoring wells, and sumps should decommissioned in accordance with WAC 173-160.

ADDITIONAL RECOMMENDATIONS

The loose and soft soils described as Unit 1 in the geotechnical report are potentially susceptible to drawdown-induced consolidation and subsequent ground settlement. We recommend that a qualified geotechnical engineer review the current plans and profiles for the proposed excavation, review the dewatering evaluation, potential radius of influence, and recommendations provided in this letter, and evaluate the potential for dewatering related ground settlement on adjacent properties.

Because of the uncertainty in the soil types that will be encountered during the detention vault excavation, we recommend potholing within the excavation footprint prior to excavation activities. We recommend two rows of potholes in the north-south direction on approximate 20-foot centers. The potholing should be performed a minimum of 10-feet from the proposed excavation sidewalls. An experienced geologist or geotechnical engineer should be on-site during potholing to observe soil and groundwater conditions. If excessive groundwater is observed or if the sidewalls become unstable, additional well points may be required adjacent to that location.

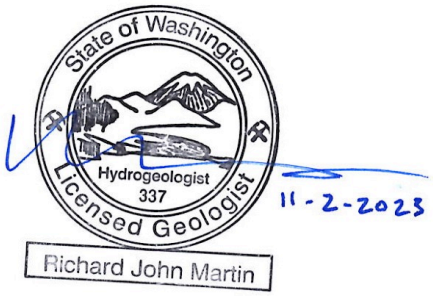
We recommend that Richard Martin Groundwater LLC be contracted during dewatering and excavation activities to observe soil and groundwater conditions and provide additional recommendations on dewatering as needed.

LIMITATIONS

This letter was prepared for the exclusive use of Xingua Groups and Johnston Architects. The opinions and conclusions provided in this report are based on review of site soil and groundwater data provided by Hart Crowser, and our experience with dewatering and drainage design in the King County area. This report was prepared in accordance with generally accepted professional principles and practice in this area at this time. No other warranty, either express or implied, is made.

If you have any questions or comments, please contact me at 206-979-1530 or at Richard.martin.gw@gmail.com.

Sincerely,



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