geoconvention
Virtual Event
September 21-23
2020
CSPG · CSEG · CWLS · GAC · MAC · IAH

Calgary Zoo Flood Mitigation: Groundwater Management and Dewatering an Island

Neal P. Barretto, Geoscientist In Training & Soren Poschmann, P.Geo
Associated Environmental Consultants Inc. and ISL Engineering and Land Services Ltd.

1 SUMMARY

In June 2013, the province of Alberta experienced catastrophic flooding resulting in total damages exceeding five billion dollars, which at the time was the costliest disaster in Canadian history. One of the hardest hit areas was the Calgary Zoo which is situated on St. George's Island, an island on the Bow River downstream of its confluence with the Elbow River. The Zoo was inundated with groundwater and surface water from the Bow River, resulting in a loss of power and making it difficult to evacuate the staff and the 200 animals which call the island their home. After the evacuation and clean up of the Zoo, the city of Calgary retained ISL Engineering and Land Services Ltd. to design a flood mitigation system to protect the Zoo from future flood events. Associated Engineering was asked to be a key partner in designing the dewatering and drainage system for the island.

2 WORKFLOW

The City agreed to support a fully sealed design of the island which would protect the Zoo from groundwater infiltration as well as overland flow. Flood protection berms and walls were conceived as suitable flood mitigation structures to withstand the overland flooding effects while preserving as much functional space as possible for Zoo operations. As the flood mitigation design progressed, investigations and flood simulations confirmed a 1:100-year flood would also result in flooding from underground sources because of a direct hydraulic connection between the Bow River and the groundwater in the underlying gravels.

Isolating the island's two-kilometre perimeter required a barrier capable of penetrating the highly permeable fluvial cobbles and boulders that make up most of the island and riverbed. Since proposed solutions would need to protect against both overland flow and increased groundwater levels, three passive options were considered: 1) driven steel/vinyl sheet pile wall, 2) drilled concrete secant/tangent pile wall, and 3) trenched slurry cut-off wall. Driving steel sheet piles into the bedrock was chosen based on total project time, difficulty of construction, and cost. Ground penetrating radar was used as an initial assessment to gauge the depth of bedrock beneath the island as the target installation depth for each sheet pile was one meter into bedrock. The 1,500 pairs of sheet pile wall (4,000 tonnes of steel) extends only a few meters above ground but were driven up to 20 metres below ground around the two-kilometer perimeter of the island. Boreholes were drilled to confirm bedrock depths throughout the pilling process.

Due to the limitations of the piling equipment and the uncertainty of how the sheet piles would hold together in the ground during the piling process, the project team recognized the barrier system would not be completely water tight. An active option was discussed which involved the operational of pumps to control high peak flows and short-lived flood events.

The project hydrogeologist developed a hydrogeological 3D numerical model based on limited geotechnical, geophysical and borehole/well data, and interpreted aquifer characteristics including thickness of the highly conductive gravel material. Based on measured Bow River hydrographs during the 2013 flood event it was clear that the model needed to focus on a dewatering system that could provide two days worth of groundwater storage capacity in the subsurface to control groundwater level increase resulting from any future 1:100-year flood events. After many model simulations and varying degrees of leakage levels, a system including ten dewatering wells were installed in underground vaults within the Zoo island which would draw down the groundwater levels each spring to mitigate against leakage of the sheet pile wall resulting from freshet snow melt, ice build up in the river, and/or heavy rainfall. In the event of a flood scenario the continuous pumping of groundwater in conjunction with the underground storage capacity would be adequate to prevent groundwater levels seeping onto surface and causing overland flood damage to Zoo infrastructure. The locations of the dewatering wells were selected based on calibrated modeling simulation results and where the highest inter-well interference would cause overall dewatering across the island. These wells were connected to outfalls that discharged to the Bow River. The biggest constraint in the well location selection was the existing infrastructure and caused some wells to be placed significantly outside the optimum well interference zones. The groundwater levels are remotely monitored using telemetric electronic water level loggers installed in five monitoring wells. The data is sent to a web application where groundwater elevations can be monitored in near real-time to allow for adjustments and early response to rising river levels. Figure 2-1 below shows the passive sheet pile wall and the active dewatering system working in conjunction.

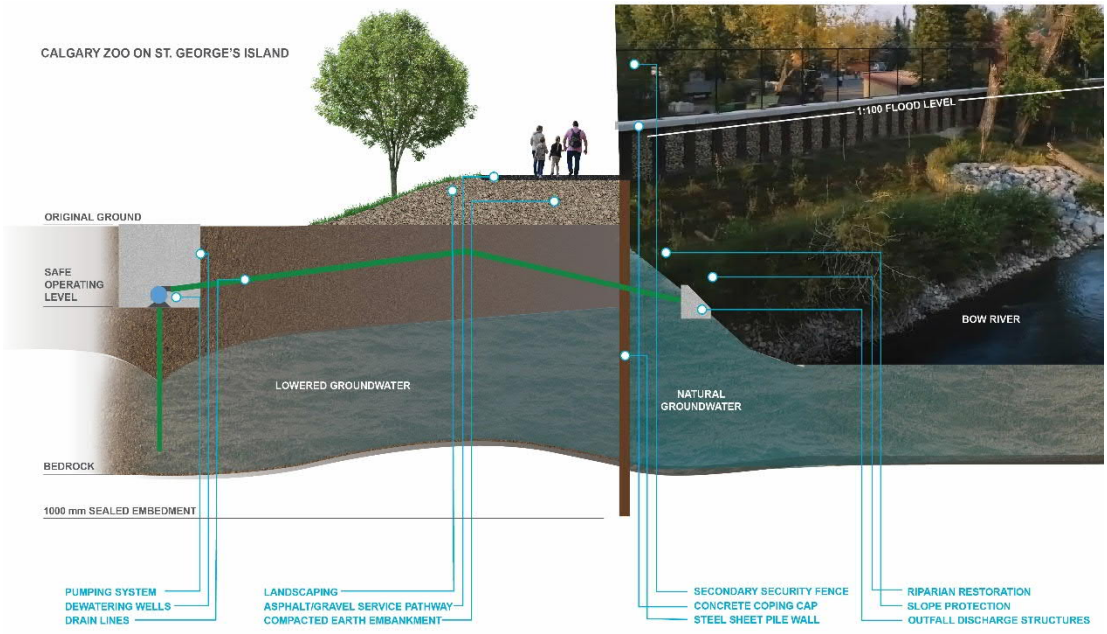

Figure 2-1

3 OBSERVATIONS AND CONCLUSIONS

Construction of all 10 dewatering wells were completed in June of 2018. The wells are turned on from May to October and have been calibrated to have a total pumping capacity of 120 L/s to handle the modelled groundwater inflows expected during a flooding scenario. During the pumping period the ground water level on the west and center section of the island was drawdown roughly one meter below the inferred river level and the east side was drawdown roughly 2 meters. Figure 3-1 below shows the groundwater levels during the pumping season from May 2019 to October 2019.

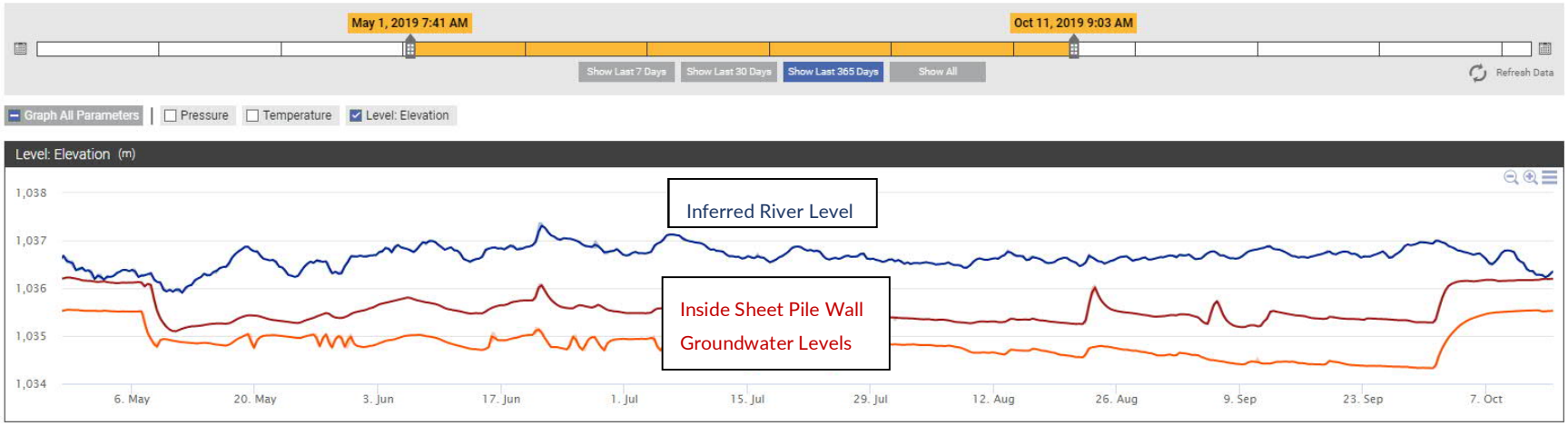
May 1, 2019 7:41 AM
Oct 11, 2019 9:03 AM
Show Last 7 Days
Show Last 30 Days
Show Last 365 Days
Show All
Refresh Data
Graph All Parameters
Pressure
Temperature
Level: Elevation
Level: Elevation (m)
1,038
1,037
1,036
1,035
1,034
Inferred River Level
Inside Sheet Pile Wall
Groundwater Levels
6. May
20. May
3. Jun
17. Jun
1. Jul
15. Jul
29. Jul
12. Aug
26. Aug
9. Sep
23. Sep
7. Oct

Figure 3-1

4 ACKNOWLEDGEMENTS

This abstract/presentation would not be possible would the help and guidance from the following people and organizations:

- Soren Poschmann, P. Geo
- Cory Lukacs, P. Eng
- Jacques Groenewald, P. Geo

- ISL Engineering and Land Services Ltd.
- Associated Environmental Ltd.
- PCL Construction