EAGLE LAKE membrane filtration facility

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Located on the foot of Hollyburn Mountain, West Vancouver is a waterfront community spanning 89 square kilometres. It is bordered by Howe Sound to the west, the Capilano River to the east, and the Coast mountains to the north. The municipality's population is about 45,000. The District supplies potable water to the residents from three sources – two are owned and operated by the District; the third is a bulk water connection to Metro Vancouver. As the primary municipally-operated supply, Eagle Lake has been used as a potable water supply since the 1920s. The lake is situated at 483 metres elevation, adjacent to Cypress Provincial Park, and is contained within a natural coast woodland environment. Until recently, only chlorination has been used for water treatment. The District recognized that additional treatment was required to protect the public from pathogens, colour and turbidity.

Although Eagle Lake is a natural lake, the top water level has been increased through the construction of two dams. The total lake volume is approximately 1.6 million cubic meters. Water flows into the lake from Nelson Creek, Black Creek and Eagle Creek, which originate near the base of the Cypress ski area. As the water supply is a lake source, there is some short-term variability in the water quality, but colour and turbidity events are generally modulated through the lake dilution. Turbidity is less than 10 NTU, normally less than 2 NTU. Colour is typically 5-10 TCU; rarely higher than 20 TCU. The water is very soft and pH is typically 6.2-6.5 units. Total organic carbon is less than 5 mg/L and UVT is between 80 and 90%.

For the past 10 years, with the assistance of Dayton & Knight Ltd., the District has been reviewing options for providing filtration on the Eagle Lake supply. This program investigated treatment technologies, plant location and overall system capacity. Throughout the program, there was a requirement to minimize the system energy requirements, costs and environmental impacts.

PROJECT DEVELOPMENT

In 2001, the District engaged several membrane manufacturers to undertake on-site pilot testing in order to demonstrate the performance of membrane technology for the removal of colour, organics and turbidity. At that time, the use of membranes for colour and organic removal was relatively new, necessitating the pilot testing requirements. The results from this testing demonstrated that, through the addition of a coagulant such as polyaluminum chloride (PAC), followed by flocculation, the membranes were able to remove up to 80% of the incoming colour and organics. Turbidity was easily removed by the membranes.

The District undertook additional studies to determine the location of the water treatment plant and further refine the business model for construction of the facility. The site review recommended a treatment plant located adjacent to the existing lake in order to maintain the high elevation and the advantage of a gravity supply to the District.

Unlike the majority of the Metro Vancouver member municipalities, the District has the option to supply a significant portion of potable water from its own supplies rather than through bulk purchases from Metro Vancouver. Prior to developing Eagle Lake, the District completed a cost-benefit analysis, which compared the near-complete reliance on Metro Vancouver bulk water to a complete reliance on its own municipal supplies. The latter would require further development of storage on Eagle Lake and significant upgrades to the District's distribution system infrastructure. The result of the cost-benefit analysis was that a 20-25 MLD municipal facility would provide the District with the most cost beneficial supply. In 2007, the District's annual average day demand was 28 MLD, and, in the month of August, the peak was around 40 MLD. The installation of universal water meters has resulted in a decrease in the water consumption rates and is predicted to keep maximum day demands below the 2007 levels well beyond 2020. Therefore, the treatment plant will operate at capacity throughout the year, optimizing the utilization of the source and maximizing the return from the capital expenditure.

MEMBRANES

GE Water and Process Technologies Canada (formerly Zenon), a Canadian company, was awarded the tender for the supply of the membranes for the Eagle Lake treatment facility. The plant consists of 12 primary membrane cassettes, each containing 48 membrane modules. Each module contains 30,000 membrane strands, or approximately 41 m^2 of filter surface area. The membranes are essentially filters that permit the passage of water, but hold back anything larger than 0.1 micron. (A human hair has a thickness of between 40 and 120 microns).

This is the first time the third generation ZeeWeed® 1000 membrane technology has been implemented in British Columbia, and the first plant in the world to use this membrane for second stage treatment.

The plant's primary membrane filtration process consists of three concrete tanks in which cassettes of membranes are suspended. Raw water is drawn through the hollow membranes using centrifugal pumps. The treated water is collected in a header pipe, where it then travels to the clearwell.

Reject water continuously flows at a controlled rate from each membrane tank and is collected in the backwash holding tank. Backwash water is pumped to the

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two secondary membranes to be further filtered. Filtered water from the secondary membranes is directed to the head of the plant and mixed with raw water. Reject water from the secondary membranes is directed to the waste holding tank and then discharged to the sanitary sewer.

Measures taken to prevent membrane fouling include cyclic agitation using compressed air and backflushing with treated water about four times each hour. Over time, the trans-membrane pressure required to produce the design flow across the membranes will exceed a pre-selected value. At this point, the membranes are cleaned using a Clean-in-Place, or CIP, system. The membranes are backflushed using citric acid and sodium hypochlorite and left to soak in the chemical solution. The solution is then circulated and neutralized before being slowly discharged to the sanitary system. The innovative membrane cleaning strategy used at this plant reduces chemical waste through the reuse of cleaning chemicals among the different trains and stages.

WATER TREATMENT

To assist the membranes process, water is first treated using a 1 mm rotating band screen which removes coarse material that passes through the lake intake screens. Screened water then flows through a rapid mix tank where caustic soda and PAC can be added when required. Three parallel flocculation tanks provide five minutes of single-stage flocculation. This short flocculation step is required to allow a pin-floc to form and provide time for the colour and organics to be adsorbed by the floc prior to membrane filtration. The membranes then remove the floc and the absorbed colour and organics. The pin-floc is a fine floc which appears as dust in the water stream, much as dust appears in a sunbeam.

In addition to removing the turbidity and flocculent, the membranes provide in excess of 5.5-log protozoa removal. As the membranes age, the removal will drop to 4-log; still in excess of the 3-log required under the current regulations. To assess the integrity of the membrane system, every 24 hours the system undergoes a membrane integrity test, which involves pressurizing the membrane from the inside with compressed air. Any weakness in the membranes is identified by the rate the air pressure drops. A membrane integrity test

Process pipe gallery and primary filtration pumps.

Membrane module being installed.

Eagle Lake Membrane Filtration Facility. A tiered vertical structure was designed to follow natural rock bluffs at the site.

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failure will result in that train being taken off-line until repairs are implemented.

Once the water passes through the membranes, 12% sodium hypochlorite is added to provide virus disinfection. Variable rate chemical dosing pumps, controlled through the facility PLC, provide a flow-paced control chemical injection.

Due to the low pH water, the facility incorporates a pH and corrosion protection facility. Sodium hydroxide (caustic soda) is used to adjust the pH to around 7.8. The PLC controls the chemical metering pumps based on a compound control loop using both flow and pH to determine the chemical application rate. A final addition of orthophosphate is used to provide corrosion protection in the distribution system.

The operation of the membrane filtration plant is fully automated. The operator has access to the process using a keyboard and a monitor screen referred to as the human machine interface, or HMI. This system can also be accessed via remote communications, permitting the operator to follow-up on and assess the nature of alarms without having to travel to the facility.

ENVIRONMENTAL SUSTAINABILITY

The facility is located at a high elevation to maximize the gravity-supplied water, which minimizes pumping requirements necessary to supply water throughout the District. The chosen site has adequate natural pressure to supply the entire District without external energy inputs.

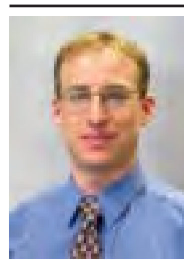
The use of Ecosmart concrete, re-use of blast rock for aggregate, minimization of habitat disturbance, and the selection of a hybrid vehicle for operator access were included in the design and construction program to ensure compliance with the District's environmental sustainability policies.

Membrane technology provides water that exceeds the treatment requirements with the smallest necessary footprint. Along with the vertical tiered building design, the habitat disturbance within the natural environment was minimized. Chemical consumption in the membrane cleaning system, water pre-treatment system and chlorination system was minimized through the design of the membrane and water treatment processes. Conventional treatment technologies would not have been able to meet these reductions.

A construction waste management plan was developed for the building construction, which included recycling of wood and steel scrap. Approximately 70% of the construction site waste was diverted from landfill.

Additional features included the selection of building lumber from certified sustainable forests, low VOC paints and waterless urinals.

During the project, excess building material such as plywood and building lumber were donated to Habitat for Humanity, a charity which specializes in the construction of subsidized housing for low income families.



Walt Bayless is a Project Manager with Dayton & Knight Ltd., specializing in water quality issues that range from supply through to disinfection and filtration.

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