Installation of Paced-to-Flow Chlorine Feed Systems at Barrie Reservoirs

In October of 2003, the Corporation of the City of Barrie (The City) retained the Ainley Group to provide design, administration and supervision services for the installation and implementation of a Paced-to-Flow Chlorine Feed System at three potable water supply reservoirs. The Project Scope included preliminary design, final design, tender call and evaluation and construction supervision of the installation of paced-to-flow chlorine feed systems at the designated facilities.

The objective of the project was to boost chlorine residuals at various points within the City's potable water supply in order to maintain a free chlorine residual of 0.5 mg/L throughout the distribution system. With residuals rarely dropping to the range of 0.2 mg/L, the design of the rechlorination system was aimed at keeping the levels in the target range, not to boost the levels from a low point to the target.

Ontario Regulation 170/03 outlines requirements regarding the sampling, reporting, the minimum level of treatment for surface and groundwater supplies and the maintenance of a chlorine residual within the distribution systems. In compliance with the regulation, the work at the City's reservoirs is being implemented to ensure the chlorine residual levels that are currently meeting the minimum requirements are maintained.

Construction personnel cutting a section of the common fill/draw line to provide a space for the flow meter at the Mapleview Elevated Tank.

The Mapleview Elevated Tank, the Anne Street Reservoir and the Bayfield Street Elevated Tank were deemed the most suitable points of entry to the system since there was existing SCADA instrumentation capability and sufficient interior space available to house the chlorine facilities. The design layout was also governed by the desire for a compact overall footprint and access to existing equipment. It was noted that, under normal operating conditions, the reservoirs were not to be used as chlorine contact facilities and would remain as potable water storage.

Common Elements of Chlorine Room Layout and Equipment

The chlorine room at each reservoir contains the majority of the process equipment associated with the gas chlorination system. Process piping, associated with the system, extends to the reservoir area and into the yard at each of the three sites. The process equipment includes the following:

- Flow meter
- Chlorination booster pumps
- Chemical feed pumps
- Storage tanks.

Chlorinators require dedicated rooms, sealed to the exterior and equipped with gas alarms. The chlorine room at each reservoir is equipped with a chlorine gas detector, which activates an alarm in the event of a chlorine gas leak. Ventilation of the room is provided using wall-mounted exhaust fans and intake louvers. Where possible, the fans and louvers are located on opposite sides of the room and orientated to use the prevailing wind to assist mechanical ventilation. In the event of a chlorine gas alarm, an emergency strobe light is activated as a warning to responding emergency personnel. The strobe light is mounted on the exterior of the building, immediately adjacent to the entrance to the chlorine room. Emergency ventilation related equipment is activated manually by responding personnel.

Mapleview and Bayfield Elevated Reservoirs

Since the construction of a dedicated door in the concrete pedestal at the Mapleview and Bayfield Street reservoirs was deemed to risky, from a structural point of view, the chlorine room was constructed within the existing valve room to the right of the entrance door. The room contains the majority of equipment associated with the gas chlorination system; including two chlorine storage tanks, gas control valves and weigh scales. The City of Barrie stocks full and empty cylinders at off-site locations; therefore, provision for cylinder storage was not required.

Completed chlorine room inside the valve room at the Mapleview Elevated Tank Reservoir.

The room, sized to accommodate the chlorination components, gas sensor and HVAC equipment, also has a viewing window, unit heater with thermostat, passive ventilation through a brick vent ducted to the floor, an eyewash station and a shower supplied with process water through a dedicated 12-mm line and a manually activated emergency exhaust fan.

Flow Meter

In order to implement paced-to-flow rechlorination, a flow measurement device was required on the fill/draw line. Selection of this device was based on commonality with existing meters, ease of installation, accuracy and compatibility with the City's SCADA system and method of flow totalization. Considering these requirements, an electromagnetic flow meter was installed on the common fill/draw line by direct-bury installation at both the Mapleview and Bayfield site. The meters were located with at least 2 metres (5 pipe diameters) of straight pipe before and after.

The electromagnetic flow meter being installed on the common fill/draw line.

System Flow Rate

The flow rates entering/leaving each reservoir were determined from analysis of the flow and/or reservoir level data supplied by the City. Although a maximum flow rate of 434 L/s occurred in the system at the Mapleview reservoir; it was important not to set the design maximum at too high a volume, as the chlorinators would be oversized for normal flows. By plotting the highest flow rate and taking the average of the high flows in Litres/second a design rate of 250 L/s was selected.

By measuring the water level in the reservoir at the Bayfield site, it was determined that the maximum equalization draw rates were in the area of 236 L/s. Working from the premise that rechlorination must be designed for reasonable flows, not the extreme/emergency flow, a design rate of 200 L/s was chosen as a realistic/normal maximum that the system would experience.

The injector and injection point installation at the Mapleview reservoir.

Chlorine Injector Feed Lines

A 19-mm fixed-throat chlorine injector with an initial rechlorination capacity of 4.5 kg/day (10 lbs/day) was selected; since this size covers the majority of the operating volumes. It was recommended that the injector be provided with sufficient capacity to draw up to 9 kg/day (20 lbs/day) in the event that higher rechlorination rates are needed in the future. The injector is a close-coupled stop style, adjacent to the point of application, which keeps the length of the chlorinated water injection pipe to a minimum.

The chlorine booster pump at the Bayfield reservoir showing the water draw and injector piping.

Chlorine Booster Pumps

A chlorine booster pump was installed at the Mapleview and Bayfield reservoirs to provide enough pressure to create a vacuum/remote-feed chlorinator system. The pump will draw water from the 400-mm intake pipe in the valve chamber and have sufficient capacity to deliver enough flow across the injectors to overcome any piping losses between the point of withdrawal and re-injection. With a vertical configuration, the pump provides a compact footprint and keeps the motor elevated from flooding. One duty pump was installed at each tank, with a second kept in inventory. The water connection supplying the booster pump, which also supplies the eyewash station and shower, is equipped with isolation and check valves. The check valve between the injector and metallic piping protects the pipe from aggressive attack from the chlorine solution.

To provide commonality between the Mapleview and Bayfield reservoir rechlorination systems, it was recommended that the flow and pumping rate be sized to make the booster pumps identical. Mapleview's tank is taller, 42 metres vs. 28 metres at Bayfield; therefore, the booster pump must be slightly larger to overcome the additional backpressure.

Continuous Monitoring

Continuous monitoring for free chlorine residue is to be provided for this water supply for the process of determining the appropriate dose. At the Mapleview and Bayfield Reservoirs, the sampling point is on the common fill/draw line as this is the point of injection.

Instrumentation and Control

The City's existing SCADA system will be expanded to include the alarms for the Mapleview and Bayfield reservoir's chlorination room using equipment consistent and compatible with the existing system.

Bayfield Street booster-pump control and monitoring equipment.

Anne Street Reservoir

The chlorine room at Anne Street was constructed on the upper level of the booster pumping station. With its own dedicated exterior access door, the room contains the majority of equipment associated with the gas chlorination system; including two chlorine storage tanks, gas control valves and weigh scales.

The room, sized to accommodate the chlorination components, gas sensor and HVAC equipment, also has a viewing window from the pump room, a convection style wall heater with thermostat, passive ventilation through a brick vent ducted to the floor and a manually activated emergency exhaust fan. The emergency eye-wash station is mounted on the outside wall of the chlorine room. Construction involved standard non-bearing block walls extending to the ceiling, which were then filled with compressible material to seal the rooms. Existing masonry brick and block was cut for the installation of permanent lintels for the exterior door and all vents and exhaust fans.

Inside the chlorine room at the Anne Street reservoir showing the chlorinators, weigh scales, vent and gas sensors.

The emergency eye-wash station on the outside wall of the chlorine room.

The dedicated access door to the chlorine room. The emergency strobe light and exhaust vent can be seen above the door frame.

Flow Meter

In order to implement paced-to-flow rechlorination, a flow measurement device was required on the Zone 1 fill/draw line. Selection of this device was based on commonality with existing meters, ease of installation, accuracy and compatibility with the City's SCADA system and method of flow totalization. Due to the limited length of straight pipe available, a considerable amount of effort was required to select a meter that would provide accuracy in both flow directions. Considering these requirements, an electromagnetic flow meter was installed on the common fill/draw line as follows:

Zone 1 – direct
Zone 2N – retain existing venture flow meter and the existing flow signal.

Electromagnetic flow meter positioned on the common fill/draw line.

Chlorine Injector Feed Lines

The Anne Street reservoir location did not require additional booster pumps as the injectors will be powered by the differential pressure between Zone 2N and Zone 1. The injectors have been sized to be a 19-mm fixed-throat injector with an initial rechlorination capacity of 4.5 kg/day (10 lbs/day). It was recommended that an injector be provided with sufficient capacity to draw up to 9 kg/day (20 lbs/day) in the event that higher rechlorination rates are needed in the future. The injector process water is supplied from tapping a blind flange on the discharge pump header. The Zone 2N injector (a corporation stop-style injector) is located on the common suction line to the booster station pumps. This location provides excellent mixing prior to monitoring the rechlorination process when the water leaves the pumping station.

The injector and injection point installation at the Anne Street reservoir.

System Flow Rate

For Anne Street pumping to Zone 2N, the system flow rate is two of the three duty pumps running for a maximum rate of 153 L/s. Records for flow and/or reservoir level data were obtained from the City for the reservoirs that fill and draw by gravity. Since there is no flow meter for the reservoir supplying Zone 1, flows were estimated by plotting the rate of change in the reservoir level and then accounting for pumping to Zone 2N. After analyzing the data supplied by the City, which contained the highest water demand days, the maximum rate of draw was calculated to be in the order of 135 L/s.

Continuous Monitoring

Continuous monitoring for free chlorine residual was to be provided for this water supply for the process of determining the appropriate dose. Samples taken from the discharge of Zone 2N and downstream from the new flow meter at the Anne Street Reservoir (Zone 1) will be analyzed, those being the points of injection.

Instrumentation and Control

The City's existing SCADA system was expanded to include the alarms for the Anne Street reservoir's chlorination room using equipment consistent and compatible with the existing system.

Construction at the Anne Street reservoir.

Site restoration