Design, Construction and Repair of Potable Water Reservoirs

By John W.C. Boyle

This article addresses a series of topics associated with the design and construction of potable water reservoirs.

Qualified Experience

When selecting a reservoir consultant, choose a consultant who has significant experience in the area. There are various factors to consider and an experienced consultant will bring a wealth of knowledge to a project.

Function

Before commencing a review of reservoir issues, it is important to understand the philosophy behind why reservoirs exist. A reservoir provides extra supply/storage for two main reasons: fire fighting and to supply peaks in water consumption.

Volume

The volume required to meet fire demands is by far the largest component of a reservoir's volume.

There are various formulas for determining reservoir volume. The formula commonly used is the calculated fire flow plus 25 per cent of the maximum day demand. This empirical formula has been found to produce a reservoir volume of realistic size. Peak hour to peak day ratios are typically a factor of 1.5–2.

Materials

Earlier reservoirs were clay lined, followed by placing a layer of shotcrete. Where above-ground structures exist, wood stave was often used and some is still in use. If the wood is kept damp, deterioration is usually not significant. A wooden coupon can be removed to check on the timber condition. The steel circumference hoop tension rods can also experience corrosion.

On a life cycle basis, concrete is typically less costly than steel if you factor in some corrosion maintenance is often required for steel. Steel reservoirs are typically used where it is not economical to transport concrete and where relatively tall reservoirs are required.

Reservoir Shapes

Round, square and rectangular shapes are commonly used. The round structure is typically less costly as the circumferential rebar provides hoop tension, which results in an economical design. A shape pioneered by Dayton & Knight Ltd. is the inverted pyramid reservoir. This is a relatively cost-efficient structure and many examples now exist throughout B.C.

Concrete Design Types

Depending on the topography, reservoirs can either be constructed above-ground or buried. The roofs of buried applications are sometimes used as tennis courts or, in Vancouver's Queen Elizabeth Park, as a parking area.

Although examples of both pre-stressed and post tensioned reservoirs exist, our preference is to stay with cast-in-place structures. Deterioration of cast-in-place reservoirs tends to be gradual while those in pre-stressed and post tensioned can be catastrophic.

Design & Construction Features

Rebar Cover. Adequate cover is required on concrete reservoirs to provide extra corrosion protection. Additional reinforcement per cubic metre is also provided to help control cracking.

Height: Diameter / Side Ratio. Where adequate natural ground height exists, it is preferable from a stability viewpoint to select a reservoir shape with a height to diameter/side ratio of less than unity.

Circulation. Older reservoirs often have a shared inlet/outlet pipe which limits circulation. The Ministry of Health requires separate inlet and outlet pipes on new construction/upgrades to existing reservoirs. These pipelines should provide separation, both horizontally and vertically.

Overflow. All reservoirs should have an overflow in case the inlet pump or the level controls malfunction. Care should be taken not to discharge to open ditches or fish bearing streams.

Drainage Manhole and Underdrains. As part of a preventative maintenance program, underdrains should be installed and discharged to a manhole to enable the monitoring of groundwater flow. Any increases in flow pattern are usually indications leakage of the reservoir is occurring.

Base Material. Where the natural subgrade is uneven, a layer of granular material should be installed on top of the natural subgrade to provide an even foundation for the reservoir.

Access/Security. Adequate access is required to allow for confined space entry requirements. Wall ladders should start two to three metres above the ground to prevent unauthorized roof access. In remote areas, video cameras can assist with providing security against tampering of access lids.

Joints. Adequate joints in concrete structures must be provided for expansion and between adjacent pours.

Vents. Vents are required to facilitate filling and emptying of the reservoir. Vents should have screens on their inlet to prevent vandalism and entry from birds/insects.

Costs

Reservoir costs are dependent on a number of variables. In general:

- The larger the reservoir, the lower the unit cost.
- Where reservoirs are partially buried and ready-mix concrete is readily available, concrete reservoirs are usually the least costly.
- Where relatively tall standpipe type reservoirs are required, steel reservoirs are usually the least expensive.

Repair

Reservoir repairs are typically minimal provided a preventative maintenance program exists. Otherwise:

- Leaks cause loss of revenue. In severe cases, undermining of the reservoir can occur. This can be rectified by pressure grouting. Leaks through joints in reservoirs can alternatively be rectified by installing a high density polyethylene liner.
- Where reservoirs are found to be seismically deficient, it is usually economically feasible to carry out seismic upgrade work. **CB**

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