Date: October 11, 2023

Submit To: **John Marsh, CPA, CMA, Administrator**
Deep Bay Improvement District
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Prepared By: MSR Solutions Inc.

Subject: DBID Reservoir Coliform Contamination

1. Introduction

MSR Solutions Inc. (MSR) has been retained by the Deep Bay Improvement District (DBID) to provide an understanding of issues surrounding the recurrence of total coliform formation within the community storage reservoir, first identified as an issue in 2018. Island Health has requested an implementation plan by November 1, 2023, to outline the steps DBID will do to mitigate the total coliform contamination concerns. They have further noted there are three options.

1. Have the reservoir repaired to prevent ongoing contamination as a short term solution.
2. Replace the reservoir as a long term solution.
3. Implement secondary disinfects as soon as reasonably achievable.

2. Background

The reservoir is a concrete tank, constructed in 1975, and holding 545 m3 of water separated by an internal wall and isolation valves. Water is supplied via four wells with the following noted capacities.

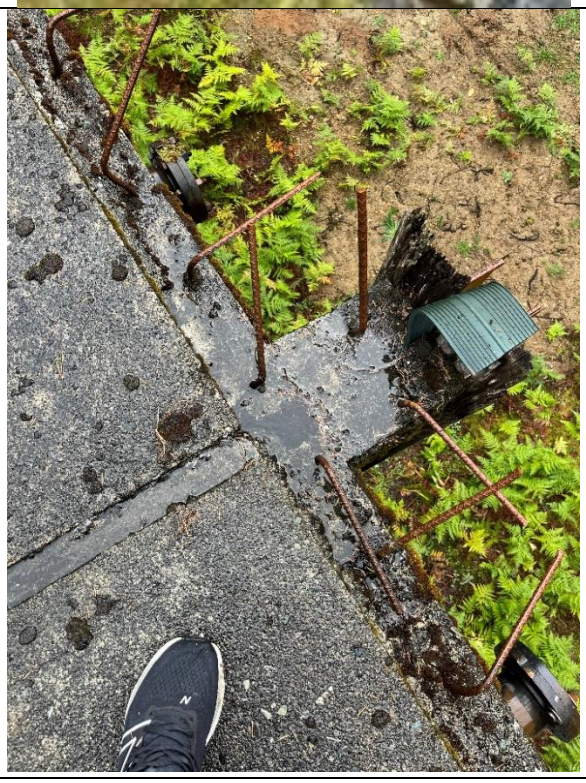
- Well#4- 70 gpm
- Well#5- 130 gpm
- Well#6- 115 gpm
- Well#8- 135 gpm

Initiation of pumps is noted by probes in the reservoir that start and stop the pumps determined by an adjustable water level. In general, two pumps operate at a time at about 200 gpm, with the pairs located 500 m and 900 m from the reservoir. Discharge is through a 100 mm Asbestos Cement (AC) pipe.

The system serves about 620 customers with meters, and an estimated average day demand of 0.8 m3/day/service. Average water usage is noted at 250 m3/day for the community in the winter and 500 m3/day in the summer. Based on this, the well pumps operate about 5.5 hr/day in winter, and 11 hr/day in summer, with 25% - 50% of the flow directed towards the distribution system, contributing to poor circulation in the reservoir.

The following photographs are of the tank as inspected on Saturday September 23, 2023. No internal inspection was completed, as the tank was in operation, and it was not deemed necessary to understand the general

condition of the reservoir. As can be seen, repairs have been completed in past and there are multiple locations with crack and potential intrusion points.



Based on discussions with representatives from DBID, it is reasonable to consider the planning for replacement of the reservoir at >45 years old is important. There is a reasonable expectation of life remaining in the tank subject to external factors such that could cause a catastrophic failure. As noted in 2009 by Herold Engineering:

> *The repairs made around 2001 are beginning to delaminate and there is seepage through the walls at these points with significant efflorescence. The wet concrete in these locations is therefore vulnerable to freeze/thaw action and it is expected to get worse each winter. There is also parging around the repairs which is delaminating and appears to have been done to surface protect the repair and cover and defects in the concrete surface. This is particularly evident on the north wall of the tank.*

As noted in the above pictures, and discussed on site, cracks continue to form and expand, and create potential for intrusion of rainwater or overland flow, directed towards the structure. The purpose of this investigation is to provide guidance and recommendations regarding the contamination and issues raised by Island Health.

3. Contamination and Causes for Concern

Coliforms are a group of bacteria that are naturally found in the environment, including soil, vegetation, and animal feces. They can be an indicator of fecal contamination in water systems.

As per the Guidelines for Canadian Drinking Water Quality by Health Canada, the maximum acceptable concentration (MAC) of total coliforms in water leaving a reservoir and in non-disinfected groundwater leaving the well is none detectable per 100 mL.

As a precursor to other bacteriological organisms, it is important to disinfect water systems to prevent the growth of coliforms and other harmful bacteria. The presence of coliforms in a concrete reservoir without disinfection is a cause for concern and should be addressed. The presence of coliforms is generally considered as a precursor to fecal coliforms, and health authorities consider risks of fecal and E.coli presence occurring sometime in the future. In their letter, they have asked for an action plan including repairs, replacement and potentially disinfection. They have stated secondary disinfection will be reviewed by them.

4. Potential Sources of Contamination

The continual regrowth of total coliforms in the storage reservoir is not easily diagnosed. Due to the age of the reservoir, the need for fire storage and slow turnover in the water, there is an environment for the growth and regrowth of coliforms in the system. Without a continuous disinfection system regrowth will always occur. Factors that could contribute to high total coliform counts in an old concrete reservoir, could be as follows.

- The age and condition of the concrete reservoir itself. Concrete will deteriorate over time and develop cracks or holes that allow contaminants to enter the water. Concrete can also leach minerals or chemicals into the water that may affect the growth of bacteria. The exposed rebar could be a potential conduit from freeze/thaw and water penetration to create micropores, which can be difficult to adequately disinfect when cleaning a tank.
- The disinfection process and residual levels of the water. There is none, and with current fill and draw method of water from the base of the reservoir, you may have stratification and poor mixing, allowing for recurrence of growth.

- The temperature and pH of the water. Bacteria tend to grow faster at higher temperatures and lower pH levels. Temperature and pH can vary depending on the season, the source water quality, and the stratification.
- The presence of biofilms or sediment in the reservoir. Biofilms are slimy layers of microorganisms that attach to surfaces and can protect bacteria from disinfectants. Sediment is the accumulation of particles or debris that can harbour bacteria and shield them from disinfection. Both biofilms and sediment can reduce the water quality and increase the risk of contamination. DBID has addressed this several times, however as noted, micropores and time will allow regrowth will occur.
- There is about 900 m of 100 mm AC Pipe in fair to poor condition. The filling and emptying of the reservoir cause water to travel back and forth between the pumps and reservoir in the filling and emptying cycle, and can be another source of contamination.

5. Potential Exterior and Interior Remedies to the Presence of Choliforms

The recurring contamination remains a troubling issue, with no clear pathway to addressing. The following are some of the potential considerations by DBID in addressing the solutions short term and longer term based on maintaining the existing reservoir for another ten years or so, to allow for adequate funding and full service life of the reservoir.

5.1. Internal Options

- A more thorough disinfection regime in accordance with the AWWA Standard C652-19 requirements for disinfection of a reservoir. The chlorine content should be checked using test strips that range up to 200 ppm chlorine.
    - Two-Stage Chlorination @ 50 ppm & 2.5 ppm
        - (1000 parts water : 1 part household bleach)
        - Fill tank with clean water to approximately 5% of total storage volume
        - Pour sufficient bleach through cleanout or inspection manhole to produce an initial concentration of at least 50 ppm (27 Litres, if using 5% bleach)
        - Let stand minimum 6 h
        - Fill tank to overflow with clean water (this will dilute the chlorine concentration to ~ 2.5 ppm). Let stand additional minimum 24 h.
    - Contact Chlorination @ 200 ppm
        - (250 parts water : 1 part household bleach)
        - Spray equipment should only be used when thorough ventilation is assured, and appropriate respiratory protection (gas mask, self-contained breathing unit) is used
        - Spray or brush all exposed inner surfaces with a 200 ppm solution of chlorine.
        - Let stand minimum 30 minutes.
        - Add enough clean water to purge drain.
    - Similarly, disinfect the 900 m of 100 mm AC Pipe at 200 ppm for six hours.
        - Isolate the flow to the reservoir, and turn the pumps on, injecting upwards of 35 Litres of standard bleach into the pipe until it reaches the reservoir.
- Epoxy Coat the interior of the tank to seal from cracks
    - Options include Chemline Gatorhyde ARC, which is ANSI NSF61 approved for use in water containment structures. Coverage is around 150 sq.ft/gallon with two coats at $250/gallon

- Drain one side of the reservoir, power wash, and seal obvious cracks. Apply the epoxy coating and allow to cure before filling.

5.2. External Options

- Install membrane liner (torch on) on roof of the reservoir and extending over the top of the reservoir and to the sides.
  - The roof of the reservoir can be power washed and cleaned before installing the membrane. Costs can vary from $50 - $100 per square foot, depending on material selected.
  - This option does not negate the potential for other sources of contamination on the tank sidewalls or overland flow to the base of the tank.
- Grading of the site
  - Currently overland flow is directed towards the base of the tank. In the event of any cracks at the base of the slab and walls, there is the potential for mixing with overland flow. By installation of ditching on the upslope side to direct water away from the base, there can be some mitigation of water interaction.
- Manual Disinfection Chlorine Residual
  - Based on a means to control regrowth within the reservoir, consideration of adding approximately 2.5 Litres of 5% bleach solution to each side of the reservoir will provide for a 1 mg/L residual in the reservoir.

5.3. Piping Improvements

- Installation of a header internal pipe with lower check valve
  - Allows for mixing of the water column by having a Tee assembly on the base of the column with a check valve open for return flow, and an open top to supply water at the top of the tank for mixing.
  - Circulation benefits of this will create a mixing and proper turn over of the water contents.
- New supply line from the wells to provide a dedicated supply line.
  - A new supply line will ensure all distribution is from the well pumps direct to the reservoir, which will support the turnover in the reservoir when combined with the internal piping.
  - This option has a higher value to future requirements and facilitates disinfection methods in the future.

5.4. Disinfection Options

We understand that DBID is desirous of avoiding disinfection. The adjusting of levels in the reservoir appears to be a contributing factor to regrowth, as well as the stratification and slow turnover of the upper water layer as noted by testing. The method of cleaning and disinfection may not have been sufficient, and Island Health is desirous of having chlorination instituted, as it removes a significant factor in water quality concerns.

With regard to disinfection, the only practical and cost effective method currently available is the manual dumping of chlorine on a regular basis as noted above. Alternative methods include ozonation and UV disinfection, neither of which provides for a residual value in the downstream distribution system. We believe there are a number of

options to undertake to manage the risk, all of which will delay the future potential, as well as develop solutions to extend the service life of the reservoir.

6. Reservoir Replacement

Reservoir replacement is proposed as a capital cost item in advance of the end of life of the reservoir. It is preferable to propose a longer term strategy for replacement over the next 10 years by increasing rates to capitalize the construction costs. Based on 6% inflation, every dollar raised today is equivalent to $0.50 in ten years, and offsets future borrowing costs for completion of the works

7. Options Costs Considerations

The following table summarizes order of magnitude costs for the various options noted above.

Item	Description	Construction	Engineering & Contingency (35%)
Disinfection	Clean and Disinfect Tanks as an interim step as per AWWA C652-19	$25,000	$8,750
Disinfection	Supply Line disinfection	$3,500	$1,225
Sealing Internal Tank	Epoxy Coating of Tank	$38,000	$13,300
Roof Membrane	Torch on Membrane	$80,000	$27,600
Grading of Site	Ditching around Tank	$7,500	$2,600
Manual Disinfection	Daily	$150 Daily	$0
Internal Tank Headers	Vertical DI Pipe with Tee	$30,000	$10,500
New Supply Line	Extend 100 PVC	$360,000	$126,000
New Reservoir	10 year Plan	$1,600,000	$560,000
Water Treatment	Chlorine Disinfection at well head	$75,000	$26,250
Totals		**$2,219,000**	**$776,000**

We recommend consideration of a step by step process to the elimination of causes. Initial works might be considered at sealing the internal tank (clean and disinfect also), installation of the internal tank headers at an estimated cost of $140,000 including engineering and contingencies. This should provide a reasonable time to effectively monitor and evaluate the need for disinfection.

Following this scope, we recommend the new supply line at $486,000 including engineering and contingencies as the reasonable next step. We believe these options will allow for a continued consideration of no disinfection in the system until such time as Island Health mandates through any risk aversion assessment.

Consideration of a water rate increase of about $450 per year per connection will support the future replacement of the reservoir in about ten years time, without need for borrowing, based on a future value of $2.7 million assuming a 6% inflation rate. Variations in this rate structure will impact future borrowing costs.

We trust this provides an understanding of the scope of work involved; the regulatory environment; and the responsibilities of both the Improvement District, and Island Health to ensure that residents are appropriately serviced with a safe water system for their continued use.

Should you have any questions, or require additional information, please contact the undersigned.

Sincerely,
MSR SOLUTIONS INC.

Mike Seymour, P.L.Eng.
Principal