McElhanney

December 15, 2017 Our File: 39202-1

Deep Bay Improvement District
5031 Mountainview Road
Deep Bay BC, V0R 1G0

Attention: Leslie Carter
Administrator

Dear Ms. Carter,

Reference: Deep Bay Improvement District
Reservoir Operating Level Review

Based on our meeting on December 13, 2016, it is our understanding that the District has recently experienced an operational issue with the well pumps. This operational issue revealed that the existing 120,000 Igal (545m3) reservoir is currently not "turning-over" the stored volume.

Our letter dated January 10, 2017 confirmed that the reservoir cannot turn-over under the current operating conditions. Based on your emails dated February 7, 2017 and November 24, 2017 as well as subsequent discussion, we summarize the existing information as follows:

- The storage volume of the supply/distribution pipe (between the reservoir and well) is greater than the live volume in the reservoir (volume of water entering system before pumps turn on). Therefore, fresh water does not enter the reservoir during a normal cycle.
- The maximum allowable top water level is approximately 0.75 ft. (0.23m) from the top of the reservoir (based on John Motherwell and Associates Engineering Ltd. Drawings dated Jan 16, 1975).
- The reservoir is currently operating with a top water level approximately 1.0 ft. (0.3m) from the top of the reservoir
- The well pumps currently turn "on" when 10% of the reservoir storage is used (bottom water level approximately 2.5 ft. from the top of the reservoir).

From the reservoir operating level review, we recommend the following changes in operational conditions to promote reservoir "turn-over":

- The live volume is to be increased by lowering bottom water level and keeping top water level the same. This will allow the reservoir to turn-over, however this will reduce the storage for balancing, emergency, and fire protection (at the low water level).
- The following operating settings are proposed:
    - Keep the top water level at 1.0 ft. (0.3m) from the top of the reservoir (pumps to turn off)
    - Lower the bottom water level to 4.0 ft. (1.22 m) from the top of the reservoir (pumps to turn on)

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With these proposed settings, we anticipate reservoir volume will turn over approximately every four days. The water storage for balancing, emergency, and fire protection (at low water level) will be reduced by approximately 50 m3 from current operating conditions. As noted in the Water System Evaluation Report completed in February 2008, the existing reservoir does not meet the water storage requirement (for balancing, emergency, and fire storage).

In regards to your request to provide a cost to engineer a top feed for the reservoir, we offer the following comments:

- Currently, some mixing of the tank occurs due to “jet-flows” during the filling of the tank.
- With a top fill inlet, water will enter and exit at separate location but will not experience the same mixing due to “jet flows”.
- Under the proposed operating conditions water from the reservoir will be entering the distribution system regularly, therefore improved mixing of the reservoir will not be required.

Therefore, we recommend that a top feed inlet is not added at this time.

We trust this provides the information that you require at this time. Please call us at (250) 716-3336 if you have any questions or wish to discuss our findings.

Yours truly,
McElhanney Consulting Services Ltd.

Prepared By,

Sean O'Connor, EIT
Project Engineer

Reviewed By,

Chris Pogson, P. Eng.
Branch Manager

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Client: **Deep Bay Improvements District**
Site: **Deep Bay Reservoir**
Project Engineer: **Sean O'Connor, EIT**
Senior Manager: **Chris Pogson, P.Eng.**

File Number: **39202-01**
Date: **December 7, 2017**

RESEVOIR SUMMARY

Cell Height	16.25	ft	=	4.95	m
Cell Width	20.0	ft	=	6.10	m
Cell Length	30.0	ft	=	9.14	m
Total Cell Volume	9750	ft3	=	276	m3
Total Tank Volume	19500	ft3	=	552	m3
Existing Dist from Top of Tank to Full*	1.0	ft	=	0.30	m
Current Operating Total Tank Volume	**18,300**	ft3	**=**	518.2	m3

* Based on information provided by DBID

DEMAND SUMMARY

Average Day Demand (ADD)*	0.85	m3/service
Number of Services (2017)**	605	

	2017 Demands				
Average Day Demand (ADD)	514	m3/day	=	6.0	L/s
Maximum Day Demand (MDD)	1543	m3/day	=	17.9	L/s
Peak Hour Demand (PHD)	3086	m3/day	=	35.7	L/s

* ADD per service, peaking factors based on MCSL DBWD system report (2008);
** Number of Services (2017) provided by DBID on 2017/02/15.

WELL SUMMARY

Well #1 Capacity	4.8	L/s	Not Used
Well #2 Capacity	3.0	L/s	Emergency Use Only
Well #3 Capacity	5.7	L/s	Emergency Use Only
Well #4 Capacity	5.3	L/s	Well Pairing #1
Well #5 Capacity	10.0	L/s	Well Pairing #1
Well #6 Capacity	9.0	L/s	Well Pairing #2
Well #8 Capacity	11.0	L/s	Well Pairing #2
Total Well Capacity**	44.0	L/s	

* Well capacities based on MCSL DBWD system report (2008).
** Total well capacity does not include well #1

FIRE FLOW DEMAND

Location	Calculated Fire Flow (L/s)	Well Supply (L/s)	Fire Duration (hours)	Required Fire Storage (m3)
Single Family Residences	70	44.0	1.55	145
Bowser ElementarySchool	53	44.0	1.3	42

* Table based on MSCL DBWD system report (2008), Table 3-2. Table updated based on well #1 no longer fuctioning.

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PIPE SUMMARY

Pipe Length	860.0	m
Inner Dia.	0.3	m
Pipe Vol.*	60.8	m3

* Volume of pipe (supply/distribution line) between well connection and reservoir. No users are on this section of main.

TRIAL #1 : Existing Operating Conditions

Operating Level Top	1.0	ft	=	0.30	m
Operating Level Bottom*	2.52	ft	=	0.77	m
Operating Total Tank Volume	18300	ft3	=	518.2	m3
Live Volume	1824	ft3		51.6	m3
Live Volume % of Operating Volume	10%				
Volume Entering System (Each Cycle)**	-9.1	m3	60.8 > 51.6 m3, therefore no water enters during normal cycle		

Reservoir Turnover Period:

* Based on 10% live volume operating condition provided by DBID
** Reservoir does not turn over as the volume of water between on and off is stored in the pipe.

Storage Volumes:

Volume Remaining in Reservoir	466.5	m3			
Provides Fire Flow Demand*	70.0	L/s	for required	1.55	hours
Volume Remaining for Balancing and Emergency Storage	321	m3			

* A fire flow of 70 L/s may not be able to be delievered to some areas of the distribtuion system as per MSCLs system report (2008)

TRIAL #2 : Increase Live Volume to 15% of total volume by lowering bottom operating level (top water level to remain)

Operating Level Top	1.0	ft	=	0.30	m
Operating Level Bottom	3.3	ft	=	1.01	m
Operating Total Tank Volume	18300	ft3	=	518.2	m3
Live Volume	2760	ft3		78.2	m3
Live Volume % of Operating Volume	15%				
Volume Entering System (Each Cycle)	17.4	m3	60.8 < 78.2 m3, therefore water from reservoir enters system		

Reservoir Turnover Period:

CT = Cycle Time, (T1 + T2)
T1 = Time for Volume of Water to be removed from Reservoir, Live Volume/Demand
T2 = Time for Reservoir to be filled, Live Volume / (Well Capacity - Demand)
RTP = Reservoir Turnover Period, (Vol of Tank / Vol Entering System) x Cycle Time
Assume Demand is ADD flows for most conservative cylce period

Well Pairing	Well #	Well Supply (L/s)	T1 (hours)	T2 (hours)	CT (hours)	RTP (hours)	RTP (days)
1	4 & 5	15.3	3.6	2.3	6.0	178.2	7.4
2	6 & 8	20.0	3.6	1.5	5.2	155.0	6.5

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Storage Volumes:

Volume Remaining in Reservoir	440.0	m3			
Provides Fire Flow Demand*	70.0	L/s	for required	1.55	hours
Volume Remaining for Balancing and Emergency Storage	295	m3			

* A fire flow of 70 L/s may not be able to be delievered to some areas of the distribtuion system as per MSCLs system report (2008)

TRIAL #3 : Increase Live Volume to 20% of total volume by lowering bottom operating level (top water level to remain)

Operating Level Top	1 ft	=	0.30 m	
Operating Level Bottom	4.0 ft	=	1.22 m	
Operating Total Tank Volume	18300 ft3	=	518.2 m3	
Live Volume	3600 ft3		101.9	m3
Live Volume % of Operating Volume	20%			
Volume Entering System (Each Cycle)	41.2 m3	60.8 < 101.9 m3, therefore water from reservoir enters system		

Reservoir Turnover Period:

CT = Cycle Time, (T1 + T2)
T1 = Time for Volume of Water to be removed from Reservoir, Live Volume/Demand
T2 = Time for Reservoir to be filled, Live Volume / (Well Capacity - Demand)
RTP = Reservoir Turnover Period, (Vol of Tank / Vol Entering System) x Cycle Time
Assume Demand is ADD flows for most conservative cylce period

Well Pairing	Well #	Well Supply (L/s)	T1 (hours)	T2 (hours)	CT (hours)	RTP (hours)	RTP (days)
1	4 & 5	15.3	4.8	3.0	7.8	98.1	4.1
2	6 & 8	20.0	4.8	2.0	6.8	85.3	3.6

Storage Volumes:

Volume Remaining in Reservoir	416.3	m3			
Provides Fire Flow Demand*	70.0	L/s	for required	1.55	hours
Volume Remaining for Balancing and Emergency Storage	271	m3			

* A fire flow of 70 L/s may not be able to be delievered to some areas of the distribtuion system as per MSCLs system report (2008)

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SUMMARY OF TRIALS

Summary				
Trial	**Live Volume (%)**	**Remaining Vol. (m3)**	**RTP 1 (days)**	**RTP 2 (days)**
1	10%	467	-	-
2	15%	440	7.4	6.5
3	20%	416	4.1	3.6

Live Volume = % of full volume leaving reservoir before wells are activated
Remaining Vol. = Volume remaining in reservoir at low water level for balancing/emergency storage and fire protection
RTP 1 = Estimated Reservoir Turnover Period based on Well Pairing #1 (Wells 4 & 5) feeding system
RTP 2 = Estimated Reservoir Turnover Period based on Well Pairing #2 (Wells 6 & 8) feeding system