



DATE: April 8, 2014
TO: Don Darling, Director of Works and Utilities
FROM: Bob Hrasko, P. Eng.
RE: **Garnett Reservoir - Reservoir Operations Procedure**

1.0 INTRODUCTION

This memorandum sets out an operational procedure for the storage and release of water from Garnett Reservoir. The Garnett Reservoir and Dam is located 10 kilometers northwest of Summerland up the Aeneas Creek Valley.

The contributing watershed to the reservoir is approximately 56 km² in size and originates at Aeneas Provincial Park. Annual inflow to Garnett Reservoir varies but has been estimated to average 2,450 ML. Water usage by the District of Summerland from Garnett Reservoir varies with the highest recorded demand being in 1978 at 1,664 ML. The long term average annual water demand from Garnett Reservoir water source is 1,132 ML. In the last five years, this amount has been only 672 ML annually as there is less agriculture and more efficient use of water.

Currently there are two provincial regulations that apply to the operations of Garnett Reservoir. The *Water Act* permits licensing for the storage of water in Garnett Reservoir and redistribution of that water for irrigation and domestic purposes. The *BC Dam Safety Regulation* sets regulations for the operations of dams. This includes Dam Safety Reviews such as the one recently carried out for Garnett Reservoir.

The recent Dam Safety Review for Garnett Reservoir resulted in the reassessment of Garnett Dam from *VERY HIGH* to an *EXTREME* level of consequence in the event of a failure. This was due to the population and value of property and structures downstream of the dam. The higher consequence rating results in higher levels of service required for the spillway which is now required to pass the Probable Maximum Flood (PMF).

Garnett Reservoir has a storage capacity of 2,339 ML to the crest of the spillway (elev. 632.7). The Agua memorandum from June 5, 2012 recommended operating the reservoir with a target HWL of 85% of full pool or 0.67m below High Water Level. A subsequent memorandum was prepared by Agua on January 2, 2014 which identified new safety requirements that resulted from the reclassification of the dam during the Dam Safety Review. Garnett Reservoir now must be able to safely convey the Probable Maximum Flood through the reservoir and spillway. The PMF is estimated at 84 m³/s with a total runoff volume estimated to be 2,800 ML. The current spillway capacity is estimated at 42 m³/s, therefore, with retention in Garnett Reservoir, the level of the reservoir would have to be maintained at or below 1,008 ML (43% of full pool). This low water level greatly impacts the reliability of water supply which is the original purpose of this reservoir.

This memorandum provides operating levels that would be an interim step until such time that sufficient funds are found to widen the concrete spillway. Until such time, this is a rational approach to mitigate the risk of a PMF until the spillway meets the current Dam Safety requirements.

2.0 RESERVOIR OPERATING GUIDELINE

A Reservoir Operating Guideline for Garnett Reservoir is presented in this section. The guideline sets out month-end target water levels throughout the year. The target is set so that a substantial portion of a PMF event can be buffered by the reservoir and routed through Garnett Dam Spillway. Once water reaches the spillway, there is no longer controlled release of water and flooding of houses is probable downstream of the dam. The reservoir levels have been set to provide sufficient storage water so that water demands in the Garnett Valley can reliably be met.

With the proposed operating guideline, there would be 830 ML of buffering storage provided within Garnett Reservoir. Operations of the reservoir is recommended at these lower water levels until the spillway capacity is increased. Once the spillway is widened, Summerland could consider raising the maximum operating level of Garnett Reservoir from 64% of full pool volume back to 85% of full pool volume.

The Operations Guideline on the following page provides a month-end reservoir target volume, average monthly inflow to the reservoir, average water system demand by Summerland customers, and monitoring indicators and when higher, moderate and lower attention is required when considering them. All numbers provided in the Guideline are in megaliters (1,000 m³).

Monitoring indicators include:

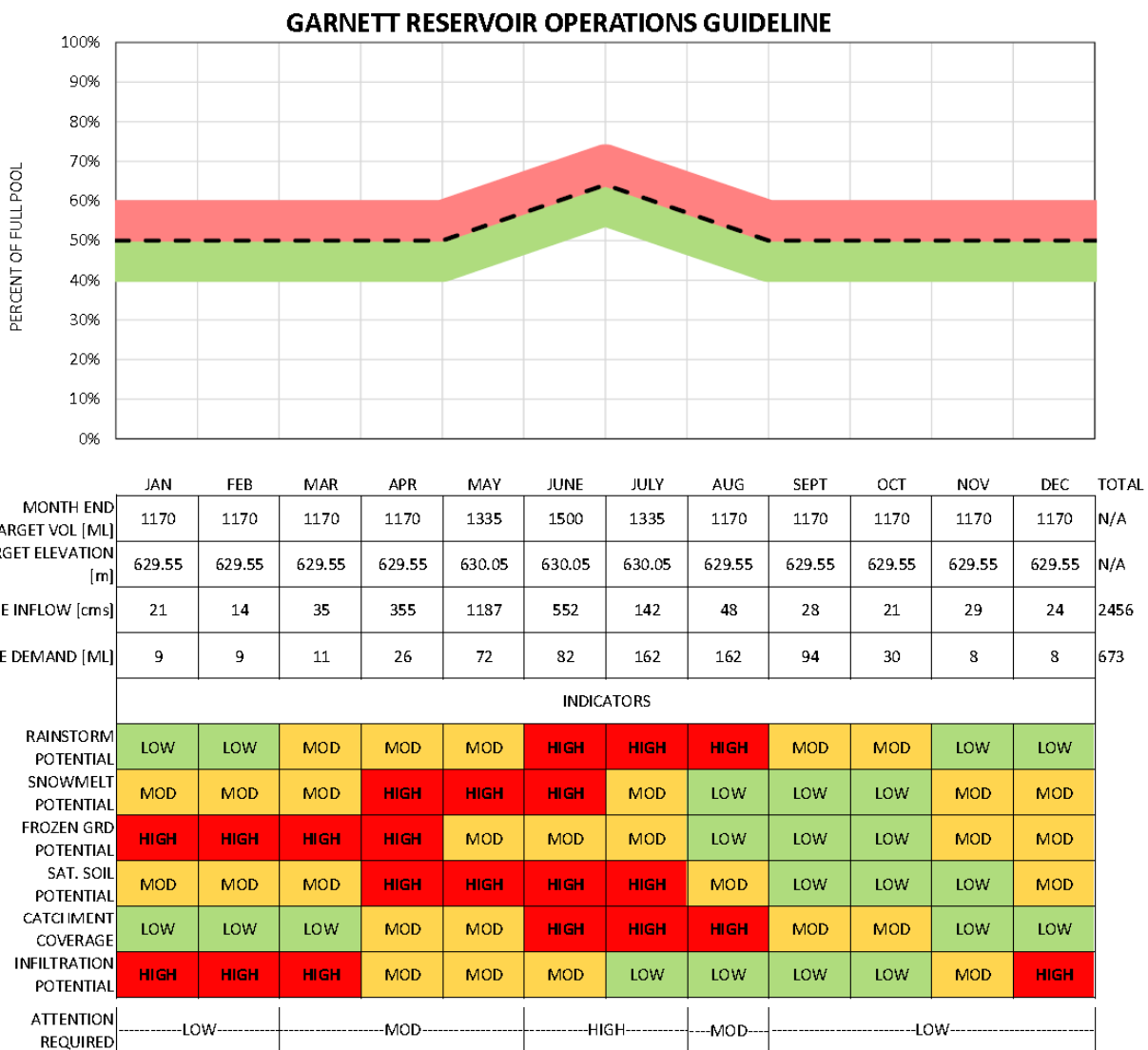
- Reservoir levels - Monitor in comparison with seasonal averages. This guides adjustment of releases from the reservoir;
- Snow pack levels – Check to determine if the the snow course data and/or available snow pillow data is above or below seasonal averages;
- Snow melt - Temperatures and snow pack can influence the rate of runoff of the snowpack;
- Monitoring the Freezing Level - The elevation and the depth of frost in the watershed will impact upon water runoff volumes. If the temperatures are colder than normal, more of the watershed may be have frozen surfaces. Frozen ground has higher runoff potential;
- Long Term Weather Trending - Particularly in the spring, warm water laden clouds can inundate an area with precipitation and cause intense localized flooding. Annually the highest runoff period for Garnett Reservoir is in May, but throughout the year, warm rain events are possible. If a wet weather trend is forecasted, releases slightly greater than normal should be considered.

The Operation Guideline on the next page presents a trigger line 10% (by volume) above and 10% below the target levels. If reservoir levels are higher than the month-end target levels, then additional water should be released from Garnett Dam outlet gate. If reservoir month-end levels are lower than the target levels, the releases from Garnett dam outlet can be lessened. Table A.4 in Appendix A provides monthly volume for varying flow release rates.

It is noted that the flow release rates should be limited to a maximum of 0.50 m³/s. If water levels continue to rise beyond the month-end target levels, then Summerland can consider releasing water at higher rates not to exceed 1.20 m³/s due to the limited downstream capacity through Aeneas Creek.

It is noted that the months of when the highest probability of high runoff are annually in June and July. This in turn is at a time of year when the ground may not be frozen through the majority of the watershed, therefore making the infiltration potential greater and lower runoff potential.

As shown by the factors in the Operations Guideline, it is improbable that all of the factors creating a PMF can occur at the same time.



3.0 SUMMARY

The following items are provided for consideration by the District of Summerland:

- S-1 Garnett Dam and Reservoir are constructed primarily for water supply and storage, and not for flood control. With the limited channel capacity through Summerland, the district is forced to consider flood control measures and must do so through reservoir operations;
- S-2 The maximum channel capacity of Aeneas Creek below Garnett Dam is estimated to be 1.20 m³/s. Releases from Garnett Reservoir should be limited to 0.50 m³/s and only increased to above 1.00 m³/s when reservoir levels are more than 10% above the reservoir operational target levels in this document. If releasing greater than 1.0 m³/s, monitoring must take place along the creek near Victoria Avenue to make sure the creek stays contained within its banks;
- S-3 When releasing at rates greater than 0.50 m³/s from Garnett Reservoir, monitoring of the flow capacity and stability of the Aeneas Creek channel near Victoria Avenue should be conducted;
- S-4 The operation of Garnett Reservoir at reduced water storage levels should be considered a temporary measure until such time that the spillway is increased to 75 m³/s, which with storage attenuation is sufficient to convey the PMF of 85 m³/s;
- S-5 The proposed project to widen the Garnett Dam Spillway is recommended. This project will ensure that Summerland is in conformance with the Dam Safety Regulations;
- S-6 In the long term, as part of the drainage planning, Summerland should develop ways to safely convey the Aeneas Creek PMF flow safely overland through Summerland to Okanagan Lake.

4.0 REPORT LIMITATIONS

As a consultant to the District of Summerland, Agua Consulting Inc. does not recommend that Summerland take actions contrary to Provincial Acts or Regulations. In this case, the objectives of the related Acts and/or Regulations conflict with one another. The recommendation by Agua is to make the required improvement which is to widen the spillway at Garnett Dam.

In the interim, until such time that funds can be allocated for these works, the District must manage the risk of having adequate water supply against the probability of the Probable Maximum Flood (PMF) occurring in the upper watershed. The procedural guideline that is developed will assist the District to manage the risks of running out of water versus the occurrence of the PMF.

APPENDIX A - REFERENCE TABLES

Table A.1 - Garnett Reservoir – Annual Inflow / Outflow Data

Month	Ave. Use (ML)	Normalized Flow (ML)
Jan	16.4	21.4
Feb	15.4	14.5
Mar	17.3	34.8
Apr	47.6	355.1
May	138.4	1186.5
Jun	193.3	552.1
Jul	243.1	142.0
Aug	240.8	48.2
Sep	136.2	28.5
Oct	49.8	21.4
Nov	17.4	28.5
Dec	16.5	24.1
TOTAL (ML)	1132.0	2457.2

Table A.1 provides a monthly breakdown of the long term water demand from Garnett Reservoir. The monthly demand has decreased in recent years as meters have been installed and there is less agriculture in Garnett Valley. The recent water demand numbers are listed in Table A.3.

The normalized flow column is the estimated flow in Aeneas Creek entering Garnett Reservoir from above. It is information that was generated as part of the hydrology work that was part of the Okanagan Water Supply and Demand Study.

Table A.2 provides a summary of the live (useable) storage within Garnett Reservoir. The total storage volume available for use from Garnett Reservoir is 2,339 ML. This is approximately three and a half times the volume of water used annually by Summerland. It is recommended for reasons of safety and conformance to regulation, the target HWL for the interim be set at 1,500 ML.

Table A.2 - Garnett Reservoir Data

Reservoir Elevation (m)	Flooded Area (ha)	Storage Volume (ML)	Comments
613.7	0.0	-422	Dead Storage
622.4	7.9		
622.8	8.6 (est.)	0	Gate Sill
623.3	8.8	23	
623.6	9.2	52	
624.8	12.1	184	
626.1	17.1	364	
627.3	22.5	609	
628.5	26.8	912	
629.6	31.0	1270	
630.9	36.2	1688	
632.7	39.4 (est.)	2339	Spillway Crest
634.0	41.7	2876	
637.0	46.3	4222	
640.1	51.8	5689	

Last Updated March 2014

Table A.3 - Garnett Valley Water Demand

	2008	2009	2010	2011	2012	2013	2014	2015	Average
Jan	7.85	10.17	12.98	7.37	6.24	6.80			8.57
Feb	7.48	9.20	14.32	7.31	6.05	6.52			8.48
Mar	8.41	10.64	17.91	8.91	7.15	7.55			10.09
Apr	26.37	35.91	29.40	21.15	15.54	23.85			25.37
May	100.64	43.60	71.24	55.55	90.91	85.81			74.63
Jun	88.19	155.87	60.18	64.91	38.86	62.44			78.41
Jul	192.80	200.93	189.57	114.20	112.14	150.89			160.09
Aug	119.96	156.38	160.60	179.46	191.04	105.72			152.19
Sep	113.82	85.01	40.78	110.28	121.94	42.00			85.64
Oct	39.70	26.82	24.61	17.30	42.45	12.70			27.26
Nov	9.04	9.50	7.88	5.90	5.93	7.86			7.69
Dec	9.89	11.87	8.74	6.04	6.56	8.11			8.53
TOTALS	724.15	755.90	638.21	598.38	644.81	520.25			646.95

Table A.3 provides the recent annual water demand from Garnett Reservoir from 2008 to 2012. There is room for tracking future years in the table.

Table A.4 provides an indication of the amount of water that can be released from Garnett Reservoir per month at the various flow rates. When lowering the reservoir, the monthly release capacity is substantial and the reason that flooding has been mitigated by District Operations for years.

Table A.4 – Release Capacity per Month

Release Rate (L/s)	ML / Month
100	260
200	520
300	780
400	1,040
500	1,300
1,000	2,600