Okanagan Basin
WATER BOARD

DROUGHT STAGE TRIGGER GUIDELINES FOR OKANAGAN MAINSTEM LAKES AND RIVER

May 2019

PREFACE

<u>**Background:**</u> In 2015, the Province of BC declared a Level 4 drought for the Okanagan Basin. There was widespread uncertainty among water purveyors about how to react to the province's request for water use reductions. Drought declarations by the Province are based on stream flows over a wide region – a general hydrological condition. In the Okanagan, purveyors manage their systems independently of the Province (under water licences issued by the Province). Purveyors with reservoirs and storage licences have plans that trigger water restriction stages based on indicators such as basin snow indices and reservoir levels. Purveyors with mainstem lake intakes do not have drought stage triggers, or storage licences.

Rapid and smooth drought response depends on all purveyors having plans in place that include rational and easy-to-quantify drought triggers, water restriction stages that apply to various user types, and internal and public communication plans. An absence of drought triggers, or a regional drought declaration that doesn't speak to local conditions, can make the decision to enact water restrictions more difficult for elected boards and councils. This can slow the response to a water shortage and lead to confusion among the public.

Many Okanagan purveyors with mainstem intakes are working on drought response plans, and have requested assistance with triggers for moving between water restriction stages.

<u>**Proposed drought stage trigger guidelines:**</u> The OBWB commissioned a technical team to develop guidelines for drought stage triggers on the mainstem system. The guidelines are based on lake levels, and consider Okanagan Lake dam operations. They fill an immediate gap. The triggers can be readily incorporated into drought plans so that mainstem purveyors will have a consistent, rational process for drought response – similar to the water use plans and reservoir management plans in place for purveyors with reservoir storage. Ideally, using these guidelines, water managers with mainstem intakes would move through water restriction stages in a coordinated way.

<u>The guidelines are not a proposal for top-down regulation</u>. Provincial water managers are supportive of local drought planning processes, with locally-derived triggers. The goal is for each water purveyor to have a robust plan adopted by its board or council; and that these plans would be coordinated throughout the basin. The OBWB has been developing a valley-wide drought response strategy to support and link the efforts of local purveyors and provincial water managers and improve communication to the public.

<u>**Broader application:**</u> As we've worked on these guidelines, a number of people have suggested that lake level triggers should apply to all water purveyors in the Okanagan basin. Our waters are connected. Water retained in reservoirs does not reach the mainstem lakes, affecting water levels. We know that pumping from some groundwater sources can directly influence surface flows. We have studies showing that withdrawals from streams and groundwater can have a sizable net impact on lake levels in drought years with low precipitation and high evaporation.

The proposed mainstem drought trigger guidelines could be incorporated into a valley-wide drought plan by applying them to withdrawals on stream, reservoir and groundwater sources, in addition to other existing triggers for these sources. Even regionally, there are benefits for neighbouring communities with more than one purveyor and a variety of water sources, to have combined drought triggers for water restriction stages, and the mainstem triggers could be part of that plan.

To scale the mainstem triggers to the entire valley, meaning that groundwater and reservoir users would also have restrictions triggered by mainstem lake levels, several things would have to be considered:

- Many reservoir and stream systems are more sensitive to water shortages than the mainstem lakes, and may be triggered, according to sub-basin specific drought plans, more frequently than they would if they used mainstem triggers.
- Reservoir sources have storage licences and conservation requirements to maintain fish flows.
- Most groundwater sources are in the process of being licensed, and more work is needed to quantify groundwater/surface water connections.

Our project scope – to develop the guidelines proposed here, focuses on the immediate need of mainstem purveyors seeking drought triggers for their individual plans – and did not allow us to address the complexities of a more comprehensive valley-wide planning process.

Establishing common triggers for mainstem intakes does not preclude arrangements between neighbouring purveyors, who may agree to move through water restriction stages based on a combination of triggers on different sources. Having examples like these would help grow trust among communities to move towards a valley-wide drought plan.

<u>Adaptation:</u> Climate change is altering the hydrology of the Okanagan Basin, shifting to less snow storage, which will affect reservoir storage and lake management over time. The lake level triggers proposed here are based on historical conditions. If mainstem purveyors adopt common triggers, and agree to a common approach for drought response, the exact lake levels that form the triggers can be adjusted, if necessary, in future years.

Sincerely,

Anna L. Warwick Sears

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1 INTRODUCTION

The Okanagan Basin Water Board (OBWB) is working to facilitate more consistent and coordinated drought planning and response in the Okanagan. As part of this effort, the OBWB is helping local water suppliers prepare drought plans that include a defensible decision-making framework for responding to drought, including when to move between water restriction stages. In 2016, the OBWB initiated a project to specifically address water suppliers on mainstem lakes and the unique challenges they face when preparing their decision-making frameworks.

Unlike water suppliers with upland storage reservoirs, suppliers on mainstem lakes do not control the level of their reservoirs – the Province of BC does. The water suppliers also share these mainstem lake reservoirs with many other water users – both extractive and non-extractive. Given these factors, it is important that water suppliers with intakes on the mainstem lakes have consistent drought stage triggers in their drought plans that relate to the provincial management of the lakes.

2 PROJECT OVERVIEW

2.1 Objectives

The objectives of the project were to:

- involve the appropriate technical experts and water suppliers to ensure a well-rounded and accurate discussion of factors to consider when setting triggers for local drought stages on the mainstem lakes and Okanagan River; and
- through that discussion, recommend drought stage triggers for the mainstem lakes and Okanagan River that will result in a consistent and coordinated response to drought conditions by local water suppliers.

2.2 Project Team

The project was managed by Kellie Garcia, OBWB Policy and Planning Specialist. Brian Symonds, former Director of Water Stewardship with the Province of BC, developed the drought stage trigger guidelines with extensive input from a team of lake management, hydrology, water supply, and fisheries experts. Okanagan water suppliers also provided considerable input throughout the project (see Section 2.3).

The technical team also included:

- Dr. Brian Guy, P.Geo., National Practice Leader, Environmental Science, Senior Geoscientist, Associated Environmental Consultants (retired)

- Bob Hrasko, P.Eng.,Principal, Agua Consulting
- Karilyn Alex, Fisheries Biologist, Okanagan Nation Alliance Fisheries Department,
- Shaun Reimer, Section Head – Public Safety & Protection, Okanagan Shuswap District Ministry of Forests, Lands, Natural Resource Operations, & Rural Development, and
- Dr. Anna Warwick Sears, OBWB Executive Director.

2.3 Consultation with Water Suppliers

Two workshops were held with water suppliers to gather feedback on the proposed drought stage triggers. At the first workshop, a full-day event held in November 2016, the water suppliers heard presentations from the Ministry of Forests, Lands and Natural Resource Operations and Rural Development about their drought assessment and response in the Thompson Okanagan region, and their management practices for the mainstem lakes and Okanagan River. Attendees were then given a detailed presentation on the project and the proposed drought stage trigger guidelines, followed by a lengthy discussion where each water supplier had the opportunity to provide feedback.

The technical team made substantial changes to the proposed drought stage triggers based on the feedback from the first workshop. Revised triggers were presented at a second workshop, held in November 2017, and additional feedback was gathered from the water suppliers. After the workshop, three different drought stage trigger scenarios (i.e. using different percentiles) were provided to the water suppliers and they were asked to choose the best option and explain why.

This collaborative and iterative process resulted in the drought stage triggers presented in Section 7.

3 HYDROLOGY OF THE MAINSTEM LAKES

The hydrology of the Okanagan watershed is dominated by the accumulation of water in the mountain snowpacks over the winter, and the melting and runoff of the snow in the spring and early summer. The high volume of runoff during freshet provides most of the annual inflow into the mainstem lakes. Heavy rainfall events throughout the year can also make important, although significantly smaller, contributions to the amount of water available in the Okanagan, particularly on tributary streams and to a lesser extent the mainstem lakes.

The mainstem lakes in the Okanagan provide a large volume of natural and regulated storage. This storage captures and retains most of the freshet runoff volume, and modifies the shape of the annual hydrograph of lake outflows. During years of high inflow the available storage in the lakes is used to attenuate the timing and magnitude of the peak downstream flows, thereby reducing the flood risks in these areas. More importantly from a water supply perspective, during years with a normal or low freshet runoff the water retained in storage is available to supplement, maintain and augment natural lake levels and river flows during the drier parts of the summer and fall when tributary contributions are typically at or near their minimum levels for the year.

4 REGULATION OF THE MAINSTEM LAKES

Regulation of the Okanagan mainstem lakes and the Okanagan River began in the early 1900s and now includes dams or control structures on each lake. Management objectives for the lakes and the sections of river that connect the lakes have evolved over time in response to changing considerations and demands, improved understanding of natural factors and the physical limitations of the regulatory works, and how different regulation of releases affect different objectives such as protecting fish spawning or supplying private intakes.

In 1969, the federal and provincial governments initiated a project to develop a comprehensive framework plan for managing water in the Okanagan with input from a diverse range of stakeholders, various levels of government and the public. The “Canada-British Columbia Okanagan Basin Agreement Report” was released in 1974. The report includes recommendations for target levels for each mainstem lake and flows in Okanagan River. The target levels and flows were developed to balance diverse and sometimes competing goals of economic development (e.g., flood control, water supply, lake shore development, tourism), environmental quality (e.g., instream flows for fish, lake level fluctuations for shore spawning kokanee), and social betterment. It was expected that the recommendations would, to the extent practicable, be met in all years except in consecutive drought years. The targets were subsequently reaffirmed in the Okanagan Basin Implementation Board's “Report on the Okanagan Basin Implementation Agreement” (1982).

Provincial decision makers continue to use the framework plan targets to provide higher level guidance regarding the management and operation of the regulatory works for each of the mainstem lakes.

Sections 4.1 to 4.3 provide more detail on the regulation of the Okanagan mainstem lakes and river.

4.1 Okanagan Lake Regulation System

The Okanagan Lake Regulation System (OLRS) regulates the lake levels and releases in Okanagan River from Okanagan Lake to the inlet of Osoyoos Lake. The main OLRS regulatory works consist of the dams on Okanagan (Penticton), Skaha (Okanagan Falls) and Vaseux lakes. The OLRS works also include the channelized sections of Okanagan River between Okanagan Lake and Osoyoos Lake, including the associated dikes and drop structures.

Although physically connected to the OLRS, Kalamalka/Wood and Osoyoos lakes are not considered to be part of the OLRS (see Section 4.2 and 4.3).

The OLRS is operated by provincial Water Management staff in Penticton to meet a range of economic, environmental and social objectives for each of the mainstem lakes and the different reaches of Okanagan River. As described in the preceding section, these management objectives include flood control, water supply, aquatic and riparian ecosystem needs, and recreational interests.

Okanagan Lake Dam is the main control point in the OLRS due to its upstream position in the system and because the surface area and storage capacity of Okanagan Lake are so much larger than the area and capacity of any of the downstream mainstem lakes.

Table 4.1 compares the drainage areas (i.e. the area that contributes flow to the lake) and surface areas of the mainstem lakes and the relative impact a 1 m^3/s change in the release from each lake will have on the level of that lake during a 24-hour period.

Table 4.1 Drainage and surface areas of the Okanagan mainstem lakes

LAKE	DRAINAGE AREA (km^2)	SURFACE AREA (km^2)	DAILY CHANGE IN LAKE LEVEL RESULTING FROM A 1 M^3/S CHANGE IN DISCHARGE (mm)
Kalamalka/Wood	569	35.20	2.45
Okanagan	5980	340.75	0.25
Skaha	6720	20.23	4.27
Vaseux	7150	2.43	35.56
Osoyoos	8275	23.18	3.72

Okanagan Lake Dam and the storage capacity it provides enable large volumes of water to be captured in Okanagan Lake during the annual freshet and other periods of high inflow. The stored water is then available to augment natural flows during drier periods to meet both instream and offstream needs on the OLRS. These needs include maintaining instream flows to meet environmental objectives; supporting direct withdrawals from the lake and downstream locations to meet community, agricultural, and other withdrawal demands; and supporting a variety of water dependent recreational and social objectives. In most years the elevation of Okanagan Lake varies from a low of 341.5 to 341.6 m GSC in the late winter to a high of 342.4 to 342.5 m GSC in late June.

As noted previously, in any given year the volume of water available from storage on Okanagan Lake is the most important consideration when estimating the amount of water that is available to meet the different requirements along the OLRS. From a water supply perspective, the careful management of the stored water and the release of this water through the dam in Penticton are most critical in months following the end of spring freshet. This is when the lake has reached its peak for the year, natural inflows to the system are typically low, and the demands and competition for any available water are greatest.

In July through September, particularly during dry years, it is common for the flows in the Okanagan River between Skaha and Osoyoos lakes to be significantly less than the rate at which water is being released from Okanagan Lake Dam at Penticton. The difference between the dam releases and downstream flows during these months is attributable to human withdrawals, seasonally higher natural losses such as evaporation and groundwater losses, and reduced inflows from tributary streams and groundwater. When these conditions occur, the water required to support both the instream flow needs along Okanagan River and the withdrawal of water from the lakes and river south of Penticton, is almost exclusively dependent on the release of water stored in Okanagan Lake. More information on the inflow forecasting and the management and operation of the OLRS is provided in Section 5.

4.2 Kalamalka/Wood Lake

Kalamalka and Wood lakes are connected by a short, low gradient section of channel in Oyama. This short channel allows the level of the two lakes to rise and fall in unison. Therefore, the two lakes (herein after referred to simply as Kalamalka Lake) are considered as a single body of water for management purposes.

A small control structure located at the north end of Kalamalka Lake is used to regulate the level of the lake and the releases from Kalamalka Lake into Vernon Creek. Although the control structure is not considered part of the OLRS, the structure is also operated by the Province to meet multiple economic, environmental and social objectives.

The normal target operating range for the lake is between a minimum elevation of 391.2 to 391.3 m GSC in the winter months and a controlled maximum target elevation of 391.7 m during freshet. The minimum winter lake level typically occurs during the weeks before the start of spring freshet when the control gates are allowed to freeboard, and the inflows and outflows are in balance. The normal range for releases from Kalamalka Lake into Vernon

Creek is 0.085 to 5.7 m^3/s. During years of high freshet runoff the maximum elevation of Kalamalka Lake and rate of release may exceed the targets due natural factors and capacity limitations of the control works.

Decisions regarding the management and operation of the control structure are based on freshet inflow volume forecasts for Kalamalka Lake, real-time lake levels and streamflows, and seasonal target levels. Given the relatively small drainage and surface areas of Kalamalka Lake compared with the much larger Okanagan Lake (see Table 4.1) management and operational decisions regarding Kalamalka Lake typically do not consider potential impacts, either positive or negative, on Okanagan Lake levels. This includes operational decisions during a drought year.

4.3 Osoyoos Lake

Osoyoos Lake is a transboundary lake with approximately 2/3 of its surface area in Canada and 1/3 in the USA. The level of Osoyoos Lake is regulated by Zosel Dam near Oroville, Washington. The dam is operated and maintained by the Washington State Department of Ecology and therefore is not considered part of the OLRS. Nevertheless, Osoyoos Lake is an important source of water for both Canadian and American interests around the lake.

The water in Osoyoos Lake also plays a critical role in supporting healthy ecosystems in the South Okanagan and in particular during key stages in the life cycle of Okanagan sockeye salmon. Over the last several years, considerable effort has been made by First Nations, senior levels of government and a number of partners in both British Columbia and Washington State to better understand and improve water management in the region to support the recovery of salmon stocks in Okanagan River and Osoyoos Lake.

Zosel Dam controls Osoyoos lake levels on both sides of the international border. Therefore, management and operational decisions regarding the dam are made by the operators in accordance with the Orders of the International Joint Commission (IJC), with an appropriate level of oversight provided by the Commission's appointed International Osoyoos Lake Board of Control. The Orders allow the operators to regulate the elevation of Osoyoos Lake between 909.0 ft and 912.5 ft USGS. The Orders recognize that during periods of high inflow from Okanagan River or naturally restricted outflows due to high water levels downstream in Similkameen River the controlled maximum lake elevation of 912.5 ft may be exceeded.

5 ANNUAL INFLOW FORECASTS AND MAINSTEM MANAGEMENT FORECASTS

5.1 Annual Inflow Volume Forecasts

As noted previously, the volume of freshet inflow to the mainstem lakes and the management of this water are critical in determining the amount of water that will be available throughout the remainder of the year. Water managers rely on forecasts made before and during freshet to prepare for and manage the anticipated inflow and available storage.

When assessing the water supplies during years of potential scarcity, water managers place the highest importance on the freshet inflow volume forecasts and the lake elevations and available storage during critical periods. A secondary consideration is the distribution and timing of the freshet runoff in the current year compared to normal. Relatively low importance is given to short term weather events and daily or weekly fluctuations in tributary inflows due to the dominant moderating influence of these short term events by the large storage capacity in the mainstem lakes, particularly Okanagan Lake.

Each year, beginning on February 1, forecasts are made of the expected freshet inflow volumes to both Kalamalka and Okanagan lakes. These forecasts are updated regularly until the end of freshet to reflect the changing snowpack conditions, observed lake levels and streamflows, and other factors. Provincial water managers use these forecasts and other information to inform their ongoing operational decisions regarding the release of water stored in each of the mainstem lakes to best meet the various operational objectives during freshet and the remainder of the year.

5.2 Operational Objectives and Considerations

5.2.1 General

As noted in Section 4, the Okanagan mainstem lakes are regulated in accordance with the recommendations of the Okanagan Basin Agreement. Since the recommendations were first released, additional information and experience gained by the operators and others has provided a better understanding of limitations and opportunities to improve the water management of the mainstem lakes. This has led to further refinements to the operational guidelines for the various mainstem regulatory works, while still respecting the recommendations contained in the Agreement.

The recommendations and the subsequent improved operational knowledge and experience have been incorporated into the Okanagan Fish/Water Management Tool (see Section 5.3), which is currently used by water managers and others to inform in-season management decisions regarding the OLRS.

5.2.2 Specific Objectives during a Drought Year

In drought years the mainstem lakes are regulated to capture and store as much of the freshet volume as possible for use later in the year. Throughout the summer and fall, levels and flows are closely monitored and releases generally kept at or near minimum levels to optimize the management of the available water to meet the different environmental and human objectives. This includes managing the releases to the extent practicable to meet the desired operational targets elevations for each of the lakes prior to the onset of winter, particularly Okanagan Lake. Meeting the pre-winter target elevations is important to reduce the potential for any adverse impacts of the current drought year to carry over into the next year.

5.3 Okanagan Fish/Water Management Tool

The Okanagan Fish/Water Management Tool (FWMT) was developed by a partnership of fishery and water managers from the Okanagan Nation Alliance, Fisheries and Oceans Canada, and the Province of BC, with support from consultants and others. The purpose of the FWMT was to identify opportunities to improve the management of the OLRS for fish without compromising other water management goals and objectives.

The FWMT is a computer-based model that uses and shares knowledge and expertise provided by various subject matter experts in combination with the best available historic and real time data to examine the implications of various potential scenarios for releasing water from Okanagan Lake on the different OLRS objectives. The FWMT runs in weekly time steps and assesses the impacts of the proposed releases on objectives at indicator locations from Okanagan Lake to Osoyoos Lake for several weeks or months into the future.

The experts are able to run the FWMT independently to game with, evaluate and share the results of their proposed release scenarios with others. Throughout the year the shared outputs are used to facilitate conversations between the experts which in turn inform future release decisions by the OLRS water manager.

6 DESCRIPTION OF PROVINCIAL DROUGHT LEVELS

6.1 British Columbia Drought Response Plan (updated June 2018)

The British Columbia Drought Response Plan was developed by the Province, with input from local authorities and others, to provide guidance on how to prepare for and respond to hydrologic droughts in BC "to assist in ensuring that the water needs of people and aquatic ecosystems are met in times of drought." Section 4 of the Plan describes the provincial drought response levels, and indicators and recommended corresponding actions.

The following is an excerpt from the Plan that describes the four drought response levels:

> "At Level 1 (Green), conditions are normal and there is sufficient water to support ecosystem and water uses. Emphasis is on preparedness and taking action in advance of droughts in order to increase readiness of water users and communities when they inevitably occur.
>
> At Level 2 (Yellow), conditions are dry and first indications of potential water supply shortages are recognized. Emphasis is on stewardship, voluntary conservation through education, communications and planning and possibly curtailing unauthorized use.
>
> At Level 3 (Orange), conditions are becoming very dry. Potentially serious ecosystem or socio-economic impacts are possible or imminent and impacts may already be occurring. Emphasis continues to be on voluntary conservation and restricting or curtailing unauthorized use, while water suppliers may impose increasing watering restrictions. If serious impacts are occurring in an area, the provincial government will likely consider regulatory action.
>
> At Level 4 (Red), conditions are extremely dry and there is insufficient supply to meet community or ecosystem needs, progressively more severe and widespread socio-economic impacts are expected. Voluntary measures and increasing use of watering restrictions will continue but may be augmented by regulatory action by the provincial government."

The Plan also includes the following table, which summarizes the four provincial drought levels, the corresponding objectives, and suggested water use targets.

Table 6.1 Provincial drought levels summary table

Level	Conditions	Significance	Objective
1 (Green)	Normal Conditions	There is sufficient water to meet human and ecosystem needs	Preparedness
2 (Yellow)	Dry Conditions	First indications of a potential water supply problem	Voluntary conservation
3 (Orange)	Very Dry Conditions	Potentially serious ecosystem or socioeconomic impacts are possible	Voluntary conservation and restrictions
4 (Red)	Extremely Dry Conditions	Water supply insufficient to meet socio-economic and ecosystem needs	Voluntary conservation, restrictions and regulatory action as necessary.
Loss of Supply		Potential loss of a community's potable or fire-fighting supply	Emergency response

Source: "The British Columbia Drought Response Plan" (updated June 2018)

It is important to note that the provincial drought **levels** and targets outlined in Table 6.1 are not the same as the drought **stages** established and used by water suppliers to trigger local water restrictions and other responses. Drought level declarations by the Province are based on moisture conditions (e.g. snow pack), weather forecasts, and stream flows over a wide region – a general hydrological condition. Local drought stages consider these factors but also examine reservoir levels, infrastructure capacity, and customer demand forecasts when determining drought stages.

7 RECOMMENDED DROUGHT STAGE TRIGGERS

As noted in Section 5.1, the water supply outlook for the Okanagan mainstem lakes in any given year, but especially in drought years, is primarily a function of the volume of water available from, or forecast to be available from, mainstem lake storage - especially during the summer and fall months. When evaluating how to best manage the water held in storage during periods of scarcity, consideration must be given to both short term objectives and priorities for use of the available water over the longer term (e.g., the full irrigation season). This contrasts with the reactive approach typically taken for managing direct water withdrawals from streams that are not supported by storage where the management focus is almost exclusively on short term objectives.

Given the importance of water stored in the Okanagan mainstem lakes to the water available for withdrawals from the mainstem lakes and river, particularly during the high demand summer and fall months, it is recommended that the triggers used to determine drought stages for the mainstem lakes and river be based on the elevation of key lakes during the critical period of July through October.

Developing drought stage triggers based on mainstem lake elevations requires a general understanding of the control works and management considerations, including the established lake elevation and river flow targets. Description of the various control works on each of the lakes, and their management and operation is provided in Sections 4 and 5.

During times of scarcity, Okanagan Lake is the primary storage and source for instream and offstream demands throughout the OLRS. Therefore, it is recommended that a common set of drought stage triggers be developed and adopted for the OLRS, including Okanagan Lake and the downstream mainstem lakes and river, based on the elevation of Okanagan Lake during the critical months of July through October (see Section 7.1).

Due to its upstream location and the fact that Kalamalka/Wood Lake has a much smaller surface area than Okanagan Lake, decisions on the management of water stored on this lake are made independent of water management decision for Okanagan Lake. In view of this, it is recommended that a similar but separate set of drought stage triggers be developed and adopted for Kalamalka/Wood Lake and Lower Vernon Creek based on the elevations of that lake (see Section 7.2).

Recommended drought stage triggers for Osoyoos Lake are discussed in Section 7.3.

7.1 Okanagan Lake Regulation System Drought Stage Triggers

7.1.1 Selection of Time Period for Trigger Development

The BC Water Management program maintains a summary of the Monthly Net Inflows (MNI) to Okanagan Lake based on available Water Survey of Canada (WSC) lake level and river discharge records from 1921 to present. This MNI summary has been used in this project to compare the MNI during the four months of July to October for both the full period of record (1921-2016) and a series of recent 30-year standard periods. A comparison of the statistical results for the different periods examined is presented in Appendix 1. The comparison shows that while there are slight differences between the MNI during a drought year for the various periods compared, statistically the periods examined are relatively similar.

It is therefore recommended that the recent 30-year standard period 1986-2015 be used to develop the triggers for the mainstem lakes. This recommendation is not only based on the statistical similarity of drought inflows during the various periods of record compared (described above), but also a preference to use the most current hydrometric data, and the advantage of being able to periodically update the triggers as future hydrometric data becomes available to reflect any emerging hydrologic trends.

Historic Okanagan Lake elevation data for the selected 30-year standard period was obtained from the lake elevation records for WSC Station No. 08NM0083, "Okanagan Lake at Kelowna." The specific elevations selected for the development of the drought stage triggers consisted of the 1st of month elevations of Okanagan Lake for July to November.

The complete set of Okanagan Lake elevations for the 30-year standard period 1986-2015 is presented in Appendix 2.

7.1.2 Analysis of Historic Okanagan Lake Levels

Using the Okanagan Lake elevations extracted from the WSC records, a series of drought percentiles and extremes (and approximately equivalent return periods) were developed for the elevation on the 1st of the month from July to November. This statistical information was then used to inform the elevation percentiles to be used to develop the drought stage triggers. Various percentile elevations (and combinations of percentiles), as well the Province's operational target elevations for Okanagan Lake were considered as potential triggers.

For reference purposes, the complete set of monthly percentile elevations for Okanagan Lake that were considered as potential drought stage triggers is presented in Appendix 3.

7.1.3 Recommended Drought Stage Triggers for Okanagan Lake

The following factors were taken into consideration when developing the recommended drought stage triggers for Okanagan Lake:

1. Ability to link with the lake management practices of the Province of B.C.;
2. Frequency with which the different drought stages might be declared;
3. Ease of application and understanding of triggers; and
4. Acceptability of drought stage triggers to key users.

After considering these factors, the results of the statistical analysis, and input received from local water suppliers it is recommended that the OLRS operational target elevations, and the 20th, 10th and 5th percentile elevations (which are approximately equivalent to drought events with 1 in 5, 1 in 10, and 1 in 20-year return periods) be used for the drought stage triggers.

Table 7.1 gives the specific operational target and selected percentile elevations for Okanagan Lake that were used to develop the drought stage triggers for Okanagan Lake, and the downstream mainstem lakes and Okanagan River.

Table 7.1 Okanagan Lake elevations (in metres GSC) on 1st of the month

	JUL	AUG	SEP	OCT	NOV
Target Elev. [1.]	342.44	342.24	342.04	341.89	341.84
20th Percentile [2.]	342.227	342.097	341.950	341.796	341.681
10th Percentile [2.]	342.046	341.929	341.802	341.655	341.575
5th Percentile [2.]	341.981	341.869	341.667	341.511	341.421

Sources:

1. Target elevations from BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development files.
2. The 1986-2015, 30-year standard percentile elevations are based on data obtained from the historical records for WSC Station 08NM083, "Okanagan Lake at Kelowna," Period of Record 1943-present, Geodetic datum 340.236 m GSC.

Based on the target and percentile elevations in Table 7.1, the following drought stage triggers are recommended for Okanagan Lake and the Okanagan mainstem downstream of the lake, including Skaha and Vaseux lakes, and the Okanagan River between the outlet of Okanagan Lake and the inlet to Osoyoos Lake:

Non-drought Stage – Water suppliers would remain at their Normal stage (or a Non-drought stage if they do not have a Normal stage in their bylaw) when the forecast or actual 1st of month elevation of Okanagan Lake is equal to or greater than the 1st of month target elevation (see Table 7.1).

Stage 1 (green)– The forecast or actual 1st of month elevation of Okanagan Lake for each of the months July through November is lower than the 1st of month target elevations and equal to or greater than the 20th percentile 1st of month elevation (see Table 7.1).

Stage 2 (yellow) – The forecast or actual 1st of month elevation of Okanagan Lake for each of the months July through November is lower than the 20th percentile 1st of month elevation and greater than or equal to the 10th percentile 1st of month elevation (see Table 7.1).

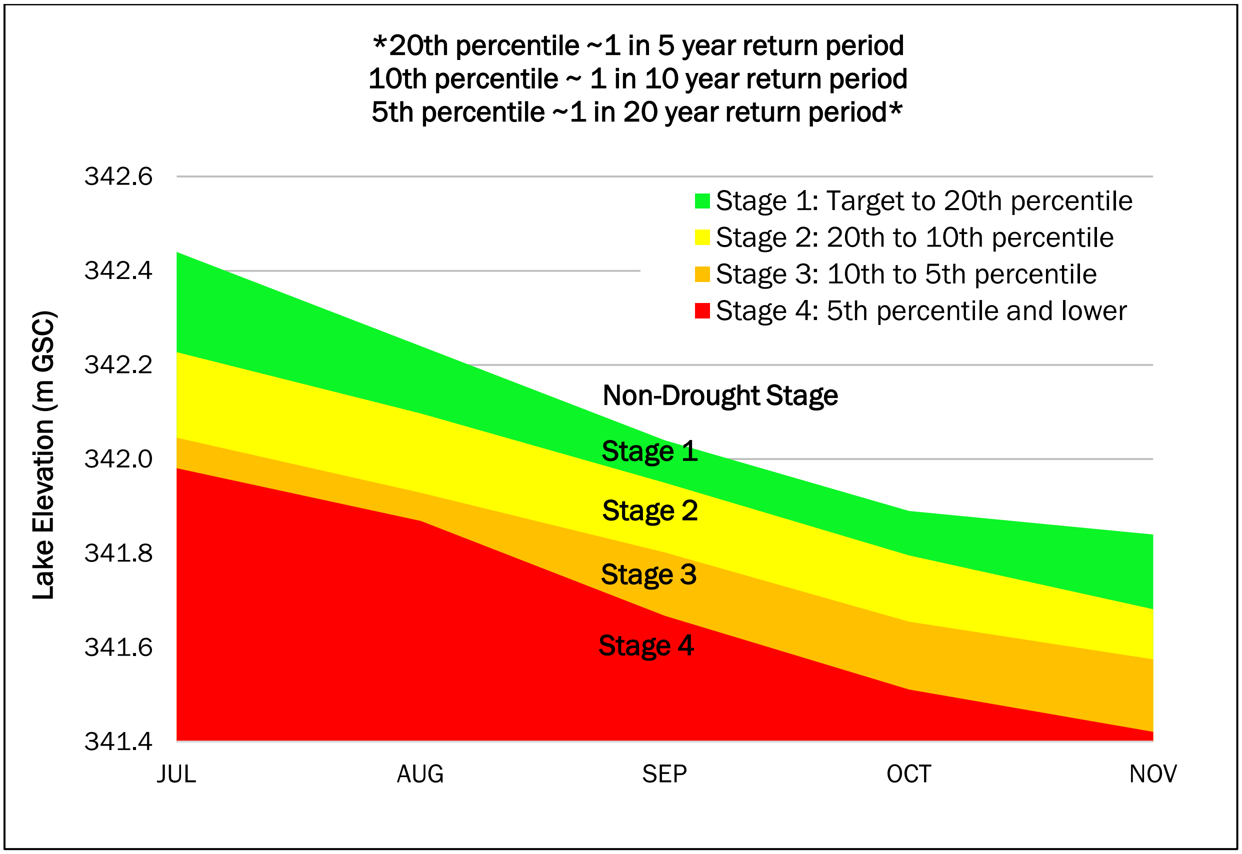
Stage 3 (orange) – The forecast or actual 1st of month elevation of Okanagan Lake for each of the months July through November is lower than the 10th percentile 1st of month elevation and greater than or equal to the 5th percentile 1st of month elevation (see Table 7.1).

Stage 4 (red) – The forecast or actual 1st of month elevation of Okanagan Lake for each of the months July through November is lower than the 5th percentile 1st of month elevation (see Table 7.1).

(Note: The Okanagan FWMT computer model should be used to forecast 1st of month elevations of Okanagan Lake for future months. The OBWB can provide this information to water suppliers.)

Figure 7.1 provides a graphical presentation of the drought stages and triggers recommended for Okanagan Lake and the downstream mainstem lakes and Okanagan River. In the figure legend, “target” refers to the lake elevation that the province attempts to achieve on the first of each month, the 20th percentile lake elevation is a lower value that only re-occurs about every 5 years, the 10th percentile elevation is a value so low that it only re-occurs about every 10 years, and the 5th percentile elevation is a value so low that it only re-occurs about every 20 years.

Figure 7.1 Recommended drought stage triggers (based on Okanagan Lake elevations on 1st of month) for Okanagan Lake, downstream lakes, and Okanagan River



In dry years, the July 1 elevation of Okanagan Lake is primarily due to inflow to the lake during the freshet period, April to June. By contrast, the November 1 elevation is influenced both by the lake elevation on July 1 and ongoing lake level management to optimize lake storage and summer/fall inflows. In moderately dry years, water managers have the opportunity to use natural inflows to Okanagan Lake during the summer and fall to supplement releases, thereby limiting the drawdown of Okanagan Lake. In extreme dry years, when net inflows are very low or even negative, water managers have less operational flexibility and the lake elevations tend to fall more noticeably despite there being very small releases from Okanagan Lake.

Table 7.2 is provided for illustrative purposes to show what the drought stages would have been for each of the months July to November during 2001-2017 if the Okanagan Lake drought stage triggers recommended in this report had been used.

Table 7.2 Hypothetical local drought stages from 2001-2017 if the recommended Okanagan Lake drought stage triggers had been used (Non-drought = white, Stage 1= green, Stage 2 = yellow, Stage 3 = orange and Stage 4 = red).

YEAR	JUL	AUG	SEP	OCT	NOV
2001	342.206	342.117	341.973	341.807	341.711
2002	342.415	342.243	342.027	341.818	341.661
2003	342.043	341.838	341.62	341.452	341.382
2004	342.232	342.092	341.987	341.869	341.796
2005	342.484	342.203	341.966	341.809	341.76
2006	342.387	342.18	341.965	341.798	341.683
2007	342.226	342.165	341.973	341.795	341.735
2008	342.443	342.269	342.104	341.866	341.731
2009	342.024	341.921	341.796	341.645	341.567
2010	342.428	342.274	342.037	341.939	341.833
2011	342.552	342.203	341.984	341.831	341.751
2012	342.628	342.319	342.024	341.86	341.786
2013	342.565	342.195	342.018	341.899	341.817
2014	342.376	342.273	342.044	341.949	341.856
2015	342.242	342.046	341.870	341.744	341.681
2016	342.478	342.274	342.071	341.926	341.933
2017	343.016	342.426	342.007	341.812	341.709

Note:

1. The 1st of month elevations for the months September 2003 through March 2004 were the lowest recorded during the 73-year period-of-record (1943-2016) at WSC Station 08NM083. It is noteworthy that in 2004 the lake elevation was 21 cm below the target elevation on the 1st of July and then returned to close to the target range in early September.

The 30-year standard data set used in this analysis and the resultant triggers should be reviewed before 2028 using the 30-year period 1996-2025. The stages and triggers may need to be updated to reflect hydrologic changes or trends, and to incorporate any learnings from the operational experiences of using the drought stage triggers during that time.

7.2 Kalamalka/Wood Lake Drought Stage Triggers

The factors to consider when determining the appropriate drought stage triggers for Kalamalka/Wood Lake (herein after referred to as Kalamalka Lake) are similar to the consideration described in Section 7.1 for Okanagan Lake and the OLRS downstream, except on a smaller and more localized scale. Therefore, a similar approach was used to develop drought stage triggers for Kalamalka Lake, based on the target and statistical lake elevations on the 1st of each month during the same 30-year standard period 1986-2015.

Historical elevations for Kalamalka Lake were obtained from WSC Station 08NM143 – "Kalamalka Lake at Vernon." The complete set of 1st of month Kalamalka Lake elevations for the 30-year standard period 1986-2015 that were used in the statistical analysis is provided in Appendix 4. Appendix 5 contains a complete series of the 1st of month percentile elevations considered as potential drought stage triggers. These include the median, minimum, and eight percentiles elevations in between, as well the Province's operational target elevations for Kalamalka Lake.

After considering the factors identified in Section 7.1.3, the results of the statistical analysis, and input from water suppliers, it is recommended that the Kalamalka Lake operational target elevations, and the 20th, 10th and 5th percentile elevations (which are approximately equivalent to drought events with 1 in 5, 1 in 10, and 1 in 20-year return periods) be used for the drought stage triggers.

Table 7.3 summarizes the operational target and key percentile elevations for Kalamalka Lake recommended for use as drought stage triggers for the lake.

Table 7.3 Kalamalka Lake elevations (in metres GSC) on 1st of month

	JUL	AUG	SEP	OCT	NOV
Target Elevation [1.]	391.700	391.600	391.500	391.400	391.350
20th Percentile [2.]	391.578	391.498	391.379	391.320	391.294
10th Percentile [2.]	391.490	391.388	391.254	391.170	391.139
5th Percentile [2.]	391.389	391.284	391.164	391.105	391.078

Sources:

1. Target Elevations from BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development files. (Note: 1st of month target elevations provided to nearest 0.1 metres only).
2. 1986-2015 percentile elevations are based on data from WSC Station 08NM143 - Kalamalka Lake at Vernon, Geodetic datum 386.122 m.

Based on the target and percentile elevations presented in Table 7.3, the following triggers for drought stages are recommended for Kalamalka Lake and Lower Vernon Creek (downstream of Kalamalka Lake):

Non-drought – Water suppliers would remain at their Normal Stage (or Non-Drought Stage if they do not have a Normal Stage in their bylaw) when the elevation of Kalamalka Lake is equal to or greater than the 1st of month target elevation.

Stage 1 (green)– The forecast or actual 1st of month elevation of Kalamalka Lake for the each of the months July through November is lower than the 1st of month target elevations and equal to or greater than the 20th percentile 1st of month elevation (see Table 7.3).

Stage 2 (yellow) – The forecast or actual 1st of month elevation of Kalamalka Lake for each of the months July through November is lower than the 20th percentile 1st of month elevation and greater than or equal to the 10th percentile 1st of month elevation (see Table 7.3).

Stage 3 (orange) – The forecast or actual 1st of month elevation of Kalamalka Lake for each of the months July through November is lower than the 10th percentile 1st of month elevation and greater than or equal to the 5th percentile 1st of month elevation (see Table 7.3).

Stage 4 (red) – The forecast or actual 1st of month elevation of Kalamalka Lake for the months July through November is lower than the 5th percentile 1st of month elevation (see Table 7.3).

The recommended Kalamalka Lake drought stage triggers are presented in Figure 7.2. In the figure legend, “target” refers to the lake elevation that the province attempts to achieve on the first of each month, the 20th percentile lake elevation is a lower value that only re-occurs about every 5 years, the 10th percentile elevation is a value so low that it only re-occurs about every 10 years, and the 5th percentile elevation is a value so low that it only re-occurs about every 20 years.

Figure 7.2 Recommended drought stage triggers (in metres GSC) for Kalamalka Lake

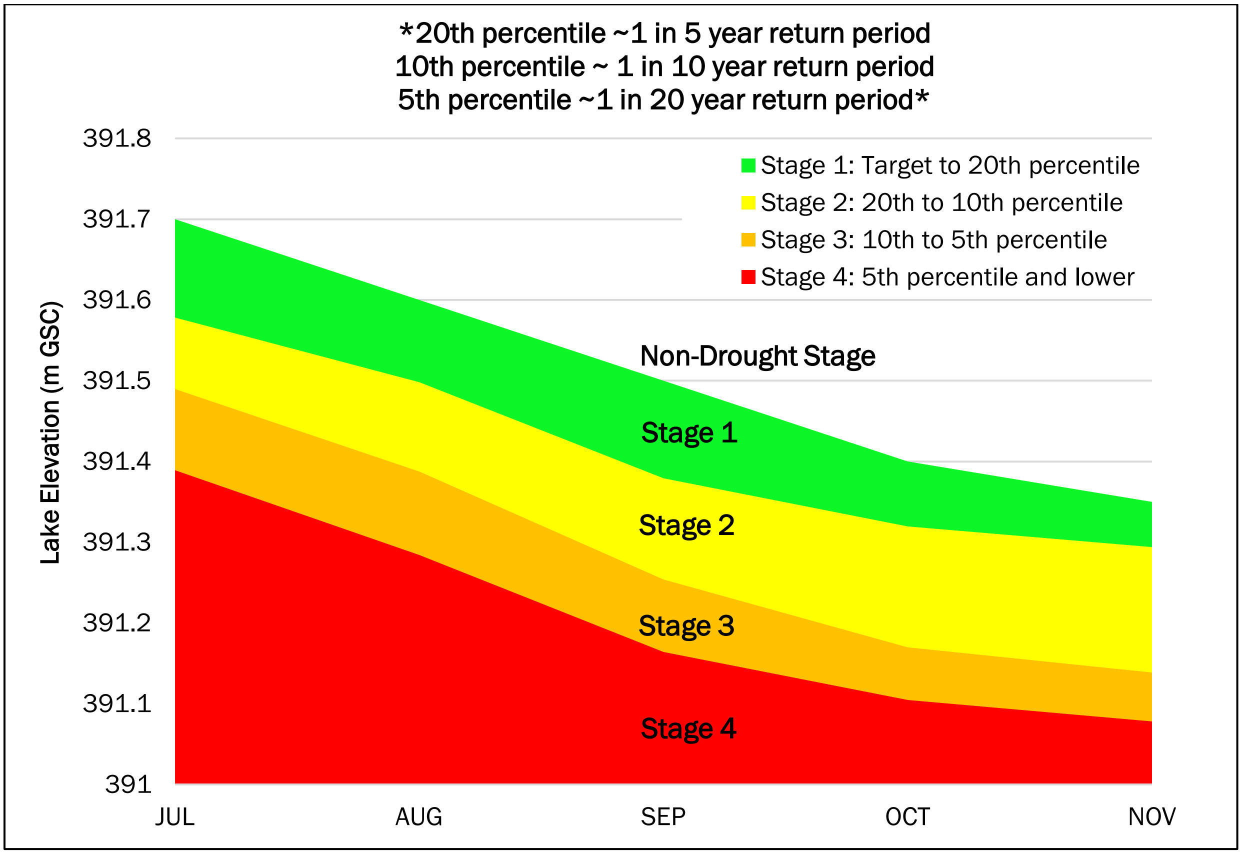


Table 7.4 is presented for illustrative purposes to show what the drought stages would have been for each of the months July through November during the years 2001-2017 if the recommended Kalamalka Lake drought stage triggers were used.

Table 7.4 Hypothetical local drought stages from 2001-2017 if the recommended Kalamalka Lake drought stage triggers had been used (Non-drought = white, Stage 1= green, Stage 2 = yellow, Stage 3 = orange and Stage 4 = red)

YEAR	JUL	AUG	SEP	OCT	NOV
2001	391.686	391.637	391.562	391.48	391.449
2002	391.670	391.544	391.469	391.373	391.313
2003	391.486	391.336	391.170	391.086	391.049
2004	391.332	391.221	391.157	391.120	391.102
2005	391.65	391.594	391.476	391.397	391.415
2006	391.723	391.615	391.488	391.413	391.357
2007	391.552	391.498	391.361	391.283	391.275
2008	391.730	391.607	391.531	391.453	391.412
2009	391.577	391.499	391.411	391.318	391.315
2010	391.585	391.526	391.404	391.355	391.293
2011	391.683	391.638	391.533	391.436	391.411
2012	391.978	391.752	391.514	391.429	391.383
2013	391.830	391.628	391.530	391.462	391.375
2014	391.788	391.627	391.514	391.451	391.410
2015	391.583	391.438	391.298	391.223	391.217
2016	391.655	391.630	391.496	391.360	391.352
2017	392.219	391.775	391.487	391.319	391.277

7.3 Osoyoos Lake Drought Stage Triggers

As discussed in Section 4.3, Zosel Dam in Oroville, Washington, is used to regulate the levels of Osoyoos Lake on both sides of the Canada/USA border. The dam is operated by the Washington State Department of Ecology in accordance with Orders of the International Joint Commission (IJC). The IJC Orders provide specific operational drought criteria and dam management rules for both drought and non-drought years, which the dam managers are required to comply with.

Although the operation of Zosel Dam is outside the scope of this project, there would be benefits to adopting drought stage triggers for the management of water withdrawals from Osoyoos Lake in BC. However, it needs to be recognized that any drought stage triggers adopted through this process for the Canadian portion of Osoyoos Lake would be considered subordinate to the drought criteria and corresponding regulatory requirements contained in the IJC Orders.

Drought stage triggers used for Osoyoos Lake should be based on considerations similar to those used elsewhere on the Okanagan mainstem. Most importantly, they should recognize that during times of scarcity the water available to those withdrawing water from Osoyoos

Lake largely depends on the water being available from Okanagan River inflows, which in turn depends on the release of water stored on the upstream mainstem lakes (Okanagan, Skaha and Vaseux lakes).

Therefore, it is recommended that the drought stages triggers adopted for Osoyoos Lake be the same as those recommended for Okanagan Lake and the Okanagan River mainstem downstream of Penticton (see Section 7.1).

8 OPERATIONAL APPLICATION OF THE DROUGHT STAGE TRIGGERS

This section provides information regarding the operation of water utilities under drought conditions for three water supply scenarios: utilities relying solely on mainstem lakes, utilities relying solely on upland storage, and utilities that have both mainstem lake and upland storage supplies. In addition, example scenarios are provided for those utilities with both creeks and lake sources. A summary of key points is provided at the end of the section.

8.1 Utilities Relying Solely on Mainstem Lakes

For utilities that rely solely on water from mainstem lakes, the drought stage triggers outlined in Figure 7.1 and Figure 7.2 can be used to determine water restrictions and other drought responses. In addition to considering the actual conditions captured in the trigger graphs (i.e. actual lake level on the 1st of the month), moisture conditions, weather forecasts, lake level forecasts, infrastructure capacity, and customer demand should also be considered to determine the appropriate response. **The OBWB will coordinate the transfer of information on current and forecasted lake levels from the Province to water suppliers.**

8.2 Utilities Relying Solely on Upland Storage

For utilities that rely on creeks, with withdrawals supported by upland storage reservoirs, the utility's drought planning should include monitoring of winter snow pack during the late winter and early spring, and monitoring of reservoir water levels throughout the summer. Reservoir storage levels should be compared with average and extreme seasonal reservoir levels. Drought plan triggers should be based on actual reservoir storage levels and how they compare to average seasonal levels. The seasonal levels are the result of water demand, flow releases, and inflow to the reservoir.

For most upper watershed drought plans, drought return periods are based on the measured range of annual reservoir inflows. The frequency is determined based on a calculated percent of runoff in a particular year as compared to average. In the 1980s, the Province developed annual runoff frequency curves for the east and west side watersheds flowing into Okanagan Lake[1] [2]. The results for specific watersheds can be determined from these frequency curves. For example, for east side watersheds, 1:100 year drought inflow is estimated to be 30% of average year runoff, and 1:25 year drought inflow is estimated to be 46% of average year runoff. This runoff frequency information can be scaled down to the local watershed above each reservoir storage dam. For this analysis, there must be a recorded summary of total flow past the dam each year (including releases and flow over the spillway). If a utility has more current runoff or locally-specific frequency data, they should use that data for their drought planning.

A utility with multiple reservoirs should have a procedure to release water from the reservoir that has the highest reliability of filling first. Those reservoirs typically get drawn down the most in a drought scenario.

Each utility should over time, collect hydrological data on their watershed to develop an understanding of reservoir and watershed reliability. The average annual runoff from each catchment area and the extreme year events should be tracked and collected for each dam. Knowing the average annual runoff and probability of refilling the reservoir greatly informs the utility's decision. The average annual runoff can be obtained by collecting the sum of releases to stream, overflow over the reservoir spillway, and including estimates for seepage and reservoir evaporation. Total rainfall in the catchment of the watershed above the dam does not need to be tracked; only the water that flows past the dam through the outlet or over the spillway.

8.3 Utilities with Both Mainstem Lake and Upland Storage Sources

It is more complicated for utilities with both mainstem and upland sources to develop consistent and logical guidelines, and drought stage triggers will need to be customized for each case. Utilities with both sources have the opportunity to use the upland source for emergency environmental flow needs (EFNs or conservation flows) in drought conditions, and maintaining an alternate point of diversion at the mainstem lake.

There are a number of preliminary tasks that utilities can do to help facilitate the process of developing drought triggers for their combined mainstem and upland sources:

1. Obtain a complete and comprehensive record of the water that is licensed to the utility by the Province. Understand and record annual irrigation (IRR), domestic/waterworks local authority (WWLA) and storage (STO) volumes permitted,

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[1] Letvak, B. 1980. Annual Runoff Estimates for West Side of Okanagan Valley. Memo prepared for the Ministry of Environment.
[2] Letvak, B. 1985. Regional Frequency Analysis – East Side of Okanagan Valley. Memo prepared for the Ministry of Environment.

points of diversion (PODs), authorized licensed period of use, and licence priority dates.

2. To use upland storage reservoir water for release to a creek to maintain conservation flows, and switching the POD to a mainstem lake, the upland licence must have a storage (STO) licence and a usage licence with an Alternate POD at the lake location. It is typically easier to amend an existing licence to add an alternate POD than to obtain a new licence for additional water rights.
3. The best practice is that the release rate from the upland watershed reservoir matches the rate of withdrawal from the lake (i.e., the release should not happen all at once, but be timed for maximum conservation benefit). The time of release from upper watershed storage should be such that water from the reservoir is able to reach the lake prior to any water being pumped from the lake by the utility. It is difficult for the Province to monitor and enforce this due to the hundreds of reservoirs being operated in BC; however, accurate reporting is a requirement. When releasing water from storage and pumping from lakes, all withdrawals and releases to streams should be accurately tracked through either metered withdrawals or weir type measured dam releases. For summarizing the flows released and pumped, tracking should be measured in megalitres per day (ML/D).
4. Once the POD and licensing issues are in order, consideration can be given to how the operation can be tracked, monitored, and defended during a drought. The issue of when to call a drought becomes more complicated with multiple sources and multiple licences. Under 'First in Time, First in Right' or FITFIR, licensees with the earlier priority dates are entitled to take their full allocation of water over junior licensees during times of water scarcity. For example a water licence with a 1930 priority date would have precedence over a licence with a 1960 priority date, regardless of the purpose for which the water is used.

   There has not yet been a wide-scale drought to the extent that the Province has had to use FITFIR, but there have been local situations where agricultural licensees were restricted or cut off completely due to limited in-stream flow capacity of specific creeks. The Province has acted in the past to protect EFNs and those licensees without upper watershed storage are most at risk of losing their supply in a drought.

   There is no clear direction from the Province on how holders of multiple licences are to use their licences, and in what order the licences should be used. For the upper watershed licensee, typically their licence is associated with a storage licence and when storage runs out, so does their allocation and ability to draw water at their creek intake. With the lake licensees, the FITFIR application may be simpler; there are fewer factors impacting withdrawals because there is only one storage reservoir to consider.

A combined drought frequency analysis should be developed for utilities that have both lake withdrawals and upper watershed storage releases. It should be a logical process based on both the availability and the reliability of the water sources.

Following is a list of information that would be useful for informing a water utility of their current condition in preparation for drought response.

1. **Track and understand the utility's monthly water demand**. This allows the utility to forecast what to expect to the end of the high-water demand season. Table 8.1 summarizes the monthly water demand of an example utility in megalitres (ML) per month. The average monthly water demand and variation due to wet or dry conditions can be understood and documented. There are many factors that influence a utility's water demand. These include the meters and pricing controls, weather patterns, changes in irrigation practices, changes in crop types, growth and utility expansion to supply additional population, and annexing a smaller utility. Once natural moisture conditions are accounted for, it is likely that the last five years provide the most representative data.
2. **Track available water.** This includes tracking the lake levels in comparison with seasonal average levels and tracking the volume of water available in upper reservoir storage. The available water can be recorded and compared to trigger levels set out in the utility's drought management plan.
3. **Review regional moisture conditions.** Understanding how the utility compares to the regional levels may have some influence in how communication with customers occurs.
4. **Understand the capacity of the utility to draw water** from each of the available sources, including pumping capacity across pressure zones so that either lake water or creek water can be used across the utility service area.
5. **Water quality** may impact the decisions of some utilities; some sources are suitable for irrigation, but not for domestic consumption because their use requires the issuance of a Water Quality Advisory or Boil Water Notice.

Table 8.1 Example monthly water demand tracking summary (ML)

Year	Jan.	Feb.	Mar.	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total ML
1996	106	105	121	464	442	821	1319	1281	249	318	98	89	5412
1997	101	91	109	185	530	607	789	1116	457	167	141	139	4431
1998	111	98	137	330	1122	1193	1489	1349	741	228	104	132	7035
1999	111	113	147	266	626	884	1044	1096	581	252	149	142	5410
2000	128	115	170	300	624	815	1131	1226	382	244	166	161	5462
2001	173	154	185	283	458	718	1178	1268	793	280	158	163	5810
2002	185	181	208	324	708	1072	1566	1254	723	355	147	173	6898
2003	189	145	270	372	737	1125	1461	1298	583	408	154	168	6909
2004	192	141	193	317	539	610	1296	1051	432	386	206	127	5491
2005	175	157	192	473	1020	768	1342	1497	710	321	199	158	7011
2006	182	166	179	328	710	873	1568	1534	765	320	208	189	7021
2007	176	187	224	415	856	751	895	1302	712	252	192	228	6189
2008	206	202	257	296	709	883	1620	1237	753	324	207	255	6947
2009	272	240	270	320	791	1461	1683	1344	696	321	223	223	7844
2010	226	200	234	398	665	757	1658	1573	585	301	202	236	7034
2011	211	193	235	280	621	802	1343	1564	968	281	225	204	6928
2012													
2013													
2014													
2015													
2016													
Average	**169**	**153**	**193**	**338**	**703**	**889**	**1336**	**1295**	**611**	**298**	**170**	**172**	**6327**

With the preceding information, a utility would have sufficient data to make informed decisions to implement drought stages.

8.4 Drought Example Scenarios (Utilities with Combined Lake and Creek Sources)

This section provides two hypothetical scenarios for how Okanagan water utilities with access to both mainstem lake and creek sources could operate during a significant drought event. The situation presented highlights some of the issues that may arise. Each utility should have in place the data described in Section 8.3 prior to a drought to help them make informed decisions.

The example utility holds:

- **4,000 ML** of water licence on a mainstem lake; 3,000 ML for domestic (WWLA) and 1,000 ML for irrigation (IRR), and
- **10,000 ML** of consumptive water licence on a creek; 2,000 ML as domestic/waterworks local authority (WWLA) and 8,000 ML as IRR, plus 5,000 ML of storage (STO).

Creek water quality is poor so the utility relies on the lake for most of their domestic demands. The utility relies heavily on water from the creek to meet irrigation demands.

Scenario 1 – Lake Low – Upper Reservoirs Average

In this scenario, the mainstem lake is at very low levels (Stage 3). The watershed storage is at average levels for the time of year (Stage 1).

With the utility restricted by the water quality objectives, the desire to use lake water is high to avoid issuing a Water Quality Advisory. With this situation, the utility has a challenge of whether to issue a higher drought stage notification to their customers (which usually affects outdoor watering to the domestic customers first) versus issuing a Water Quality Advisory to allow a greater volume of upper watershed creek water into the domestic water system.

A likely outcome for this scenario may be that the utility calls a Stage 2 drought where the irrigation is affected only in a minor way. The lawn watering and domestic customers are affected more with limited lawn watering throughout the entire utility. Issues such as POD locations for licences, pumping capacity across the system, water quality, and water available all influence the decision.

Scenario 2 – Lake Average – Upper Reservoirs Low

In this scenario, the mainstem lake is at average levels (Stage 1). The watershed storage is at very low levels for the time of year (Stage 3).

This is a situation where the domestic customers that are supplied by the mainstem lake would not necessarily be on water restrictions; however, the supply for the upper watershed customers would be stressed, which could affect the amount of supply available for all utility customers. This situation would be one of the most difficult to communicate to the customer base due to the difference in supply conditions for the various service areas of the utility. The drought plans are typically developed to allow water for agriculture well into the drought season. The decision of which drought stage to call would be based on source water levels, but also the capacity of the utility to pump from the lake to the higher elevation customers. The water supplier may decide to move to a higher drought stage for the entire utility or for specific service areas if there is limited pumping capacity and/or limited capacity to supply the entire utility from the lake.

A likely outcome for this scenario may be that the utility does not have the licensing or pumping capacity to supply sufficient additional water from the lake. The utility would, in accordance with their drought plan, call a higher-level drought with restrictions on all customers and limit the amount of available water to the agriculture customers.

For more intense drought conditions, tracking water demands from specific service areas or user types, as well as tracking reservoir levels, should be increased from monthly to weekly.

8.5 Summary

When working through these scenarios, the outcomes lead us to the following key points:

- Tracking daily water use is key for trending and forecasting water demand. Summarizing the data on a monthly time step as per Table 8.1 is appropriate for most water utilities. During a drought event, summarizing the data on a weekly basis may become necessary.
- Track water that flows past the reservoir gates and prepare a frequency analysis.
- There are other factors that utilities consider in determining how to best supply water to their customers, including source water quality. Although this is not written into many drought plans, it does have a direct bearing on the decisions made by the water staff and elected officials.
- Having both mainstem lake and creek sources adds a level of complexity to the decision-making for the calling of drought stages. Water utilities are wise to maximize the physical ability to use both sources. This would involve the development of internal pumping, piping and water treatment as necessary to match water demand volumes.
- Utilities with both creek and mainstem lake sources should consider revising their creek licences to have an alternate point of diversion (POD) for the creek licences at their lake intake. This provides capacity benefits to the utility and environmental flow need benefits to the lower creek sections downstream of the utility's water intake.
- As noted in the example scenarios, licence priority date is not considered during any of the earlier phases of drought measure implementation. For extreme droughts, licence priority dates may become a consideration.
- In the future, water utility operators and provincial staff should work together to determine the highest beneficial uses of the raw water. The volumes and timing of releases from upland reservoirs represent a significant flow benefit to creeks and the ecosystems they support. There is no additional cost to the Province or the utility in working together to conduct targeted water releases from upper watershed storage to benefit the downstream environment.

9 RECOMMENDED DROUGHT STAGE RESPONSES

Drought stage responses can include voluntary conservation, water restrictions, changes to operations, and communication and enforcement. Responses should be clearly outlined in the water purveyor's drought management plan.

9.1 Water Restrictions

All water purveyors on the mainstem system currently have water regulation bylaws that enable them to use water restrictions when needed; however, there is inconsistency across the valley on how the drought stages and associated restrictions are defined. Having a consistent definition for each 'Stage' would greatly improve clarity and support communication efforts during drought.

The definitions in Table 9.1 are recommended for regulating residential, commercial, and industrial water use. Restrictions may be different for agricultural customers. The drought stages and watering restrictions are based on what is currently used by several water utilities in the Okanagan Valley. The details of each restriction stage, including reduction goals, vary by utility.

It is important to note again that the local drought stages are independent of provincial drought levels (see Section 6.1), nor are they intended to do so. As demonstrated in 2015, it was not necessary for many Okanagan water utilities supported by storage to increase water restrictions beyond Stage 1 despite a provincial drought Level 4 declaration. The provincial drought levels are based on streamflow conditions, and while they provide guidance on the general water supply conditions within the region, they do not directly correlate to system operations, water restrictions, or reservoir management responses.

Table 9.1 Recommended drought stages and associated watering restrictions for regulating residential, commercial and industrial water use in the Okanagan.

Drought Stage	Description	Watering restrictions	Reduction Goal
Normal – Normal or Above Average Conditions	Represents normal, non-drought (i.e. average) conditions for local area. Water use restrictions focus on efficiencies and drought awareness. In place year-round during normal conditions.	3 days per week - Odd address number - Tues, Thurs, and Sat, Even address number - Wed, Fri, and Sun	On-going efficient water use practices
Stage 1 – Dry Conditions	Represents below normal conditions for local area or **mild** drought conditions. First indication of potential water shortage has been determined. Inform public of the potential for more severe drought to occur. Water use restrictions necessary to heighten awareness and encourage stewardship and voluntary conservation.	3 days per week: Odd address number - Tues, Thurs, and Sat; Even address number - Wed, Fri, and Sun	10% reduction in peak and total water use
Stage 2 – Very Dry Conditions	Represents low water supply conditions for local area or prolonged, **moderate** drought conditions. Water use restrictions necessary to sufficiently reduce water demand to allow for sustainable supply and to meet environmental requirements.	2 days per week: Odd address number – Tues and Sat; Even address number – Wed and Sun	20% reduction in peak and total water use
Stage 3 – Extremely Dry Conditions	Represents very low water supply conditions or **severe** drought conditions for local area. Water use restrictions necessary to maintain supplies during a period of critical water shortage.	1 day per week: Odd address number – Sat; Even address number – Sun	50% reduction in peak and total water use (depending on utility)
Stage 4 – Emergency Conditions	Strict water use restrictions are necessary to maintain critical supply. No spare water is available. Represents an emergency **loss of supply** during which water is spared for consumptive and sanitary purposes only. Emergency Response Plan invoked.	No outdoor water use	Maintain minimum water supply to sustain community health (90% reduction)

9.2 Communication and Enforcement

The declaration of a drought stage may have consequences such as personal hardship, economic losses to the agricultural and industrial-commercial-institutional communities, damage to infrastructure such as parks, and lost revenue to the water purveyor. In addition to having informed, defensible triggers, a purveyor should have a well-structured and clearly defined strategy to guide internal and public communications and enforcement.

An example drought management communications plan is included in Appendix 6. It is recommended that all purveyors withdrawing from the mainstem system use this example to inform their own communications plans. To help encourage consistency in messaging about the mainstem drought stage triggers, a 'key messages' information sheet is provided in Appendix 7.

10 SUMMARY AND NEXT STEPS

Water suppliers that withdraw from Okanagan mainstem lakes and the Okanagan River do not control the level of their "reservoirs," which makes it difficult for them to develop a drought response plan with rational and easy-to-quantify drought stage triggers. An absence of informed, defensible drought triggers can make the decision to enact water restrictions more difficult for staff and elected boards and councils, potentially slowing the response to a water shortage and lead to confusion among the public.

To address this gap, the OBWB convened a technical team of lake management, hydrology, water supply, and fisheries experts to develop drought stage triggers for water suppliers who withdraw from Okanagan mainstem lakes and the Okanagan River. The triggers can be incorporated into drought plans so that mainstem water suppliers will have a consistent, rational process for drought response – similar to the water use plans and reservoir management plans in place for purveyors with reservoir storage. Ideally, using these guidelines, water managers with mainstem intakes would move through water restriction stages in a coordinated way.

Given the importance of water stored in the Okanagan mainstem lakes to the water available for withdrawals from the mainstem lakes and river, particularly during the high demand summer and fall months, the triggers recommended in this report are based on lake levels during the critical period of July through October. The recent 30-year standard period 1986-2015 was used to develop the triggers. Various percentile elevations (and combinations of percentiles), as well the Province's operational target elevations for Okanagan Lake, were considered as potential triggers. The ability to link the triggers to the Province's lake management practices, frequency with which the different drought stages might be declared, ease of application and understanding of triggers, and acceptability of drought stage triggers to key users were considered when developing the mainstem drought stage triggers. After considering these factors, the results of statistical analyses, and input from Okanagan water suppliers, the **Province's operational target elevations, and the 20th, 10th and 5th percentile 1st of the month lake elevations** are used for the mainstem drought stage triggers. The chosen percentiles are approximately equivalent to drought events with 1 in 5, 1 in 10, and 1 in 20-year return periods. Two trigger graphs were developed– one for Okanagan Lake, downstream mainstem lakes (Skaha, Vaseux, and Osoyoos) and the Okanagan River, and one for Kalamalka/Wood Lake.

Five stages are recommended:

Non-drought Stage – Water suppliers would remain at their Normal stage (or a Non-drought stage if they do not have a Normal stage in their bylaw) when the forecast or actual 1st of month lake elevation is equal to or greater than the 1st of month target elevation.

Stage 1 (green)– The forecast or actual 1st of month lake elevation for each of the months July through November is lower than the 1st of month target elevations and equal to or greater than the 20th percentile 1st of month elevation.

Stage 2 (yellow) **–** The forecast or actual 1st of month lake elevation for each of the months July through November is lower than the 20th percentile 1st of month elevation and greater than or equal to the 10th percentile 1st of month elevation.

Stage 3 (orange) – The forecast or actual 1st of month lake elevation for each of the months July through November is lower than the 10th percentile 1st of month elevation and greater than or equal to the 5th percentile 1st of month elevation.

Stage 4 (red) – The forecast or actual 1st of month lake elevation for each of the months July through November is lower than the 5th percentile 1st of month elevation.

The trigger graphs provided in this report must be considered in conjunction with other factors (e.g. lake level and weather forecasts) before moving between drought stages. The Province should also be consulted throughout the process so water suppliers are aware of upcoming lake management decisions.

The local **drought stages** recommended in this report are independent of provincial **drought levels.** Drought level declarations by the Province are based on moisture conditions (e.g. snow pack), weather forecasts, and stream flows over a wide region. Local drought stages may consider moisture, weather, and stream flow indicators, but also closely examine reservoir levels, infrastructure capacity, and customer demand forecasts when determining drought stages. But, it is important for local water suppliers to be knowledgeable about the provincial drought levels because they indicate the general hydrological condition of the region.

Guidance on water restrictions and other drought responses is also provided in this report with the intended goal of achieving better alignment. There are considerable differences across the valley in the number of stages included in drought plans, watering restriction definitions for each stage, and goals for water use reduction. Having more consistency would greatly improve clarity and support communication efforts during drought.

The OBWB is committed to helping Okanagan water suppliers operationalize the mainstem drought stage triggers outlined in this report. We can assist with the integration of the triggers into local drought plans and we will coordinate the piloting, evaluation and refinement of the triggers until they are truly suitable for their intended purpose. The OBWB will also provide information on current and forecasted lake levels and provincial water management decisions to local water suppliers and can make recommendations on drought stages based on the guidelines outlined in this report.

Appendix 1: COMPARISON OF PERCENTILES FOR OKANAGAN LAKE MONTHLY NET INFLOWS
(Entire Period of Record (1921-2016) vs. Various 30-Year Periods)

Surface Area of Okanagan Lake: 340.78 sq. km.

Net Inflow Units: 1. Volume in $kdam^3$ 2. Equivalent Depth on Lake in cm

TIME PERIOD:	JUL -	OCT	AUG -	OCT	SEP -	OCT		OCT
NET INFLOWS:	Vol.	Depth	Vol.	Depth	Vol.	Depth	Vol.	Depth
<u>Entire Period of Record:</u>	(1921-2016)							
Median	-16.57	-4.86	-28.36	-8.32	-13.34	-3.91	-0.90	-0.26
35th Percentile	-37.71	-11.07	-40.75	-11.96	-23.28	-6.83	-6.30	-1.85
30th Percentile	-45.73	-13.42	-44.49	-13.05	-25.14	-7.38	-7.93	-2.33
25th Percentile	-50.74	-14.89	-46.21	-13.56	-27.90	-8.19	-9.84	-2.89
20th Percentile	-57.64	-16.91	-52.94	-15.53	-30.97	-9.09	-11.76	-3.45
15th Percentile	-68.08	-19.98	-61.51	-18.05	-33.12	-9.72	-13.06	-3.83
10th Percentile	-77.96	-22.88	-63.12	-18.52	-36.50	-10.71	-15.55	-4.56
5th Percentile	-86.46	-25.37	-75.45	-22.14	-41.18	-12.09	-20.35	-5.97
Minimum	-108.72	-31.90	-78.48	-23.03	-54.12	-15.88	-29.85	-8.76
<u>1961-1990:</u>								
Median	-4.20	-1.23	-22.72	-6.67	-7.56	-2.22	-0.82	-0.24
35th Percentile	-29.05	-8.52	-32.56	-9.55	-18.65	-5.47	-7.13	-2.09
30th Percentile	-37.15	-10.90	-38.68	-11.35	-22.65	-6.65	-9.71	-2.85
25th Percentile	-40.03	-11.75	-44.17	-12.96	-26.62	-7.81	-10.86	-3.19
20th Percentile	-63.49	-18.63	-59.27	-17.39	-31.75	-9.32	-12.08	-3.54
15th Percentile	-71.58	-21.00	-62.50	-18.34	-32.79	-9.62	-13.06	-3.83
10th Percentile	-85.36	-25.05	-67.62	-19.84	-34.62	-10.16	-13.31	-3.90
5th Percentile	-92.95	-27.28	-76.25	-22.38	-44.36	-13.02	-21.90	-6.43
Minimum	-99.07	-29.07	-77.45	-22.73	-54.12	-15.88	-29.85	-8.76

1971-2000:

Median	-7.59	-2.23	-18.84	-5.53	-7.56	-2.22	-0.71	-0.21
35th Percentile	-36.05	-10.58	-32.51	-9.54	-16.41	-4.82	-6.18	-1.81
30th Percentile	-46.65	-13.69	-36.61	-10.74	-24.67	-7.24	-6.64	-1.95
25th Percentile	-55.26	-16.22	-42.52	-12.48	-27.26	-8.00	-8.09	-2.37
20th Percentile	-58.36	-17.13	-50.69	-14.87	-30.01	-8.81	-11.08	-3.25
15th Percentile	-66.74	-19.58	-61.94	-18.17	-31.64	-9.28	-13.06	-3.83
10th Percentile	-69.01	-20.25	-63.49	-18.63	-32.65	-9.58	-13.31	-3.90
5th Percentile	-96.33	-28.27	-76.72	-22.51	-44.58	-13.08	-25.51	-7.48
Minimum	-108.71	-31.90	-78.48	-23.03	-54.12	-15.88	-29.85	-8.76

1981-2010:

Median	-7.59	-2.23	-23.47	-6.89	-11.39	-3.34	-0.33	-0.10
35th Percentile	-36.05	-10.58	-40.19	-11.79	-27.23	-7.99	-6.24	-1.83
30th Percentile	-46.65	-13.69	-41.72	-12.24	-28.58	-8.39	-7.42	-2.18
25th Percentile	-55.26	-16.22	-45.62	-13.39	-29.75	-8.73	-8.94	-2.62
20th Percentile	-58.36	-17.13	-58.88	-17.28	-31.15	-9.14	-12.39	-3.64
15th Percentile	-66.74	-19.58	-62.09	-18.22	-35.04	-10.28	-14.53	-4.26
10th Percentile	-69.01	-20.25	-73.17	-21.47	-36.64	-10.75	-19.97	-5.86
5th Percentile	-96.33	-28.27	-76.72	-22.51	-47.12	-13.83	-25.51	-7.48
Minimum	-108.71	-31.90	-78.48	-23.03	-54.12	-15.88	-29.85	-8.76

1986-2015:

Median	-7.59	-2.23	-36.43	-10.69	-14.59	-4.28	-0.46	-0.13
35th Percentile	-39.01	-11.45	-42.17	-12.37	-27.23	-7.99	-6.24	-1.83
30th Percentile	-53.88	-15.81	-44.47	-13.05	-28.58	-8.39	-7.42	-2.18
25th Percentile	-56.37	-16.54	-46.03	-13.51	-29.75	-8.73	-8.94	-2.62
20th Percentile	-65.06	-19.09	-58.88	-17.28	-31.15	-9.14	-12.39	-3.64
15th Percentile	-67.83	-19.91	-62.09	-18.22	-35.04	-10.28	-14.53	-4.26
10th Percentile	-75.72	-22.22	-73.17	-21.47	-36.64	-10.75	-19.97	-5.86
5th Percentile	-96.33	-28.27	-76.72	-22.51	-47.12	-13.83	-25.51	-7.48
Minimum	-108.71	-31.90	-78.48	-23.03	-54.12	-15.88	-29.85	-8.76

Appendix 2: OKANAGAN LAKE WATER LEVELS ON THE 1st OF EACH MONTH [1.]
(for the 30-Year Period 1986-2015)

YEAR	JUL	AUG	SEP	OCT	NOV
1986	342.394	342.272	341.949	341.859	341.815
1987	342.260	342.131	341.987	341.811	341.647
1988	342.069	341.997	341.855	341.752	341.722
1989	342.427	342.215	342.107	341.938	341.799
1990	342.843	342.517	342.074	341.880	341.757
1991	342.408	342.244	342.006	341.863	341.712
1992	341.928	341.894	341.706	341.559	341.453
1993	342.398	342.457	342.127	341.950	341.891
1994	342.407	342.214	342.048	341.876	341.760
1995	342.346	342.217	342.058	341.883	341.803
1996	342.583	342.337	342.020	341.961	341.948
1997	342.827	342.683	342.200	341.914	341.901
1998	342.407	342.221	341.991	341.821	341.743
1999	342.399	342.224	341.953	341.806	341.739
2000	342.378	342.215	342.010	341.851	341.767
2001	342.206	342.117	341.973	341.807	341.711
2002	342.415	342.243	342.027	341.818	341.661
2003	342.043	341.838	341.620	341.452	341.382
2004	342.232	342.092	341.987	341.869	341.796
2005	342.484	342.203	341.966	341.809	341.760
2006	342.387	342.180	341.965	341.798	341.683
2007	342.226	342.165	341.973	341.795	341.735
2008	342.443	342.269	342.104	341.866	341.731
2009	342.024	341.921	341.796	341.645	341.567
2010	342.428	342.274	342.037	341.939	341.833
2011	342.552	342.203	341.984	341.831	341.751
2012	342.628	342.319	342.024	341.860	341.786
2013	342.565	342.195	342.018	341.899	341.817
2014	342.376	342.273	342.044	341.949	341.856
2015	342.242	342.046	341.870	341.744	341.681

Data Source:

1. Elevation records from WSC Station 08NM083 – “Okanagan Lake at Kelowna,” Geodetic datum 340.236 m.

Appendix 3: OKANAGAN LAKE TARGET AND PERCENTILE ELEVATIONS ON THE 1ST OF EACH MONTH (for the 30-Year Period 1986-2015)

	JUL	AUG	SEP	OCT	NOV
Target	342.44	342.24	342.04	341.89	341.84
Median	342.399	342.215	341.999	341.855	341.754
40th	342.382	342.203	341.985	341.819	341.737
35th	342.372	342.193	341.973	341.811	341.730
30th	342.286	342.170	341.968	341.808	341.715
25th	342.240	342.128	341.962	341.804	341.704
20th	342.227	342.097	341.950	341.796	341.681
15th	342.158	342.029	341.865	341.749	341.656
10th	342.046	341.929	341.802	341.655	341.575
5th	341.981	341.869	341.667	341.511	341.421
Minimum	341.928	341.838	341.620	341.452	341.382

Appendix 4: KALAMALKA LAKE ELEVATIONS ON THE 1st OF EACH MONTH [1]
(for the 30-Year Period 1986-2015)

YEAR	JUL	AUG	SEP	OCT	NOV
1986	391.695	391.665	391.568	391.514	391.448
1987	391.597	391.513	391.435	391.359	391.298
1988	391.523	391.458	391.373	391.344	391.335
1989	391.623	391.592	391.539	391.525	391.477
1990	391.951	391.667	391.48	391.417	391.367
1991	391.673	391.576	391.521	391.45	391.375
1992	391.436	391.382	391.249	391.164	391.13
1993	391.685	391.722	391.587	391.402	391.392
1994	391.711	391.614	391.533	391.386	391.331
1995	391.627	391.545	391.541	391.377	391.338
1996	392.102	391.708	391.476	391.467	391.465
1997	391.979	391.987	391.732	391.578	391.445
1998	391.674	391.568	391.406	391.326	391.303
1999	391.662	391.577	391.478	391.415	391.317
2000	391.642	391.64	391.535	391.522	391.382
2001	391.686	391.637	391.562	391.48	391.449
2002	391.67	391.544	391.469	391.373	391.313
2003	391.486	391.336	391.17	391.086	391.049
2004	391.332	391.221	391.157	391.12	391.102
2005	391.65	391.594	391.476	391.397	391.415
2006	391.723	391.615	391.488	391.413	391.357
2007	391.552	391.498	391.361	391.283	391.275
2008	391.73	391.607	391.531	391.453	391.412
2009	391.577	391.499	391.411	391.318	391.315
2010	391.585	391.526	391.404	391.355	391.293
2011	391.683	391.638	391.533	391.436	391.411
2012	391.978	391.752	391.514	391.429	391.383
2013	391.83	391.628	391.53	391.462	391.375
2014	391.788	391.627	391.514	391.451	391.41
2015	391.583	391.438	391.298	391.223	391.217

Notes:

1. Elevation records from WSC Station 08NM143 – "Kalamalka Lake at Vernon", Geodetic datum 386.122 m.

Appendix 5: KALAMALKA LAKE TARGET AND PERCENTILE ELEVATIONS ON THE 1ST OF EACH MONTH (for the 30-Year Period 1986-2015)

	JUL	AUG	SEP	OCT	NOV
Target	391.70	391.60	391.50	391.40	391.35
Median	391.672	391.593	391.484	391.408	391.362
40th	391.645	391.571	391.476	391.381	391.333
35th	391.626	391.545	391.464	391.371	391.317
30th	391.605	391.531	391.418	391.356	391.314
25th	391.585	391.510	391.406	391.340	391.302
20th	391.578	391.498	391.379	391.320	391.294
15th	391.542	391.451	391.339	391.262	391.255
10th	391.490	391.388	391.254	391.170	391.139
5th	391.389	391.284	391.164	391.105	391.078
Minimum	391.332	391.221	391.157	391.086	391.049

APPENDIX 6: EXAMPLE DROUGHT COMMUNICATIONS PLAN

Thank you to Regional District of North Okanagan – Greater Vernon Water for sharing this communications plan.

	NORMAL	STAGE 1	STAGE 2	STAGE 3	STAGE 4
Explanation of Supply Status:	Average water storage Available. Ongoing water conservation education and practicing efficient water use. Strive to maintain, not exceed, average summer usage.		Represents low water supply conditions for local area. Water use restrictions are necessary to sufficiently reduce water demand. Intended to reduce water use by roughly 20%. If triggered by drought, represents moderate drought conditions.	Represents very low water supply conditions. Water use restrictions are necessary to maintain supplies during a period of critical water shortage. Intended to reduce water use by roughly 50%. If triggered by drought, represents severe drought conditions for local area.	Strict water use restrictions are necessary to maintain critical supply. Intended to reduce water use by 90%. Represents an emergency loss of supply during which water is spared for consumptive and sanitary purposes only.
Goal:	Promote demand management initiatives to support long term water efficiency.		20% reduction in total and peak flow. Implement short term strategies to ensure existing supplies last and do not further decrease to an unsustainable level.	50% reduction in total and peak flows to maintain critical supply levels. Implement short term strategies to ensure existing supplies last and do not further decrease to an unsustainable level.	90% reduction in total and peak flows to maintain critical supply levels. Maintain minimum water supplies needed to support basic community health and sanitation.
Public Messaging and Communication: What is our Message?	Customers should strive to be efficient water users.	Avoid worse restrictions by taking steps now to be more efficient water users.	Communicate likelihood/risk of needing to increase to a higher stage. Avoid worse restrictions by taking steps now to be more efficient water users. Set goals such as: "Reduce consumption by 20%" or "Today's Water Use Goal: 95 ML / Yesterday's Water Use: 104 ML"	Communicate likelihood/risk of needing to increase to a higher stage. Avoid worse restrictions by taking steps now to be more efficient water users. Set goals such as: "Reduce consumption by 50%" or "Today's Water Use Goal: 80 ML / Yesterday's Water Use: 84 ML"	Community Emergency - work with PEP (if deemed appropriate) to coordinate and ensure customers are aware of emergency supply options to ensure basic/hygiene needs met.

	Make Water Work - OBWB Campaign, e.g. lawns usually only need an inch per week of water.	Ensure strategies do not create undue economic hardship. Efforts made now to change behavior may even save money in long term.	Short term hardship now will help us get through in the long term.	Recognition that restrictions may cause some hardship and that certain water uses have to be prioritized for the good of the community. Efforts made now will save water in long term.	The utility recognizes hardship and appreciates the community's efforts.
Public Messaging and Communication: What is our Message?		Increase awareness of what is causing supply situation - drought, infrastructure issues, etc.	Increase awareness of what is causing supply situation - drought, infrastructure issues, etc.	Increase awareness of what is causing supply situation - drought, infrastructure issues, etc.	
		Communicate likelihood/risk of needing to increase to a higher stage.	The utility recognizes hardship and appreciates the community's efforts.	The utility recognizes hardship and appreciates the community's efforts.	
Water Utility Actions:	Communicate Normal year-round restrictions online and at public events, but focus message on how people should use water, not why they can't use water.	Implement Stage 1 Water Use Restrictions and communicate change in stages in local media & online, as well as jurisdictional partners.	Implement Stage 2 Water Use Restrictions and communicate change in stages in local media & online, as well as jurisdictional partners, major water users, and sensitive customers (i.e. Hospital).	Implement Stage 3 Water Use Restrictions and communicate change in stages in local media & online, as well as jurisdictional partners, major water users, and sensitive customers (i.e. Hospital).	Implement Stage 4 Water Use Restrictions and communicate change in stages in local media & online, as well as jurisdictional partners, major water users, and sensitive customers (i.e. Hospital).
	Publish educational materials targeted to high water use activities via media, public events, online.	Analyze water use (meter data) to determine possible high water users. Publish educational materials targeted to high water use activities via media, public events, online.	Increase frequency of media Public Service Announcements (PSAs). Directly contact high water use customers and ask for support in curbing consumption.	Increase frequency of media Public Service Announcements (PSAs). Directly contact high water use customers and ask for support in curbing consumption.	Increase frequency of media Public Service Announcements (PSAs). Directly contact high water use customers and ask for support in curbing consumption.
	Research Best Management Practices (BMP) for water efficiency as per	Meet with municipal partners to ensure municipal staff are	Target efforts at high (inefficient) water users within major water use	Target efforts at major water users (use largest % of supply) and communicate	Advertise to public options for short-term supplemental supply sources to

	DMP recommendations.	implementing restrictions in public facilities and investigate concerns.	sectors, based on metered use data analysis.	priorities for supply use.	meet basic needs.
Water Utility Actions:	Seek out opportunities to promote water efficiency through public events, speaking engagements, children's activities.	Seek out opportunities to promote water efficiency through public events, speaking engagements, children's activities.	Contact high water users via letter and inform them of current restriction status, required actions under bylaw	Investigate alternative water sources for short term supply supplementation	Meet with Sensitive customers with critical water needs (e.g. hospital) and assess supply options.
	If available, summer student will aid in restriction complaint response, otherwise will be part of regular staff duties.	Increase enforcement activities - increase time allotted to summer student monitoring and complaint response.	Increase enforcement effort - hire second student	Meet with municipal partners to ensure municipal staff are implementing restrictions in public facilities and investigate concerns. Do so with other public institutions - School District, Interior Health, etc. Encourage those agencies to put out media releases/communications materials to note their actions.	Meet with municipal partners to ensure municipal staff are implementing restrictions in public facilities and investigate concerns. Do so with other public institutions - School District, Interior Health, etc. Encourage those agencies to put out media releases/communications materials to note their actions.
		Focus residential/commercial education efforts on minimizing outdoor water use so to avoid higher stages.	Meet with municipal partners to ensure municipal staff are implementing restrictions in public facilities and investigate concerns. Do so with other public institutions - School District, Interior Health, etc. Encourage those agencies to put out media releases and/or signs to note their actions (e.g. Metro Van water	Increase enforcement effort - seek assistance from municipal bylaw staff.	Increase enforcement effort - seek assistance from municipal bylaw staff.

			wise park/ pool/splash pad signs informing customers as to why water turned off).		
Water Utility Actions:		Monitor supply status and demand levels, as per Section 5.3.1 of DMP, to determine if necessary to move to Stage 2	Monitor supply status and demand levels, as per Section 5.3.1 of DMP, to determine if necessary to move to Stage 3	Monitor supply status and demand levels, as per Section 5.3.1 of DMP, to determine if necessary to move to Stage 4	Implement signage as listed under Stage 2 with updated Stage information
			Investigate posting "Water Supply Shortage Graphic" (rainbow reservoir) in public locations. This may include, but not be limited to, billboard signs, sandwich board/A-Frame signs (utilizing frames held by municipalities for this purpose), digital information signs at arenas or on highways.	Implement signage as listed under Stage 2 with updated Stage information	

Appendix 7: GUIDELINES FOR COMMUNICATING ABOUT THE MAINSTEM DROUGHT STAGE TRIGGERS

What is a drought trigger?

A drought trigger is a specific value of a drought indicator that activates a management response. A drought indicator is a single observation or combination of observations that contribute to identifying the onset and/or continuation of a drought. Examples of drought indicators are basin snow indices, moisture conditions, weather forecasts, and reservoir levels. An example of a drought trigger could be a reservoir decreasing below 50% of its storage capacity.

What are the Okanagan mainstem drought stage triggers?

The mainstem drought stage triggers use elevations of Okanagan Lake and Kalamalka Lake between July and November to indicate potential water shortages. The province's operational target elevations and the 20^{th}, 10^{th} and 5^{th} percentile elevations (which are approximately equivalent to drought events with 1 in 5, 1 in 10, and 1 in 20-year return periods) are used for the drought stage triggers.

Who developed the Okanagan mainstem drought stage triggers?

The Okanagan mainstem drought stage triggers were developed by a team of lake management, hydrology, water supply, and fisheries experts led by the Okanagan Basin Water Board. Okanagan water suppliers also provided considerable input.

Why do we need common drought triggers for the mainstem lakes and Okanagan River?

In the Okanagan, purveyors with their own reservoirs and storage licences have plans that trigger water restriction stages based on set indicators. Water suppliers with intakes on mainstem lakes and Okanagan River have a different situation. They do not control the level of their "reservoirs" – the Province of BC does. These water suppliers also share the mainstem lake reservoirs with many other water users – both extractive and non-extractive. Given these factors, it is important that water suppliers with intakes on the mainstem lakes have consistent drought stage triggers in their drought plans that relate to the provincial management of the lakes.

The declaration of a drought stage may have consequences such as personal hardship, economic losses to agriculture and businesses, damage to infrastructure such as parks and sports fields, and lost revenue to the water purveyor. Having informed, defensible triggers helps staff and elected boards and councils decide when to move their customers to higher watering restriction stages. An absence of drought triggers can slow the response to a water shortage and lead to confusion among the public.

Okanagan Lake has the largest water storage capacity in the region and although the impact of any one utility moving to a higher drought stage may be small, the longer a drought lasts the more that every withdrawal matters. There are also public communication benefits to having a consistent, valley-wide approach to drought response.

How does the Province decide on lake elevations?

The Province regulates the Okanagan mainstem lakes in accordance with the target releases and flows recommended in the Okanagan Basin Agreement (OBA) of 1974. Since the recommendations were first released, additional information and experience gained by the operators and others has provided a better understanding of limitations and opportunities to improve the water management of the mainstem lakes. This has led to further refinements to the operational guidelines for the various mainstem regulatory works, while still respecting the recommendations contained in the OBA.

The recommendations and the subsequent improved operational knowledge and experience have been incorporated into the Okanagan Fish/Water Management Tool (FWMT), which is currently used by water managers and others to inform in-season management decisions. The FWMT uses real-time information about spawning patterns, water temperature, lake levels, and weather conditions to help water and fisheries managers in making the optimum water release decisions to balance all water management priorities.

The Province considers four key objectives when regulating lake levels and releases:

1. minimizing flooding damage around the lakes and along the Okanagan River;
2. satisfying domestic and irrigation water supply demands;
3. protecting fisheries and other ecosystem values, especially Okanagan Lake shore-spawning kokanee eggs and alevin, Okanagan River sockeye eggs and alevin, and rearing sockeye fry in Osoyoos Lake; and
4. supporting recreation, navigation and tourism (maintaining acceptable water levels for boat docks and ramps and for river float tourist businesses).

<u>In water-short years, meeting objectives 2, 3 and 4 becomes very difficult</u>. Factors such as fish mortality, shoreline habitat loss, exacerbation of blue green algae by exposed soils and higher water temperatures, exposed water intakes, navigation hazards, and loss of recreational access must be considered and tough decisions made.