Report

International Joint Commission

Climate Change and its Implications for Managing Water Levels in Osoyoos Lake: Summary Report

Project: 2011-8009.000

April 2011

1 Background

Osoyoos Lake lies partly in Canada (British Columbia) and partly in the United States of America (Washington State). Water levels on the lake are managed according to Orders of Approval issued by the International Joint Commission (IJC). The Orders specify the range within which the lake level should be maintained. The specified lake level ranges are different between summer and winter, and the summer range depends on the amount of spring runoff that is expected that year.

The Orders of Approval are due to expire in 2013. They will be revised if necessary and then renewed at that time. In advance of the renewal date, the IJC is considering issues that relate to the management of the lake, and whether the current Orders should be changed in 2013. Climate change is one of the factors that could affect lake level management. A changing climate could change the amounts or timing of river inflows to the lake, and could change the amount of water withdrawn from the lake for irrigation and other uses. This study was completed to provide information to the IJC on how future climate change might affect the ability to manage the lake according to the current Orders. The study also provides advice to the IJC on how the Orders could be modified before their renewal in 2013 to accommodate the potential for climate change.

The Okanagan River flows into Osoyoos Lake at the north end of the lake (in B.C.) and is the largest source of input to the lake. The outlet of Osoyoos Lake is located at the south end of the lake (in Washington State); and the river flowing out of the lake is referred to as the Okanogan River. Zosel Dam, which regulates the lake levels, is located on the Okanogan River approximately 2.5 km downstream from the outlet of the lake. The Similkameen River flows into the Okanogan River downstream of the dam, so normally it doesn't affect Osoyoos Lake. However, when the Similkameen River is high, it can raise the level of the Okanogan River near the confluence of the two rivers, and this reduces the rate of outflow from Osoyoos Lake. In extreme high water, the Similkameen River can cause the Okanogan River to flow backwards up over the dam and into Osoyoos Lake (although this hasn't occurred since 1976).

The Osoyoos Lake operating ranges are presented graphically in Figure 1-1. For the summer operating range, it is necessary to identify whether "drought" or "non-drought" conditions are expected before the operational range of Osoyoos Lake water levels is specified. On Figure 1-1 the term "normal" rather than "non-drought" is used. However, in this report we use the term "non-drought" instead, because the non-drought conditions include both average and wet years. The identification of drought or non-drought conditions is based on three separate criteria outlined by the Orders. These criteria are based on:

- Forecast Similkameen River flow for April 1 to July 31 [drought is indicated if the total flow is expected to be, or is measured to be, less than 1.0 million acre-feet (1.2 million dam^3) in this period];
- Forecast inflow into Okanagan Lake for April 1 to July 31 [drought is indicated if inflow is expected to be, or is measured to be, less than 195,000 acre-feet (240,000 dam^3) in this period]; and

- Forecast maximum Okanagan Lake level in June and July [drought is indicated if the lake fails to rise to, or is not expected to rise to, 1122.8 feet (342.2 m) elevation in June or July].

Beginning April 1st, the International Osoyoos Lake Board of Control (IOLBC), which is a body created by the IJC to oversee the management of Osoyoos Lake, reviews each forecast. If any of the three forecasts falls below the criteria outlined in the Orders, a drought is declared, and the lake is maintained within the drought operating range.

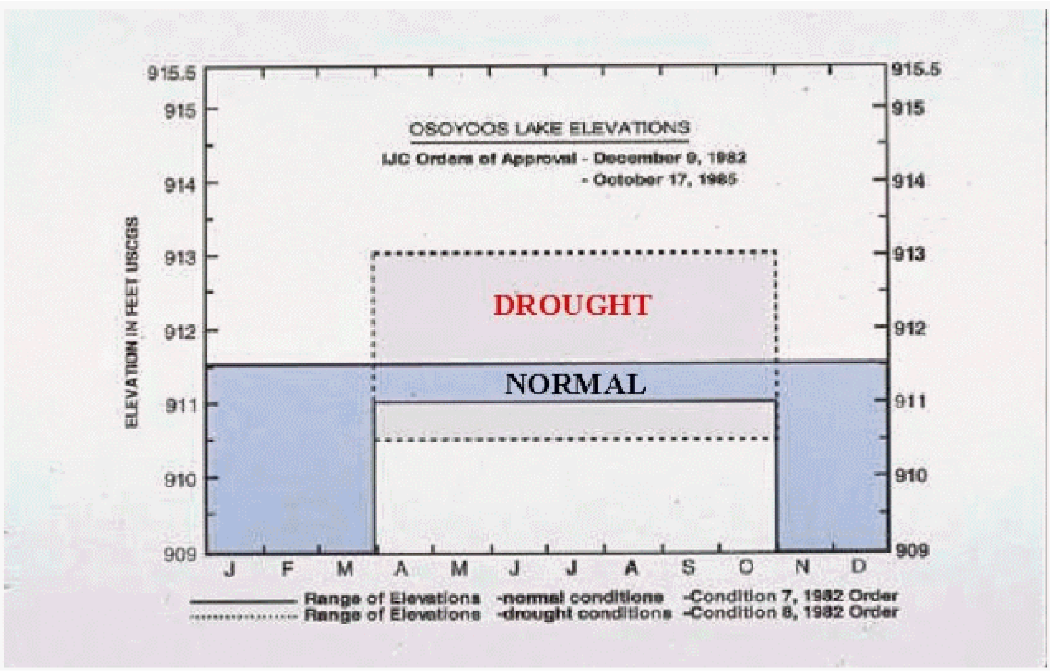

Figure 1-1
Osoyoos Lake operating ranges according to the IJC's Orders of Approval

2 How Climate and Hydrology are Expected to Change

2.1 SUMMARY OF CLIMATE CHANGE RESEARCH

A great deal of research has been conducted on historical changes in climate and hydrology in the Pacific Northwest, as well as on likely future changes in climate and hydrology. Climate scientists in both the U.S. and Canada were contacted and asked to provide relevant research results. Current research initiatives relevant to Osoyoos Lake are summarized in Table 2-1.

Table 2-1
Current Climate Research Initiatives in the Okanagan and Similkameen River Basins

Name	Current Research Initiatives
Cannon, Alex	Okanagan Water Supply and Demand Project Phase 3 climate scenarios: collaborating with Denise Neilsen from Agriculture and Agri-Foods Canada to develop improved climate datasets for the Okanagan Basin, and running additional climate-driven scenarios for the Okanagan. Also developing new climate datasets for the Similkameen River watershed
Hamlet, Alan	The Climate Impacts Group at the University of Washington has recently completed a comprehensive modelling study of the hydrologic impacts of climate change in the Columbia watershed.
Neilsen, Denise	Working with Ted van der Gulik of the B.C. Ministry of Agriculture to provide information on current and future irrigation demands in the Similkameen River watershed.
Pacific Climate Impacts Consortium (PCIC)	PCIC is continuing development of the Plan2Adapt Tool – an excellent tool for deriving climate projections and related hydrological implications. The tool generates maps, plots and data describing projected future climate conditions for British Columbia.
Schnorbus, Markus	PCIC currently has a hydrology model set up for the Okanagan and Similkameen watersheds (including historical and future climate data), and plan to complete additional hydrologic projection work sometime this year.

Based on research from the Pacific Climate Impacts Consortium (PCIC) at the University of Victoria and the University of Washington in Seattle, the following general trends in climate are expected. In future, air temperatures are expected to increase. Winter precipitation is expected to increase and summer precipitation is expected to decrease, with an overall increase in annual precipitation. More winter precipitation will occur as rain at lower elevations, so low and middle elevation snowpacks are expected to decrease. Summer lake evaporation will likely increase. More specific climate predictions for the South

Okanagan – Similkameen region, developed by PCIC, are provided in Table 2-2. These values are derived from 15 Global Climate Models, using two global CO_2 emission scenarios.

Table 2-2
Climate Change for the South Okanagan-Similkameen Region

Climate Variable	Time of Year	Projected Change (from 1961-90 baseline)					
		2020s		2050s		2080s	
		Median	Range	Median	Range	Median	Range
Mean Temp. (ºC)	Annual	+1.1ºC	+0.6ºC to +1.4ºC	+1.9ºC	+1.2ºC to +2.7ºC	+3.0ºC	+1.7ºC to +4.4ºC
Precip.	Annual Summer Winter	+4% -9% +2%	-1% to +7% -15% to +10% -3% to +10%	+6% -14% +6%	-2% to +10% -31% to 0% -2% to +15%	+8% -16% +10%	+1% to +17% -38% to -4% +3% to +24%
Snow Depth	Winter Spring	-6% -33%	-16% to 0% -58% to -4%	-14% -57%	-25% to -3% -73% to -20%	-22% -78%	-41% to -9% -88% to -24%
GDD	Annual	+175	+89 to +275	+379	+217 to +547	+571	+380 to +972
HDD	Annual	-379	-521 to -234	-680	-961 to -422	-1056	-1560 to -609
FFD	Annual	+15	+8 to +20	+26	+14 to +37	+39	+23 to +62

Notes:
GDD: Growing Degree Days
HDD: Heating Degree Days
FFD: Frost-Free Days

Although there is a wide range in predictions, depending on which climate model is used, there is general agreement that the hydrologic changes resulting from these climate changes are likely to be as follows:

- Earlier start to the spring runoff
- Lower runoff in spring and late summer/fall
- Higher runoff in winter (with increased precipitation, and greater proportion as rain)
- Slight increase in annual runoff, and
- Small changes in daily peak flows.

Water demands for irrigation and other uses are expected to increase. Combining this with an expected lengthening of the growing season will further stress the available water supply, which is likely to be more and more scarce at critical times, for example in the late summer and early fall. In addition, droughts are expected to occur with increasing frequency.

The predicted hydrologic changes for the Okanagan River at Oliver (this is the main inflow to Osoyoos Lake), based on research conducted at the University of Washington, are summarized in Figure 2-1. These figures show the projected changes in streamflow in the 2020s, 2040s, and 2080s compared with current conditions. The range of results shown reflects the output of 10 GCMs.

Finally, the models developed during Phase 2 of the Okanagan Water Supply and Demand Project produced predictions of weekly inflow to Osoyoos Lake via the Okanagan River for the calibration period 1996-2006 and for each of 15 future scenarios. These models agree with the hydrologic predictions generated by PCIC and the University of Washington. In addition, these models were used to estimate future water withdrawals from Osoyoos Lake for irrigation and other uses. For the year as a whole, the extractions from the lake by the mid-2020s and mid-2050s are expected to increase by 11.3% and 21.6% respectively.

While there is significant convergence in the research predictions for both climate and hydrology, the study highlighted areas where improvements could be made to increase accuracy and narrow the range of the future predictions. These include improvements in the global climate models used to make predictions and in the methods used to scale the outputs down to the local scale of relevance for the Okanagan and Similkameen River basins. Suggestions also include improvements to the models developed by the Okanagan Basin Water Board (OBWB) in its Phase 2 study, and continuing work to improve estimates and future predictions of water demands and lake evaporation.

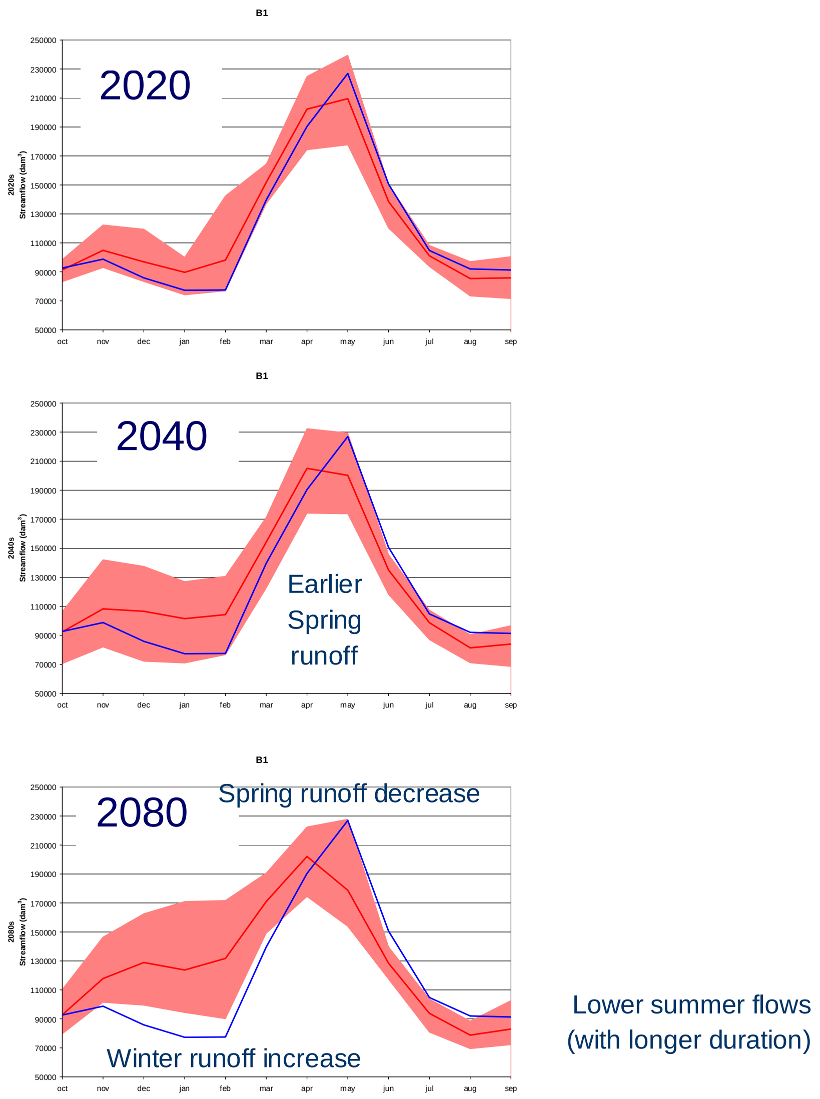

Figure 2-1
Okanagan River at Oliver: future projections and baseline conditions

Notes:

- Blue = historical; Red band = range of projections of 10 GCMs; Red line = average of projections of 10 GCMs

3 How will Climate Change affect the Management of Osoyoos Lake

Future management of Osoyoos Lake levels will likely have to contend with a suite of gradually changing conditions, including:

- Earlier spring runoff, which may necessitate changes to decision dates (e.g. when drought/non-drought conditions are declared) and the dates at the beginning and end of the summer and winter operating ranges.
- Reduced snowpack and lower April – July runoff, which could increase the frequency with which droughts are declared, and may affect the total water supply in summer.
- Increased winter precipitation and warmer temperatures, which may cause more rain and less snow resulting in increased winter runoff. This additional water may help mitigate the lower spring runoff, but only if storage is available and utilized. If winter runoff were stored, summer lake levels could possibly be reached earlier.
- Smaller and earlier peak flows in the Similkameen River, which will advance the timing of the backwater events on the Okanogan River, and reduce the duration of these events.
- Projected higher water demand and higher evaporation from Osoyoos Lake, which will further increase the pressure on the reduced water supply.
- Potentially less accurate streamflow forecasts used to decide between drought and non-drought summer conditions (mitigated by the practice of continuous improvement that is applied to the current forecast methods)
- Overall reductions in water supply and increases in demand, which may mean that water will have to be stored earlier and held in the lake for a longer period of time in summer.

4 Recommendations for Amending the Orders

Recommendations for amending the Orders are based on a desire to preserve the scientific linkage between the Orders and the changing hydrologic regimes of the Okanagan and Similkameen Rivers, and improve management flexibility while at the same time having no negative impact. Based on the projected climate and hydrologic changes identified above, we recommend that the following changes be considered:

1. Advance the date on which drought declarations are made in the spring. Given that there may be considerable flow earlier in the season, the first declaration could be made on March 1.
2. Allow more flexibility in filling the lake. Increased flows are projected through winter, and the spring high flow period is expected to begin earlier. Earlier storage may be required to take advantage of the available water in winter and early spring.
3. Allow gradual changes in lake level (known as “ramping”) as opposed to setting strict date-specific water level requirements. This will provide flexibility for the future, which is particularly important given the wide range of projections for future water supply.
4. Evaluate whether the distinction between drought and non-drought conditions is required. In its place, a flexible lake management strategy that applies to all years could be developed.
5. Evaluate the use of fixed-dates for the summer and winter operating ranges in light of the projected future advance of the spring lake inflows.
6. Incorporate an adaptive management strategy that includes re-evaluation of performance under the Orders every 10 years, or after any year, with a view towards periodic refinement of the Orders. This concept recognizes the wide range in projected future conditions.