

# Natural Factors Affecting the Level of Osoyoos Lake

## Background

Osoyoos Lake is operated under conditions prescribed by the International Joint Commission (IJC) and Figure 1 shows the ranges within which Osoyoos Lake should operate. In normal summers, Osoyoos Lake is maintained between elevations 911 and 912 ft whenever possible. When drought conditions are deemed to have occurred, through regulation of the outflow through Zosel Dam, Osoyoos Lake can be deliberately raised to elevation 912.5 ft. In non-drought years, however, due to natural flows during the spring and early summer, levels in excess of the normal upper limit of 912 feet may occur. This document explains the circumstances that can cause this.

In a natural lake (i.e. one with no artificial controls such as a dam at its outlet), the level of the lake is generally controlled by the inflow and the geometry of the outlet. The lake level determines the outflow. In a natural system, a lake will always adjust its level in an attempt to balance inflow and outflow. When the inflow exceeds the outflow, the level of the lake will rise to provide the additional energy, or head, necessary to increase the outflow. Conversely, if the inflow is less than the outflow, the lake level will drop and outflow will decrease. If inflow remains constant, the lake will find the level required to produce outflow equal to inflow.

When there is a dam at the lake outlet, such as Zosel Dam for Osoyoos Lake, outflow can be controlled by opening or closing gates in the dam. Obviously, if it is controlled such that outflow is less than inflow, the lake will rise, and vice-versa.

In the case of Osoyoos Lake there is another complication. The Similkameen River, with a mean annual flow 3.5 times greater than that of the Okanogan River, joins the Okanogan just below Zosel Dam. Because the land at the confluence is relatively flat, high water levels in the Similkameen River effectively impede or block the flow out of the Okanogan River and Osoyoos Lake. With extreme high water in the Similkameen River, flow in the Okanogan River may reverse and flow upstream into Osoyoos Lake. This is a natural phenomenon that would occur whether there was a dam at the outlet of Osoyoos Lake or not.

## Control of Osoyoos Lake Levels during non-drought years

The following is a summary of the various conditions that can occur in Osoyoos Lake during the period April through October in a year in which runoff is average or greater.

### 1. Normal inflow to the lake, normal flow in the Similkameen River

*Osoyoos Lake inflows less than 2,000 cubic feet per second ( $ft^3/s$ ) ( $57 m^3/s$ ), and Similkameen River flow less than 10,000  $ft^3/s$  ( $283 m^3/s$ ).*

Under these conditions there is no outflow restriction downstream from Zosel Dam due to the Similkameen River and the gates are operated to maintain the level of Osoyoos Lake between 911.0 and 912 ft as required by the IJC. There is relatively little difference between the water level at the lake and at the dam (Figure 2).

### 2. High inflow to the lake, normal flow in the Similkameen River

*Osoyoos Lake inflows greater than 2,000 cfs ( $57 m^3/s$ ), and Similkameen River flow less than 10,000  $ft^3/s$  ( $283 m^3/s$ ).*

Although there is no restriction downstream from Zosel Dam from the Similkameen River, high inflow may cause the level of Osoyoos Lake to exceed 912 ft Under the terms of the IJC Order of

Approval, the gates at Zosel Dam are to be fully opened whenever the level of Osoyoos Lake will exceed 912 ft (912.5 ft in case of drought declaration). During high inflows, the level of Osoyoos Lake will rise to provide enough head to force water out of the lake. For example, at an inflow of about 3,000 ft<sup>3</sup>/s (85 m<sup>3</sup>/s), the lake would have to rise to about 913 ft for the outflow to balance the inflow. Inflows are unlikely to exceed 3,700 ft<sup>3</sup>/s (105 m<sup>3</sup>/s) which would be associated with a lake level of about 913.5 feet (Figure 3). However, it should be noted that lake levels greater than 912.5 ft are likely to occur more frequently due to the conditions outlined in the following paragraph.

### **3. Outflow Restricted by Similkameen River flows**

*Flows in the Similkameen greater than 10,000 ft<sup>3</sup>/s (283 m<sup>3</sup>/s).*

The Similkameen River is a natural river with no controls. Its peak flows can be more than ten times as great as those in the Okanogan River leaving Zosel Dam.

The relationship is complex, but, in general, when the flow of the Similkameen River as measured at Nighthawk exceeds about 10,000 ft<sup>3</sup>/s (283 m<sup>3</sup>/s), the Similkameen River level becomes high enough to restrict outflow in the Okanogan River. The greater the flow in the Similkameen, the greater is this blocking effect. (Figure 4). If the outflow is restricted to less than the Osoyoos Lake inflow, the lake level will rise. Under certain circumstances it is possible for the level of the Similkameen River to exceed the water levels at Zosel Dam with the result that the water in the Okanogan River flows upstream into the lake (Figure 5). This reverse flow only occurs relatively rarely, the last occurrence being in 1976.

#### **What can be done?**

High Osoyoos Lake levels (other than during a drought) are a natural phenomenon caused by hydrologic factors and the natural physical layout of the area. As a result, little can be done to reduce Osoyoos Lake levels when high flows occur. Two commonly suggested remedies are:

#### **1. Reduce flows into Osoyoos Lake**

When high Similkameen River flows occur, every effort is made to reduce Okanogan River flows into Osoyoos Lake to reduce both the rate of rise and-peak lake levels. However, flows greater than 10,000 ft<sup>3</sup>/s (283 m<sup>3</sup>/s) in the Similkameen can be continuous for several weeks in high runoff years - which also tend to be high runoff years in the Okanogan basin in Canada. This makes it impractical to reduce flows in the Okanogan River for an extended period (via Okanogan River flow control structures).

#### **2. Lower the level of Osoyoos Lake in anticipation of high flow in the Similkameen River**

Osoyoos Lake cannot ameliorate high flood levels because the storage volume available in the lake is very small compared with the total flow volume into the lake. At low Osoyoos Lake levels, the outflow capacity is also low. The lake level can rise by several inches per day if there is a large difference between inflow and outflow. Thus, any benefit of lowering the lake level in advance would be lost in only a few days once inflows increased and/or outflows were naturally restricted. When there is a large difference between inflow and outflow, the lake would rise rapidly and there would be little or no difference in the peak level attained by the lake nor the duration of high lake levels. Consequently, attempts to hold Osoyoos Lake at a lower level do not significantly influence the peak freshet water level.

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Figure 1

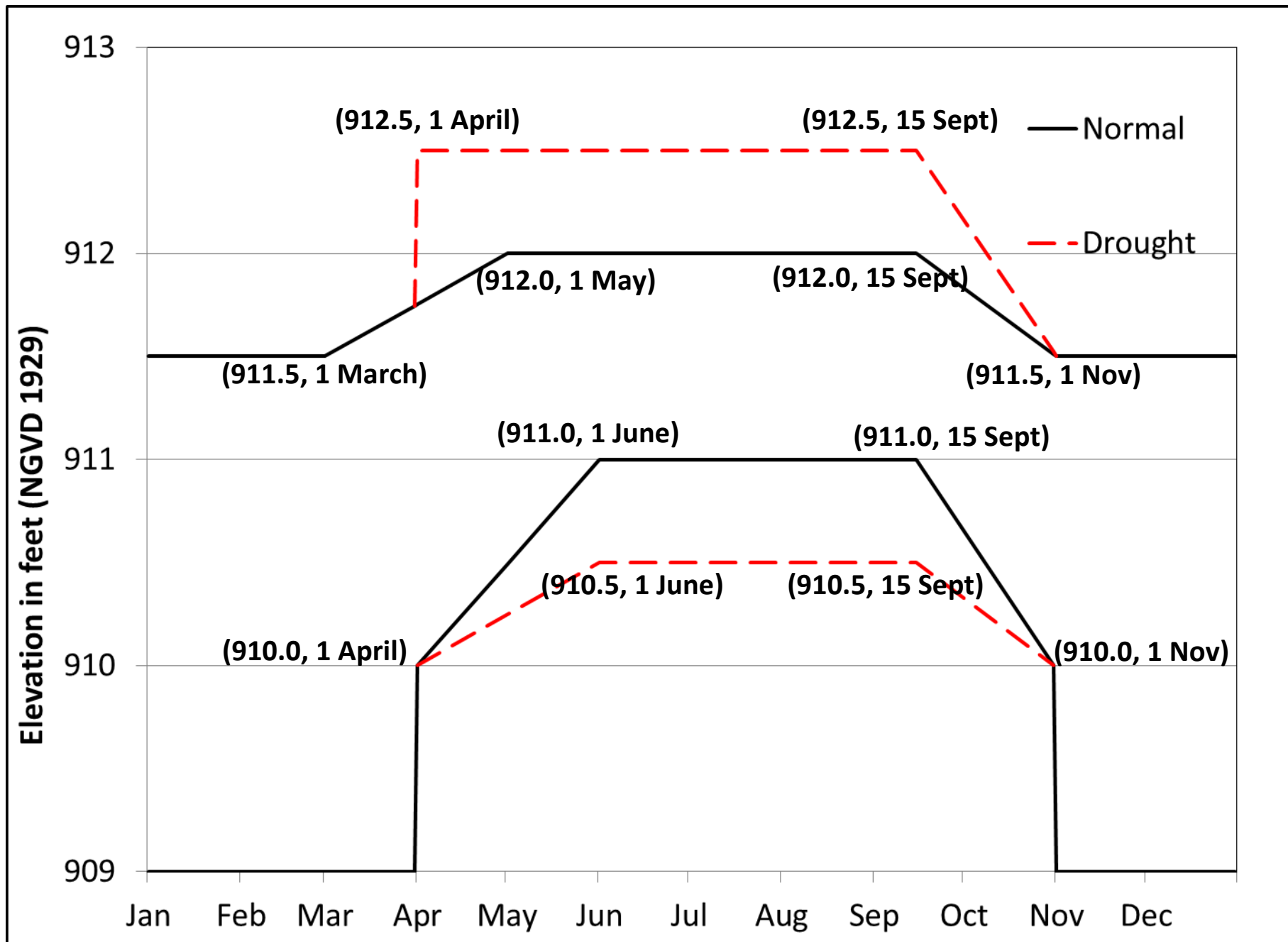
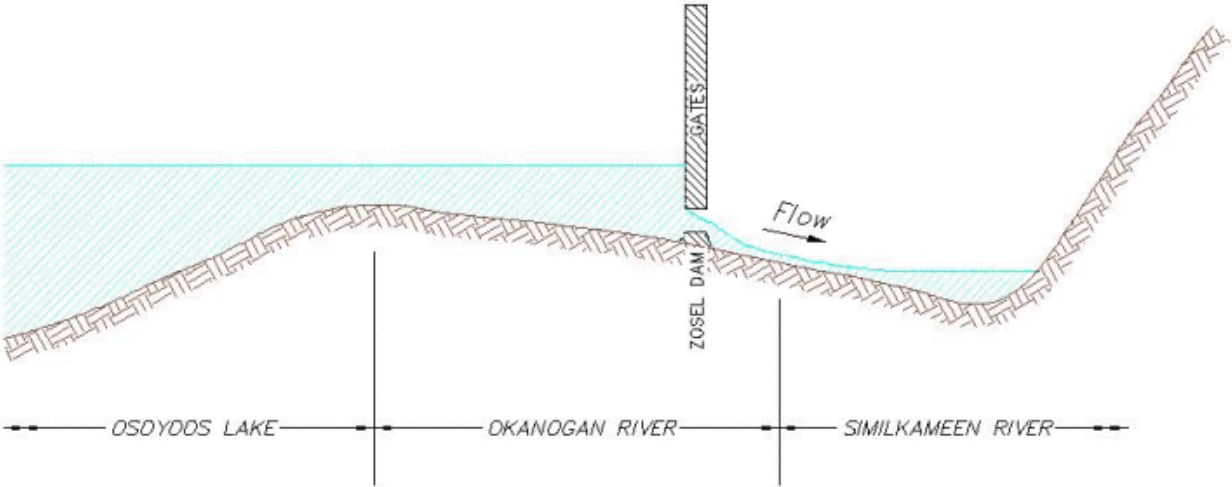


FIGURE 2

### OSOYOOS LAKE / SIMILKAMEEN RIVER RELATIONSHIP

NORMAL:

OSOYOOS LAKE INFLOW LESS THAN 2000 cfs (57m<sup>3</sup>/s), approx.  
SIMILKAMEEN RIVER FLOW LESS THAN 10,000 cfs (283m<sup>3</sup>/s), approx.



NOTES:

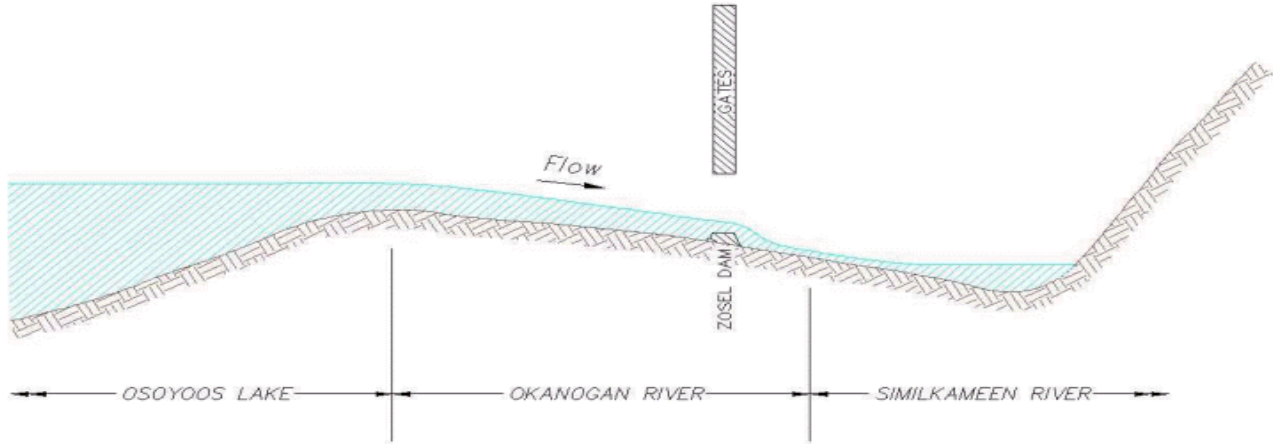
- 1. NOT TO SCALE, SCHEMATIC ONLY
- 2. ZOSEL DAM GATES ADJUSTED TO MAINTAIN OUTFLOW EQUAL TO INFLOW
- 3. OSOYOOS LAKE LEVEL NORMALLY BETWEEN 911.0 AND 911.5 FT. ELEVATION

FIGURE 3

### OSOYOOS LAKE / SIMILKAMEEN RIVER RELATIONSHIP

HIGH INFLOWS TO OSOYOOS LAKE:

OSOYOOS LAKE INFLOW GREATER THAN 2000 cfs (57m<sup>3</sup>/s), approx.  
SIMILKAMEEN RIVER FLOW LESS THAN 10,000 cfs (283m<sup>3</sup>/s), approx.



NOTES:

1. NOT TO SCALE, SCHEMATIC ONLY
2. ZOSEL DAM GATES LIFTED ABOVE WATER IF OSOYOOS LAKE ELEVATION ABOVE 911.5 FT.
3. OSOYOOS LAKE RISES UNTIL OUTFLOW EQUALS INFLOW
4. OUTFLOW DETERMINED BY OKANAGAN RIVER CHANNEL GEOMETRY

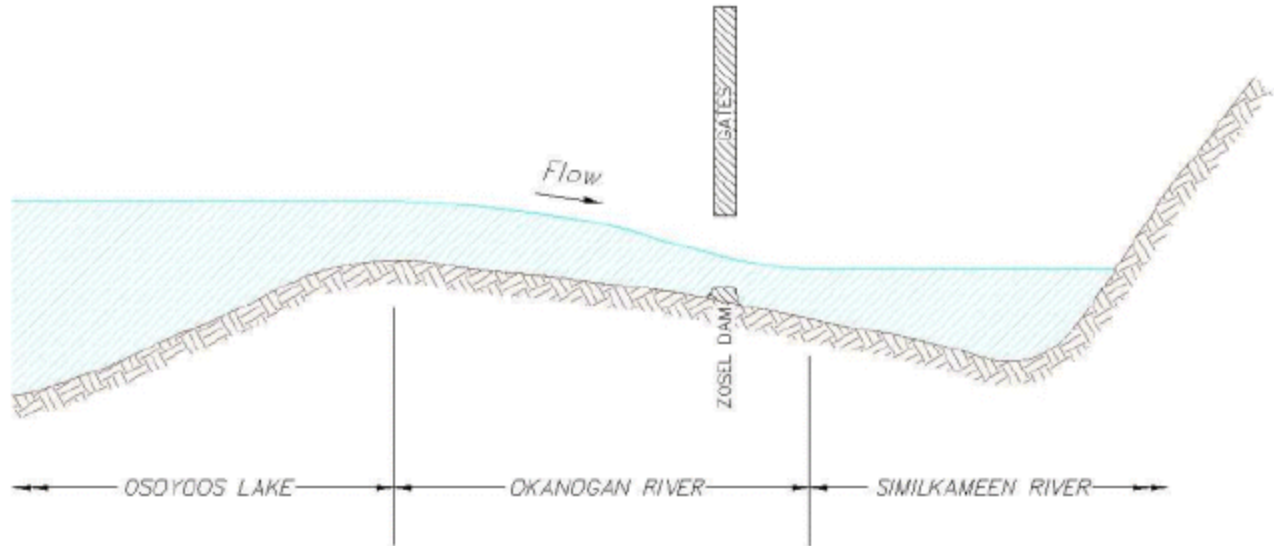
FIGURE 4

## OSOYOOS LAKE / SIMILKAMEEN RIVER RELATIONSHIP

### SIMILKAMEEN CAUSES BACKWATER:

OSOYOOS LAKE INFLOW – SEE NOTES

SIMILKAMEEN RIVER FLOW GREATER THAN 10,000 cfs ( $283\text{m}^3/\text{s}$ ), approx.



### NOTES:

1. NOT TO SCALE, SCHEMATIC ONLY
  2. ZOSEL DAM GATES LIFTED ABOVE WATER IF OSOYOOS LAKE ELEVATION ABOVE 911.5 FT.
  3. OUTFLOW DETERMINED BY OKANAGAN RIVER CHANNEL GEOMETRY AND LEVEL OF SIMILKAMEEN RIVER
  4. OSOYOOS LAKE WILL RISE UNTIL OUTFLOW EQUALS INFLOW
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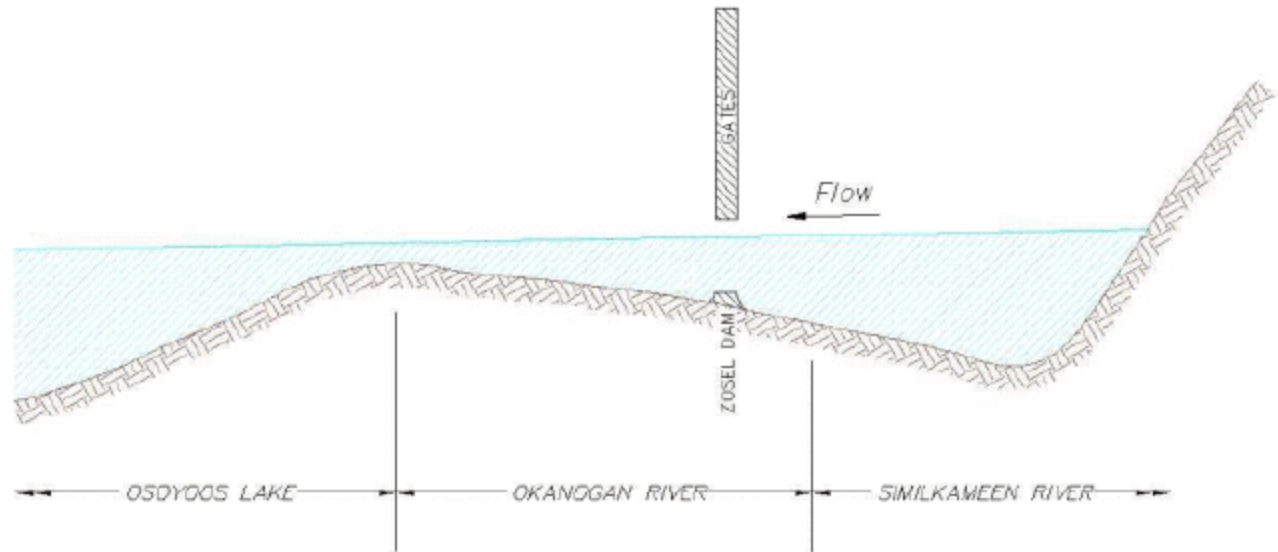
FIGURE 5

## OSOYOOS LAKE / SIMILKAMEEN RIVER RELATIONSHIP

### REVERSE FLOW:

OSOYOOS LAKE INFLOW – IMMATERIAL

SIMILKAMEEN RIVER FLOW GREATER THAN 20,000 cfs ( $567\text{m}^3/\text{s}$ ), approx.



### NOTES:

1. NOT TO SCALE, SCHEMATIC ONLY
2. ZOSEL DAM GATES ABOVE WATER.
3. THIS CONDITION OCCURS RELATIVELY RARELY AND ONLY WHEN THE SIMILKAMEEN RIVER HAS RISEN VERY RAPIDLY.