



**The Okanagan Fish/Water Management Tool:
Guidelines for
Apprentice Water Managers**

v.2.0.000

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November 2006

Citation: Alexander, C.A.D., Symonds, B. and K. Hyatt, eds. 2006. The Okanagan Fish/Water Management Tool (v.2.0.000): Guidelines for Apprentice Water Managers. Prepared for Canadian Okanagan Basin Technical Working Group, Kamloops, BC. 127 pp. Can. Manuscr. Rep. Fish. Aquat. Sci. *in prep.*

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Acronyms

ATU	Accumulated Thermal Units
COBTWG	Canadian Okanagan Basin Technical Working Group
CWRA	Canadian Water Resources Association
DCPUD	Douglas County Public Utility District
FWMT	Fish/Water Management Tools (refers to the program, not the software system)
OBA	Canada - British Columbia Okanagan Basin Agreement
OBIA	The Canada-British Columbia Okanagan Basin Implementation Agreement
OKFWM	Okanagan Fish/Water Management Tool (the software system, not the program)
RFC	BC Ministry of Environment River Forecast Centre
WSC	Water Survey of Canada

Acknowledgements

The ideas in this guidebook were developed jointly by members the Canadian Okanagan Basin Technical Working Group (COBTWG) and their partners between 1999 and 2006. Project vision and oversight was provided by the Fish/Water Management Tools (FWMT) Steering Committee under the direction of its Chair, Dr. Kim Hyatt.

We gratefully acknowledge the COBTWG and FWMT Steering Committee and their associates who provided data and technical expertise on the appropriate structure and parameterisation of the OKFWM model during numerous workshops and meetings. Throughout design and development of the tool Brian Symonds, the Okanagan valley's senior water manager, participated closely, enthusiastically (and often patiently) in the development and testing of the software. Mr. Symonds' and FWMT fisheries experts are thanked for sharing their insight. We would also like to thank our "apprentices": Dawn Machin, Margot Stockwell and Cindy Harlow for participating in a rigorous retrospective analysis in 2004. Rowena Rae is thanked for helping to structure portions of this document and greatly improve its readability for the novice audience. Many others have not been mentioned who deserve thanks. Suffice it to say, this work has truly been a team effort and produced many "most valuable player" awards.

The FWMT program is a showcase in what can be achieved through trust-based multidisciplinary dialogue. The technical advances in fish/water management achieved stemmed directly from the unparalleled collaboration sustained by the COBTWG and their partners over a 6 year period. It is the success of these collaborations that permitted FWMT's cognitive and technical advances to be realised. In short, we are very proud of the extent to which water and fisheries managers representing private industry, First Nations, federal and provincial interests have enthusiastically adopted the tool.

Funding for the FWMT program and OKFWM software was provided Douglas County Public Utility District in association with dedicated in-kind support from several staff with the Canadian Department of Fisheries and Oceans and the Provincial Ministry of the Environment.

CHAPTER 1

Background

The Okanagan basin is characterised by a gently sloping plateau with elevations ranging from about 1,200m to 2,200m and steep valley sides dominated by bedrock at or near the surface descending to a valley bottom containing a series of lakes. The valley floor is covered by Okanagan Lake which extends from Penticton in the south (where lake level is controlled) to 10 km north of Vernon (Figure 1.1). Okanagan Lake's surface covers an area of 351 km² and contains roughly 24.6 billion m³ of water (Canada-British Columbia Okanagan Basin Agreement 1974). The physical drainage basin upstream of the Okanagan River at Penticton covers 5,960 km². Annual precipitation in the Basin varies with elevation, and is relatively low, averaging about 600 mm per year throughout the Basin. Inter-annual variation in annual run-off is significant in the Okanagan. Snowmelt between April and June represents the primary source of this run-off in the Okanagan River system. More specifically, about 95% of the net annual lake inflow occurs between February 1 and July 31. The average annual inflow (as determined for the period 1970-1999) is 565 million m³ which translates to a 1.66 m elevation gain on the lake. However, the annual inflow varies widely, and has ranged from 147 million m³ to 1,340 million m³ since 1970. When combined with present and future water demands, this range has significant practical water management consequences.

Several major tributaries drain into Okanagan Lake including (from north to south) Vernon, Equis (Six-Mile), Kelowna, Mission, Powers, Peachland, Trout, and Penticton Creeks. Mission Creek is the largest tributary, contributing an average of 21% of the total annual inflow to Okanagan Lake (Canada-British Columbia Okanagan Basin Agreement 1974a,b,c). At Penticton, Okanagan Lake flows into the Okanagan River, which empties into Skaha lake. Downstream of Skaha lake, the river flows through Vaseux, and Osoyoos Lakes before entering the Columbia River at Brewster, Washington.

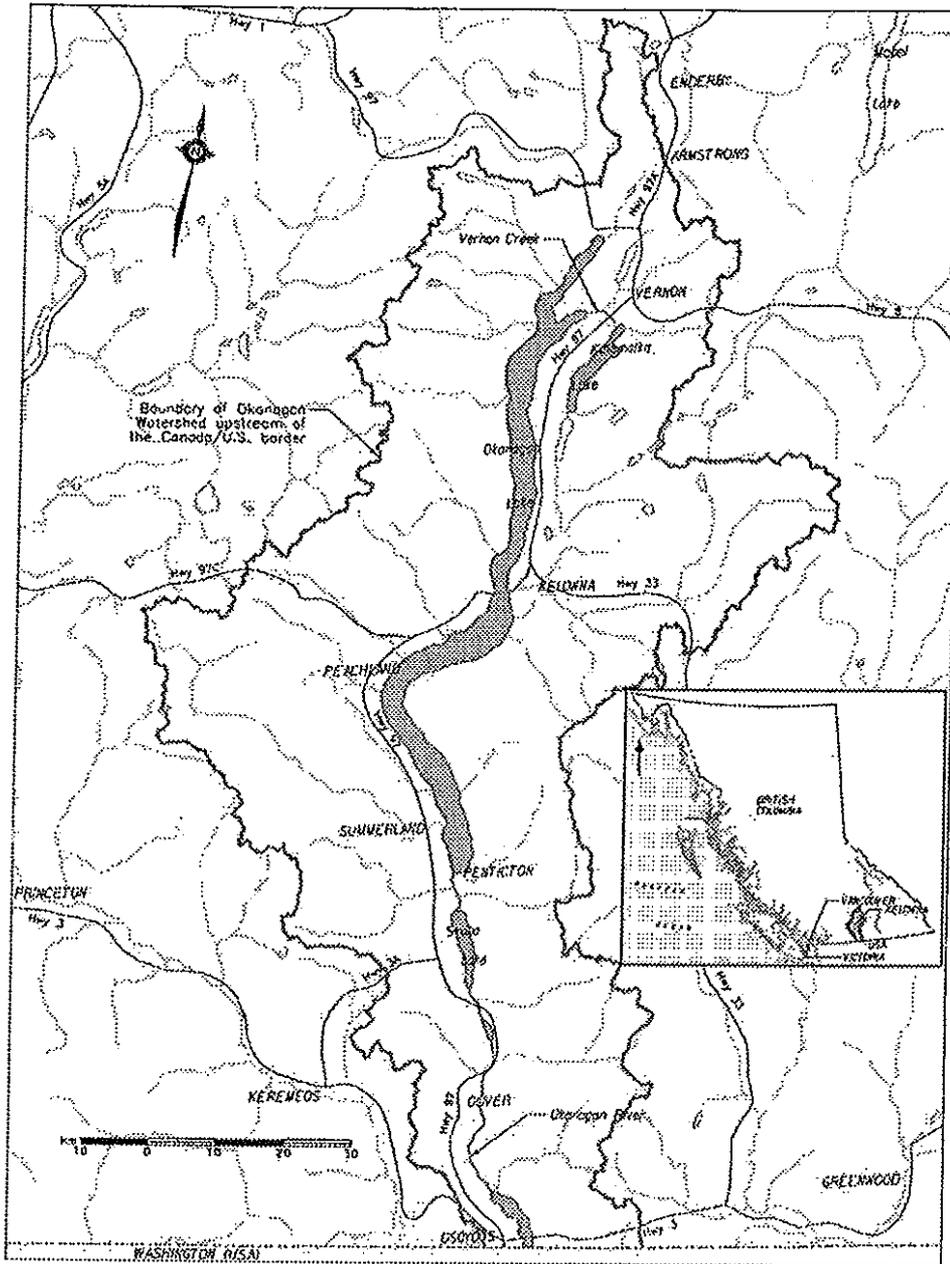


Figure 1.1. Okanagan basin watershed. Source: Summit Environmental Consultants.

Water management issues & history

The water resources of the Okanagan basin face increasing stress due to both continued population growth and climate change. A recent study published by Statistics Canada identified the Okanagan-Similkameen basin as having the lowest amount of water available per person in Canada. The Canadian Water Resources Association (CWRA) suggested at a conference in 2005 that at present per capita usage rates, the water resources of the basin will be totally allocated in less than 25 years. Communities that rely on reservoirs or streams are already starting to experience shortages in drought years, and minimum flows in streams are often well below acceptable survival thresholds for aquatic species. The Okanagan basin Water Board, the Okanagan Partnership, CWRA and other organisations have all recognised that these pressures on water have ecological and socio-economic consequences. Improvements in the way water is managed and consumed are required to sustain both the integrity of ecological systems and the standard of living in the valley.

In the case of Okanagan Lake (British Columbia), water levels are managed to provide a balance between flooding, agriculture, fisheries, urban water supply and other interests. However, natural variation in seasonal inflows, scientific uncertainty, competing objectives and multi-agency communication barriers are significant challenges faced by resource managers responsible for deciding how to allocate limited and variable water supplies in the basin. Value differences often come into play, with wide variations in weight placed on flood control vs. other considerations such as water for ecological needs. In the Okanagan, this typically involves explicit consideration of fish population needs.

Canada-BC Okanagan Basin Agreement

In 1969 the British Columbia and Canadian governments formally agreed to pursue the development of a comprehensive framework plan to manage water resources for the social betterment and economic growth of the Okanagan valley. The study was called *The Canada - British Columbia Okanagan Basin Agreement* (hereafter OBA). At the time, the OBA study (Canada-BC Okanagan Basin Agreement 1974) was highly innovative. It considered alternative future population demands and for the first time recognised the need to supply water for fish and wildlife, recreation and aesthetic values. This led to the signing of an Operating Plan by the British Columbia and federal governments in 1976, with sole responsibility for operations and maintenance falling to the Province. The OBA Operating Plan specifies operating ranges for Okanagan Lake elevation for normal, drought and flood years. Likewise, it specifies operating ranges for other lakes in the basin as well as in-stream flow requirements in Okanagan River.

The Operating Plan devised during the OBA was (and generally still is) considered reasonable in that it attempts to accommodate a wide range of interests and specifies flows and lake levels for fish. However, fishery losses have sometimes been substantial, owing not to a systematic failure of the plan, but to an inability to follow it in practice. Water managers have had to try to control floods, meet rapidly rising demands for domestic and agricultural water and also supply water for fisheries and recreation. In recent years, the task has been made even more challenging by extremes of climate and a more rapid than expected gain in human population—one that has exceeded even the highest population growth trajectory envisioned by the OBA.

In addition to rules for flood control and water supply management, the OBA recognised that water management decisions influence fish survival. Specifically, the OBA recognised that water

management decisions influence fish production because of their effects on: (1) seasonal water level variations at Okanagan Lake beaches where kokanee spawn; (2) discharge, water level and flows downstream in both natural and channelized sections of the Okanagan River where sockeye salmon spawn; and (3) water quality of the lake rearing-habitats of both sockeye and kokanee. Consequently, specific provisions of the OBA focus on the maintenance of seasonal lake and river discharge levels to protect the productive capacity of various life history stages of sockeye and kokanee salmon throughout the system. However, a review by Bull (1999) suggested that water management decisions frequently depart from compliance with OBA targets.

Furthermore, recent data from sockeye and kokanee field investigations and discussions with expert sockeye and kokanee biologists suggest the OBA targets themselves could be improved to provide additional protection. The study by Bull (1999), a sockeye egg scour and egg desiccation mortality investigation by Hyatt et al (2001) and subsequent expert workshops with fisheries biologists and hydrologists clearly suggested that significant fisheries survival gains are possible by taking into account recent scientific understanding and better integrating information sources when making water release decisions at Okanagan Lake dam.

Okanagan sockeye

Legally speaking, Canada and the United States share responsibility for conservation and management of Okanagan River sockeye under the terms of the Pacific Salmon Treaty (1985). In addition, Canadian resource management agencies are constitutionally obligated to conserve and restore First Nations' access to food, social and ceremonial fisheries for salmon. Given their biological, economic and cultural significance, Okanagan River sockeye salmon are the subjects of several significant stock and habitat restoration initiatives.

Fish population restoration in the Okanagan has taken on a higher profile in recent years owing to efforts by First Nations and greater awareness by regulatory agencies about the significant declines in fish abundance. In spite of curtailment of both marine and freshwater harvest, Okanagan sockeye abundance has generally declined (Figure 1.3). This poses a major concern as Okanagan River sockeye salmon are the only significant remnant stock of salmon returning to Canada through the Columbia River system in the U.S.

Of course, local water management practices in the Okanagan basin are not the sole (or primary) issue causing this trend. The Okanagan sockeye population's decline follows the development of the Columbia River hydrosystem (Figure 1.2), which is widely believed to have eliminated all but three Columbia River sockeye populations in the Okanagan, Wenatchee, and Redfish lakes. In addition to the increases in mortality imposed by Columbia River dams, other factors contributing to the decline include agricultural, urban, recreational and forest land use practices, including a flood-centric engineering paradigm that governed the design of Okanagan River channel in the 1950s (Figure 1.4). Climate changes in the North East Pacific Ocean associated with warmer sea surface temperatures and shifts in other eco-oceanographic conditions, while very poorly understood, are increasingly suspected of placing additional strain on southerly distributed stocks of salmon. *Cumulatively*, these factors and activities have acted to further restrict Okanagan River sockeye to suboptimal habitats (freshwater and marine).

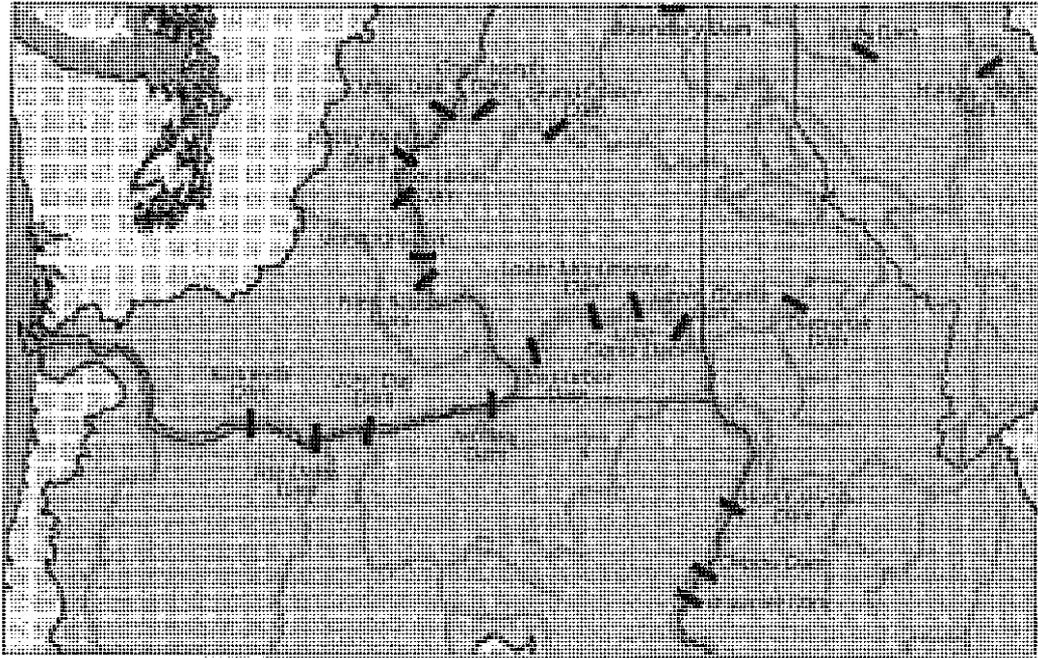


Figure 1.2. There are nine major Columbia River dams separating migrating sockeye salmon from the North Pacific Ocean and Okanagan River. Juveniles migrating towards the ocean may be re-directed by screens and hydraulic features into fish by-pass systems on some dams, travel over spillways (~97-99% survival), or through power production turbines. Certain species and stocks are also captured at select by-pass facilities and barged beyond the dams. The fraction of juveniles that do encounter turbines are believed to experience anywhere from 2% to 17% mortality (depending on the project). Adults returning from the Ocean to Okanagan River move up-river through a series of fish ladders. (The thin blue centre line shows the migration path to Okanagan River, which lies to the north of Wells Dam, before Chief Joseph Dam).

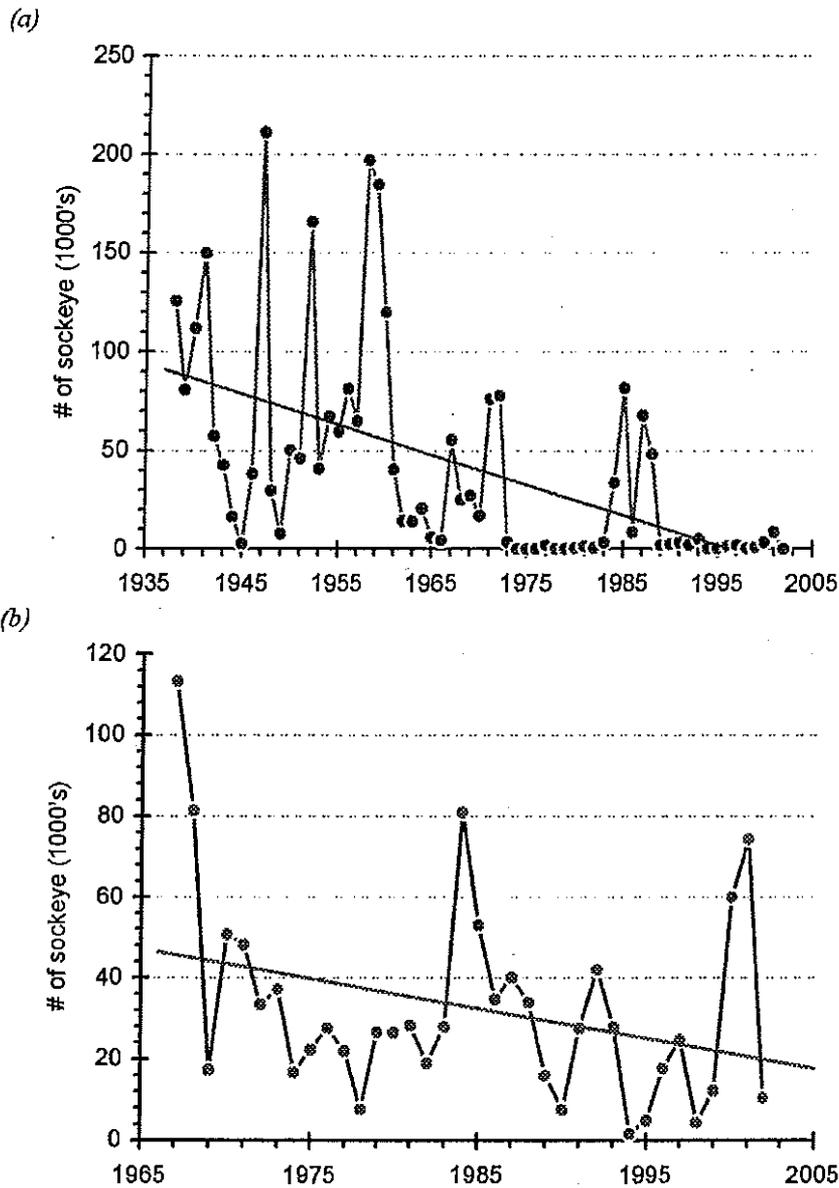
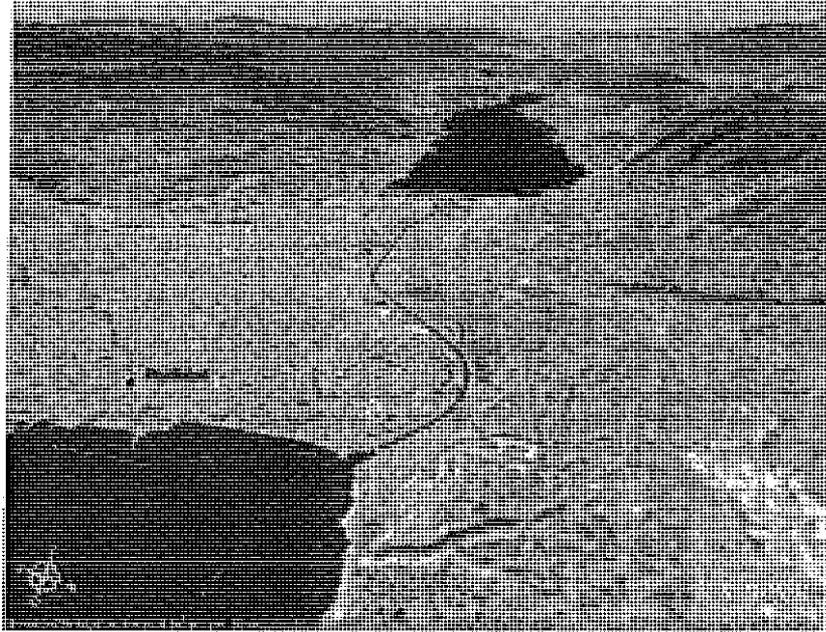


Figure 1.3. (a) Columbia River sockeye salmon catch and (b) Okanagan River sockeye salmon abundance as indexed by passage at Wells Dam, Columbia River (Hyatt and Rankin 1999).

(a)



(b)



Figure 1.4. Okanagan River (channel) (a) at Penticton and (b) near Oliver; British Columbia. Panel b shows artificial straightening and dyking for flood conveyance. The remnant natural channel meander pattern and associated oxbow cut-offs associated with a healthy river system are also visible. *Source: Google Earth.*

Okanagan kokanee

As with Okanagan sockeye, numbers of Okanagan Lake shore-spawning kokanee have seriously declined over the last three decades (Andrusak and Sebastian in Andrusak et al. 2000) (Figure 1.5). Prior to this decline, kokanee in Okanagan Lake supported a sport fishery (Ashley and Shepherd 1995) valued at more than a million dollars annually. Reasons for the decline have been attributed to competitive interaction with introduced *Mysis relicta* for the same zooplanktors and a general decline in lake carrying capacity due to nutrient imbalance (Andrusak et al. 2001). A third explanation for the decline involves regulation of the lake level at time of spawning and egg incubation that potentially results in stranding of eggs and/or early hatched eggs (Andrusak et al. 2002). It is likely that a combination of these factors acts together.

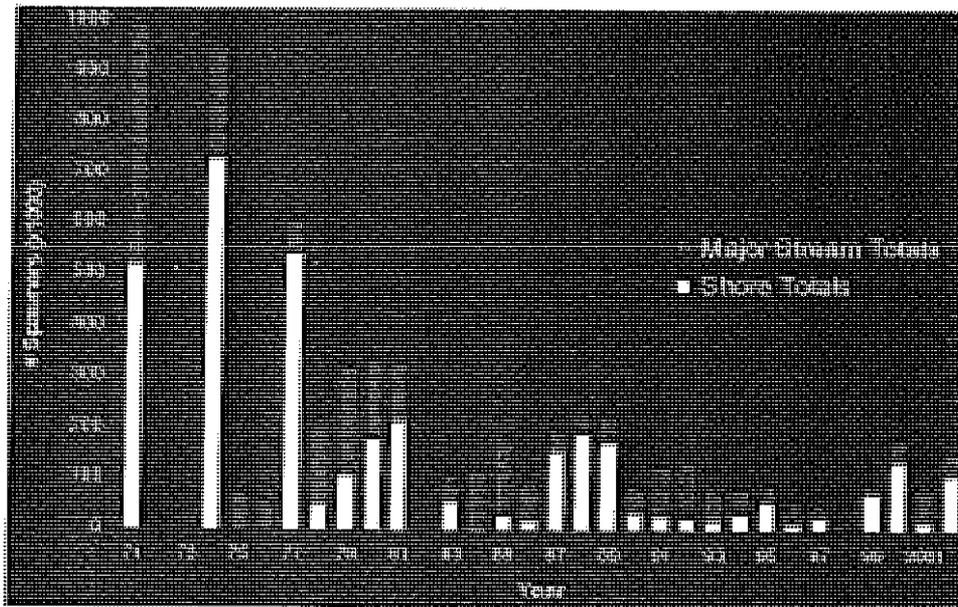


Figure 1.5. Okanagan Lake kokanee spawning abundance indices. Source: Ministry of Water, Land and Air Protection, 102 Industrial Place, Penticton BC, V2A 7C8.

Fish/Water Management Tools Program

In an effort to help reverse the sockeye and kokanee population trends, extensive consultation between the Canadian Okanagan Basin Technical Working Group (COBTWG) and Douglas County Public Utility District (DCPUD) began in 1999. This led to the Fish/Water Management Tools (FWMT) program aimed at identifying local water release practices that increase the overall production of Okanagan sockeye salmon. The initial work dealt with an assessment of the potential benefits, costs and feasibility of several salmon stock restoration options (Bull 1999) including: (i) a general program of riparian and in-stream habitat restoration; (ii) construction of a sockeye spawning channel; (iii) an adult trap-and-transport program; and (iv) juvenile salmon production increases through improvements to water release practices at Okanagan Lake dam, Penticton.

Early in 2001, members of the COBTWG reviewed results from these initial studies with representatives of DCPUD (March 22, 2001) and then with members of both DCPUD and the Wells Committee (March 27, 2001). At both of these sessions, personnel from DCPUD emphasised that further support for restoration actions in Canada would only be provided to pursue restoration options that:

- would provide readily quantifiable benefits;
- have the potential to provide average sockeye production benefit on the order of 100,000 smolts per annum;
- appear economically attractive relative to alternate approaches;
- have the potential to achieve regulatory approval by each of several levels of government; and
- could be developed and implemented within a 1-3 year interval.

The COBTWG acknowledged these requirements and provided additional criteria based on their commitment to the conservation and restoration of Okanagan fisheries resources within an "ecosystem based management framework". These criteria included:

- restoration activities should provide benefits at the single-species level directly to sockeye as well as at the ecosystem level to other, high-value, indigenous fish species such as resident kokanee (i.e., provide ecosystem benefits);
- manipulations of fish or habitat should be amenable to formal risk assessment as one component of benefit-cost analysis; and
- manipulations of fish or habitat components should follow an adaptive management process (i.e., build in experimental learning opportunities and long-term monitoring during and after project completion, with periodic reviews of field information to reduce key uncertainties).

Following further consideration of the criteria above, the COBTWG members agreed that the flow management option of the FWMT program was DCPUD's best option given that:

- analyses by Hyatt et al. (2001) indicated changes to water management practices had the potential to increase average sockeye production by roughly 15%;
- costs to achieve this increase were economically superior to other options (e.g., spawning channel development);
- implementation of the water management option could be achieved within the context of the existing OBA (i.e., no special regulatory approvals would be required to implement water management actions contemplated under the FWMT program);
- initial development, testing, refinement and deployment of an FWMT decision-support system could be completed within 3-4 years;
- provision of a state-of-science decision-support tool to key water resource managers for improving water release decisions for juvenile sockeye production could also provide benefits for other high-value fish species (namely kokanee); and
- alterations to seasonal water storage and/or release practices could be implemented through an adaptive management procedure.

Guidebook contents

The remainder of this guide introduces readers to the key issues and science of Okanagan Lake and River water management. These topics will be introduced in incremental detail so that readers will have a firm grasp of the key considerations and trade-offs associated with in-season management of Okanagan Lake and river to balance multiple objectives, such as sockeye and kokanee survival and avoiding flooding of property. The guide goes on to give some background to the Okanagan Fish/Water Management Tool (OKFWM) software application, the main product of the FWMT program. It also provides concrete guidelines and discusses strategies for balancing these objectives.

The guide then provides step-by-step instructions for operating the Okanagan Fish/Water Management (OKFWM) software. Instructions are given separately for retrospective (training) and in-season modes, as well as details on interpreting the output of the software.

The ideas in this guidebook were developed jointly by members of the COBTWG between 1999 and 2005, including enthusiastic support from the basin's senior dam operator who had over 14 years experience operating Okanagan River mainstem dams at the time of writing.

What is OKFWM?

In several FWMT workshops during 1999-2003, "front-line" fisheries and water managers discussed the complexity of balancing fisheries, flood control and other water allocation objectives in Okanagan basin. The complexity and uncertainty are such that "mental arithmetic" or "rules of thumb" were insufficient to meet the targets for multiple objectives. In addition, it was clear that a fixed-rule "cook book" or an experience-only approach lacked scientific credibility across disciplines.

It quickly became apparent that a common science foundation was missing. Without this, water and fisheries managers would continue to have problems communicating their rationale for desired and actual water release decisions. This lack of a common foundation and language wasted time—a significant barrier for any in-season management regime. Moreover, lack of a common base and poor communication proved frustrating and engendered a lack of trust. Without common ground, compromise and consensus on important water release decisions would continue to evade water and fisheries managers in the basin.

Using a series of meetings and workshops, the FWMT program provided the vision, structure and forum to develop a common foundation and language. Water and fisheries managers were given equal footing at the table and could for the first time meaningfully discuss the complexities and uncertainties associated with such things as:

- forecasts of seasonal water supplies;
- risk of significant property damage or irrigation losses associated with maintenance of "fish friendly" lake elevation and river discharge levels given either flood or drought events;

- the exact timing of sockeye and kokanee life history events (especially fry emergence) that control their vulnerability in a particular year to losses from flood-and-scour or drought-and-desiccation processes; and
- the potential magnitude of these fish losses owing to specific deviations from recommended lake level or river flow ranges.

Water and fisheries managers refined the program's scope, clarified its bounds and performance measures, and conducted comprehensive data reviews and new field surveys to gather relevant information. This work was then documented in a series of reports. Using the information in these reports, the FWMT Steering Committee directed the development of a state-of-science tool to help make water management decisions in Okanagan basin.

The tool—referred to as OKFWM—is a software program that is accessible on the internet and can be used by many users simultaneously. The data model that underlies OKFWM automates complex biophysical calculations, incorporates real-time data on inflow to Okanagan Lake, incorporates kokanee-sockeye emergence timing estimates and simplifies the presentation of results to show how well objectives have been met. The result has been to greatly improve in-season water release decisions occurring at Okanagan Lake dam.

OKFWM was tested with both in-season and retrospective analyses. The retrospective analyses used data from past years and compared results from running OKFWM with the actual outcome during a particular year. Both types of analysis demonstrated the potential of OKFWM, and water managers and fisheries biologists in the Okanagan basin have adopted OKFWM for routine use in establishing sensible releases at Okanagan Lake dam.

Greater detail about OKFWM and its underlying models is provided in Chapter 3.

Who is this guide for?

This report has two primary audiences:

1. Previous users of the OKFWM software who need a refresher in its use and in the objectives for water and fisheries management in Okanagan basin. Previous users may also be assisting an apprentice user.
2. Apprentice or trainee users who are learning about water and fisheries management in Okanagan basin and who are receiving guidance from an experienced user of OKFWM.

To use OKFWM, an apprentice fish/water manager must have:

- general training in environmental sciences at a university or technical institute (2-5 years);
- one to several years of work experience as a water, fisheries or habitat management professional;
- better than entry-level knowledge of general physical, biological and engineering concepts shaping fish/water management issues in regulated watersheds;
- basic computer skills, and in particular, familiarity with Microsoft Internet Explorer™ and Microsoft Excel™.

An apprentice fish/water manager may have, but does not have to have:

- experience in dealing with fish/water management issues in Okanagan basin.

For the apprentice user, this guide is meant to serve as an efficient training aid to rapidly orient the new user to OKFWM. It is not, however, a stand-alone tutorial or a “cook book”. This guide does not substitute for the valuable training and insight that can only be acquired through collaborations with experienced managers.

For existing users, this guide will serve as a helpful reference to refresh decision-making skills for fish and water management issues throughout the year in Okanagan basin. The guide will also assist a previous user to train a new user by summarising all key information about fish/water management in Okanagan basin.

How to use this guide

This guide contains the following information:

Chapter 2 – An overview of the Okanagan basin water system and how variations in water supply affect water allocation and fisheries objectives. The chapter also includes some basic guidelines (a “cheat sheet”) about acceptable water levels in Okanagan Lake and water flows in Okanagan River at various times of year.

Chapter 3 – Some background information about how OKFWM was built. This includes the biophysical basis of the model and how five sub-models contribute to the overall model.

Chapter 4 – The results of extensive testing of the model with previous years’ data (retrospective analyses).

Chapter 5 – Step-by-step instructions for an apprentice to work through a complete water year in training mode. The instructions walk an apprentice through water year “2047” (could be any year) and describe how to operate the OKFWM software and how to read the main output report. The instructions are sufficiently detailed that an apprentice can become familiar with operating the software without outside assistance. The chapter also includes a glossary of terms used during the step-by-step instructions.

Chapter 6 – Step-by-step instructions for using the real-time, in-season mode of OKFWM. The instructions assume basic familiarity with the software and are less detailed than in Chapter 5.

Chapter 7 – An explanation of OKFWM output reports and a table of hazard definitions to use while reading the reports.

If you are an apprentice user of OKFWM:

- Read Chapter 2 thoroughly.
- Skip to Chapter 5 and follow the instructions through a practice year.

- Refer to the guidelines in Chapter 2 and the glossary at the end of Chapter 5 as you work through the practice year. The table of hazard definitions in Chapter 7 may also be useful—you will be reminded of this when you are in Chapter 5.
- You should have at the ready at least one experienced user of OKFWM. Seek assistance from them at any time.
- When you have performed the practice year, go back to Chapter 3 and Chapter 4 and read these. They will make more sense when you have some idea of how the Okanagan system works.
- Continue practising in training mode and complete several different types of water year (dry, wet, average).
- Refer to Chapter 7 whenever you need to remind yourself of report output details.
- When you are ready, read Chapter 6 and begin using the real-time mode of OKFWM.

If you are training an apprentice user:

- Have your apprentice follow the steps above.
- Don't expect your apprentice to understand or appreciate all the details of OKFWM, especially of Chapter 3 and Chapter 4, until he or she has performed several training water years.
- Be prepared to assist your apprentice with decisions and to explain why you would take particular actions. The guide is not a substitute for the knowledge you have and can pass on to your apprentice.

If you are a previous user of OKFWM:

- Re-read Chapter 2 through Chapter 4 as necessary.
- Skip to Chapter 6 to remind yourself about how to use OKFWM in real-time mode.
- Refer to Chapter 7 to remind yourself about the various outputs from OKFWM and how to interpret them.
- Refer to the water management guidelines in Chapter 2, the glossary in Chapter 5, and the table of hazard definitions in Chapter 7 if needed.

CHAPTER 2

Overview of Okanagan Lake Management & Impacts of Water Supply Variations

Key objectives & trade-offs

There are four key objectives for the water manager to consider when regulating Okanagan Lake and River:

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

It is difficult for the water manager to make decisions about how much water to release and when to release it from Okanagan Lake dam because the amount and timing of inflow to the system vary significantly each year. The water manager must draw down or lower lake elevation (water level) during winter months (November to February) because Okanagan Lake dam doesn't have the capacity to handle high inflows during peak snow-melt from March to June. This requires the water manager to understand predictions of inflow to Okanagan Lake based on early winter snowpack and long-term weather forecasts.

The water manager must also understand and keep in mind the consequences of trading off each of the following objectives:

Flood control around Okanagan Lake

Okanagan Lake is like a big bath tub with a small drain (Okanagan Lake dam). It takes a long time to empty the lake, even when the dam is fully opened. The slow decline in lake elevation as water flows out Okanagan Lake dam is of critical significance in day-to-day management. Failure to lower the lake sufficiently before spring (March) results in flooding of lakeshore properties. This is because Okanagan Lake dam can release only $60 \text{ m}^3 \cdot \text{sec}^{-1}$ and cannot keep pace with

spring inflows. (During floods when Okanagan Lake is at flood stages, the dam can release upwards of $77.9 \text{ m}^3 \cdot \text{sec}^{-1}$, but this is generally not advisable).

To put this into perspective, the average net May inflow for all years of data, referred to as the all-year average, is close to $88 \text{ m}^3 \cdot \text{sec}^{-1}$, which is about $28 \text{ m}^3 \cdot \text{sec}^{-1}$ more than Okanagan Lake dam can release. If the extra $28 \text{ m}^3 \cdot \text{sec}^{-1}$ continued for a full month, it would raise Okanagan Lake's elevation by 21 cm. Furthermore, the average inflow ignores the *large* interannual variation—short-term inflow rates greater than $250 \text{ m}^3 \cdot \text{sec}^{-1}$ are not unheard of.

If we assume an average winter inflow of around 10.8 million m^3 per month (or $\sim 4.15 \text{ m}^3 \cdot \text{sec}^{-1}$), the water manager must release an average of $10.7 \text{ m}^3 \cdot \text{sec}^{-1}$ during a given month of the late fall/winter to lower the lake elevation by 5 centimetres (just 0.166 cm per day).

Additional guidelines on lake elevation responses to different releases from Okanagan Lake dam are provided in the section titled "Relationship of net inflow to releases at Okanagan Lake dam" (pg. 30).

Survival of incubating sockeye eggs

If the water manager fails to lower Okanagan Lake's elevation over the winter, two things are likely to happen. First, as mentioned above, lakeshore properties will be flooded. Second, the water manager will likely have to resort to "panic" releases during one or more of April, May and June. These months overlap with the time when sockeye eggs are incubating in Okanagan River. April and May panic flows at Okanagan Lake dam are doubly bad for sockeye eggs because they combine with often sizeable unregulated downstream tributary inflows (which always enter the River and cannot be controlled). Together, panic flows and tributary inflows result in unacceptably high rates of mortality to sockeye eggs through gravel scour (movement of spawning gravel particles, grinding and crushing eggs, and premature flushing of eggs downstream). Field studies suggest that if flows exceed $50 \text{ m}^3 \cdot \text{sec}^{-1}$ during the incubation period, over 60% of eggs die (Summit 2002a as cited in Alexander and Hyatt 2005).

Flood control along Okanagan River

In the scenario above (panic releases from Okanagan Lake dam, large uncontrolled tributary inflows), significant river flooding would also be expected. River flooding often must be traded-off relative to the expected magnitude of lakeshore flooding. This highlights the importance of lessening flood risks in the late fall and winter months by drawing down Okanagan Lake, particularly in December and January when snowpack information becomes available.

Survival of shore-spawned kokanee eggs

If the water manager draws down Okanagan Lake too far during fall and winter, several adverse impacts can occur. On the fisheries side, significant numbers of shore-spawned kokanee eggs will be desiccated and will die if the lake elevation drops more than 20 cm below its October 15 level. October 15 is the approximate median date that kokanee spawn their eggs along Okanagan Lake's shore. These eggs do not normally emerge and swim up from gravels until April.

Safe navigation and recreation

If Okanagan Lake is drawn down too far, it may not reach full pool (~ 342.53 m) in June. Low lake elevations can cause problems for summer navigation by boats and can render boat docks unusable. Fixed boat docks may also become unusable should the lake elevation exceed certain thresholds.

River recreation businesses also benefit from summer flows within a certain range during July and August ($>10 \text{ m}^3 \cdot \text{sec}^{-1}$).

Water intake operation

A low lake elevation typically has important downstream implications for Okanagan River. With low lake elevation, the water manager would likely reduce flows to minimum obligations during the summer months. (There are minimum volumes of water that the water manager is obliged to release for certain downstream uses). Low downstream flows can cause insufficient water for agricultural and domestic water intakes along Okanagan River. Low lake elevation also affects water intakes around the lake.

These same water intakes, especially those around Okanagan Lake can be rendered inoperable should water elevation become too high, flooding pump houses.

Survival of rearing sockeye fry

High water temperatures and low oxygen levels, which can establish in Osoyoos Lake in particularly warm summers, are detrimental to rearing sockeye fry and limit their potential to survive. Pulse releases of water in the range of $30\text{-}36 \text{ m}^3 \cdot \text{sec}^{-1}$ in July and August are hypothesized to alleviate these rearing limitations. To be effective, a summer pulse release should continue for as long as is required to inject approximately 128 million m^3 of water into Osoyoos Lake. An alternative hypothesis is that total inflow to Osoyoos lake from July 1 to September 30 of approximately 145 to 167 million m^3 may also be sufficient to alleviate rearing limitations (i.e., average water releases to Osoyoos Lake of $18\text{-}22 \text{ m}^3 \cdot \text{sec}^{-1}$ July through September). The exact time weighted distribution of the inflow required within this summer/early fall period is the subject of ongoing adaptive management investigations.

Tactically, these releases are only possible in certain classes of inflow years (not possible in very dry years), and are only plausible in average, below-average water years when the water manager has considered the potential need for these pulse releases early enough in the spring, and hedged enough water in reserve. In other words, during the spring fill period the water manager would need to err on the *higher* side of full pool to realize enough water in storage to permit release of this volume during the summer months without excessively drawing down Okanagan Lake. In practice therefore, a change in risk attitudes related to the balance of flood protection vs. fish population survival needs may be required.

Figure 2.1 provides the geographic context for the objectives and trade-offs introduced above. Further details on inflow hydrology and the biophysical consequences of water supply variations are discussed later in this chapter and in Chapter 3.

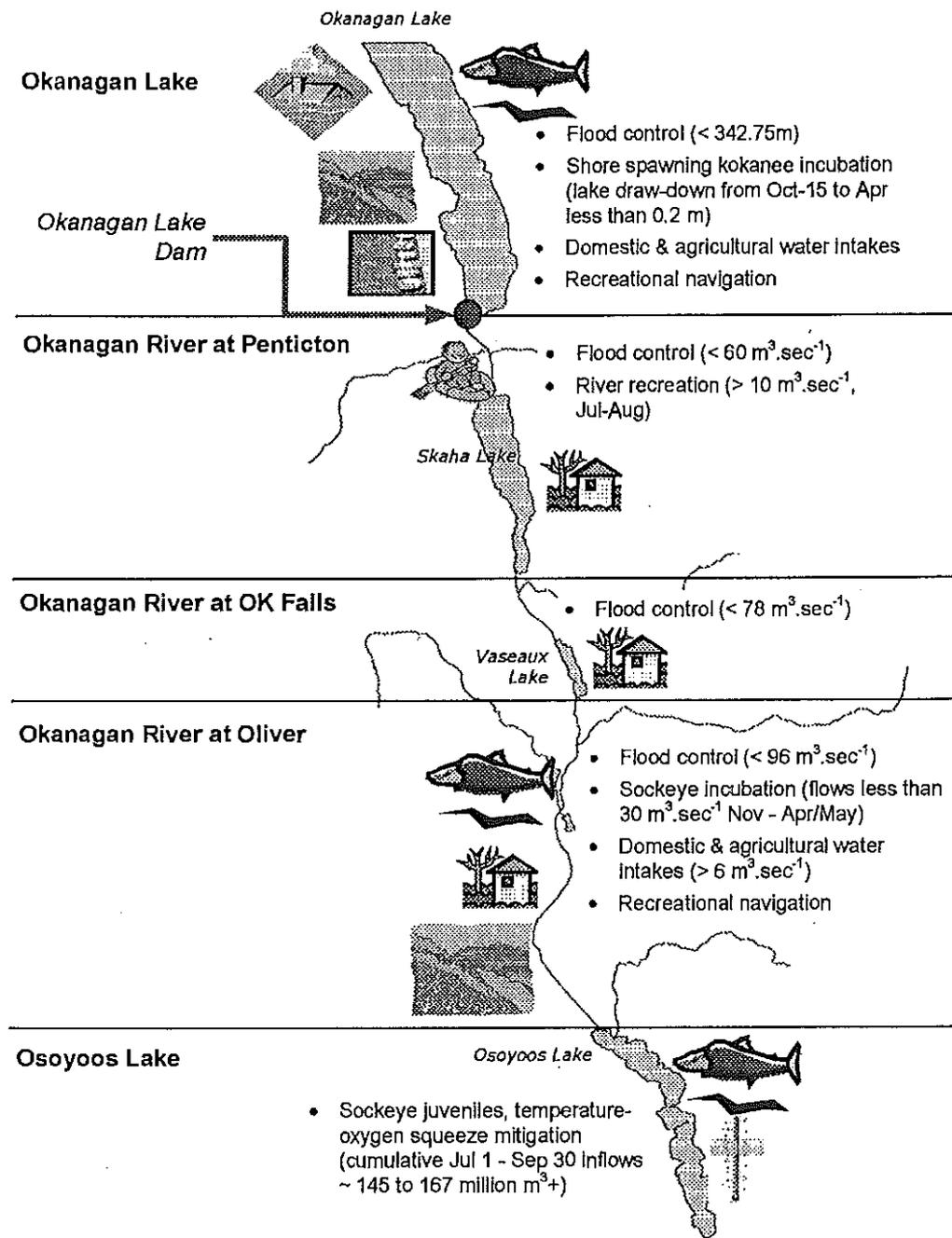


Figure 2.1. The five sections of Okanagan basin that are included in OKFWM. The bullet points summarise the key fish/water management objectives that must be considered within each section.

OBA operating guidelines (pre-FWMT)

In addition to the general objectives outlined above, the water manager has specific operating guidelines for Okanagan Lake water level and Okanagan River discharge at Penticton, Okanagan Falls, McIntyre Dam, and Oliver. The Canada-British Columbia Okanagan Basin Implementation Agreement (OBIA 1982) recommended managing Okanagan Lake and Okanagan River using the following guidelines:

Okanagan Lake

- The normal operating range of Okanagan Lake is 341.3 m to 342.5 m in all but anticipated extreme flood years and successive drought years.
- If high inflows are anticipated, the lake may be drawn down to 341.0 m.
- During prolonged drought, the lake may be drawn down to 340.4 m.
- Target water level on February 1 is 341.8 m.
- To protect the kokanee, the target water level for end-July is 342.3 m and on October 15 the target level is 341.9 m.
- To protect spawning kokanee, the drawdown between October 1 (beginning of week 40; week 1 begins on January 1) and February 28 should be less than 0.15 m if possible (in years in which anticipated spring inflow is low or normal, it should be possible to meet this constraint).

Okanagan River

To protect spawning and juvenile sockeye salmon, the OBIA identified the following—loosely biologically relevant—discharge guidelines (as measured at Oliver):

- During sockeye migration the flow at Oliver should be maintained between $10.5 \text{ m}^3 \cdot \text{sec}^{-1}$ and $28.3 \text{ m}^3 \cdot \text{sec}^{-1}$ for August 1 to 31 (i.e., beginning of week 31 to within week 35), and between $9.1 \text{ m}^3 \cdot \text{sec}^{-1}$ and $28.3 \text{ m}^3 \cdot \text{sec}^{-1}$ for September 1 to 15 (Brian Symonds, pers. comm. 2002).
- During sockeye spawning (September 16 to October 31) the flow at Oliver should be maintained between $9.9 \text{ m}^3 \cdot \text{sec}^{-1}$ and $15.6 \text{ m}^3 \cdot \text{sec}^{-1}$.
- During sockeye incubation and emergence (November 1 to April 30) the flow at Oliver should be maintained between $5.0 \text{ m}^3 \cdot \text{sec}^{-1}$ and $28.3 \text{ m}^3 \cdot \text{sec}^{-1}$ (but not less than 50% of the September 16 to October 31 inflow to avoid de-watering).
- No fisheries guidelines are in effect between May 1 and July 31 (e.g., water quality limitations in Osoyoos Lake are ignored).

These OBIA operating guidelines pre-date the Fish/Water Management Tools (FWMT) program. By using the OKFWM system, the water manager can better balance flooding, fisheries, navigation and water supply objectives. In many types of water years, this cannot be achieved by stringent application of the operating guidelines above.

Annual management cycle

A water year begins on October 1 when sockeye and kokanee begin to spawn and continues through to the end of November when sockeye fry complete a critical portion of their first year of rearing in Osoyoos Lake. Over this time-frame, the intensity and significance of fish/water decisions are not even. It is helpful to think of a water year as having three major phases:

1. *A winter drawdown phase lasting from October 1 to January 31;*
2. *A spring inflow phase from February 1 to June 30; and*
3. *A summer recovery phase from July 1 through September 30.*

Winter drawdown phase

The water manager should adjust winter drawdown of Okanagan Lake according to (i) real-time inflow information; and (ii) the manager's subjective judgement of observed information (e.g., early snow pack, antecedent (or background) ground moisture, previous year's lake elevation).

More drawdown will provide the water manager with greater flexibility during the spring inflow phase (but will come at the expense of shore-spawned kokanee eggs and could also result in missing full pool or downstream water shortages in the summer). In contrast, less drawdown means the water manager might have to release a lot of spring inflow in a short window of time. This generally exposes the water manager to a higher risk of lake and/or down-river flooding, often causing unacceptable levels of sockeye mortality from scour. Ultimately, the magnitude of winter drawdown is a matter of experience.

One important guideline is to pay particularly close attention to the trajectory of lake elevation between the first week of March and the third week of April.

There is moderate to extreme flood hazard when all three of the following occur simultaneously from approx. March 1 to April 21:

1. Okanagan Lake's elevation remains constant (or increases);
2. Okanagan Lake dam outflows are in the range of 18-30 m³.sec⁻¹; and
3. Okanagan Lake's elevation is greater than 341.6 m.

In most years, the water manager should aim for a declining slope in lake elevation from November to April 21 to "make room" for freshet inflows. The rate of this decline varies depending on inflows and the emphasis placed on flooding vs. fisheries objectives (See Key objectives & trade-offs).

Spring inflow phase

The importance of each of the three phases varies depending on the type of water year (dry, average or wet; see subheading below). In general however, the spring inflow phase (February through June) requires the most frequent adjustments to Okanagan Lake dam outflows and the greatest number of decisions to balance the water system. Climatic conditions and inflow can

change rapidly during this phase. Hence, water releases from Okanagan Lake dam require adjustment as often as every 2-3 days during specific intervals of the spring inflow phase.

The spring inflow phase corresponds with the start of BC Ministry of Environment River Forecast Centre (RFC) seasonal inflow estimates. The RFC conducts snow surveys at the beginning of each month from January through June with additional small surveys on May 15 and June 15. Within about 4-6 days of these surveys, the RFC predicts the net amount of run-off on February 1, March 1, April 1 and May 1. For the Okanagan basin, these forecasts represent net inflows from the date of the forecast through to July 31.

Summer recovery phase

When the summer recovery phase begins sometime in July, the water manager's decisions about water releases are generally the least complicated of the three phases. The primary goal is to again drawdown Okanagan Lake to its October target levels (or risk flooding the next year).

In hot dry years, however, the summer recovery phase can involve important decisions. In this case, the water manager must ensure adequate flows for water withdrawals along Okanagan River, be prepared to provide a significant pulse release to Osoyoos Lake to improve sockeye survival, and meet trans-border flow obligations to the United States (Table 2.1). The water manager must also consider flows for spawning sockeye salmon by ensuring that the discharge near Oliver at the end of September is less than twice the expected average flow between October and April. (Otherwise, an unacceptable proportion of deposited sockeye eggs may be de-watered.)

Table 2.1. Recommended minimum trans-border flows and minimum flows at Oliver to meet trans-border flows. These targets originate from the non-binding cooperation plan between the Province of British Columbia and the State of Washington.

Month	Minimum Daily Flow (m³/sec)	Minimum Daily Flow at Oliver required to meet the transborder flow (m³/sec)
January	1.00	3.00
February	1.00	4.00
March	1.00	4.00
April	1.00	4.00
May	1.00	4.00
June	1.00	4.00
July	1.00	4.00
August	1.00	4.00
September	1.00	4.00
October	1.00	4.00
November	1.00	4.00
December	1.00	4.00

Source: Province of British Columbia and State of Washington (1980)

Wet, dry and average years

When the first RFC inflow estimates are made shortly after February 1, fish/water managers get the first indication of the type of water year that may lie ahead: dry, average or wet. The toughest years in which to manage multiple objectives are wet years (net February 1 to July 31 inflow approaching 800 million m³). In these years, there must be a tight emphasis on flood management, and there are very limited opportunities to consider other flow management objectives.

Dry years are also challenging for making water release decisions. Failure to hold sufficient water during the winter drawdown phase in a hot dry year will leave the water manager impotent to direct pulse releases in July and August. Without the ability to provide these pulse releases, the water manager cannot mitigate for sockeye mortality from the temperature-oxygen squeeze in Osoyoos Lake. However, even if the water manager tries to hold water over the winter, summer pulse releases are not feasible when net February 1 to July 31 inflows are below roughly 310 million m³. So, the bracket for having greatest flexibility to balance multiple objectives is in the range of 310 million m³ to 800 million m³ (Hyatt and Alexander 2005). Summer pulse releases are discussed in greater detail in Chapter 4.

Average years pose their own challenges, especially when the water manager is trying to reach an optimal balance of trade-offs among all the objectives. Relatively speaking, however, the importance of *knowing* inflow in these years is not as significant as for wet and dry years.

To avoid lakefront flooding, lake elevation must be drawn down more in wetter years and less in average and dry years. The key challenge, however, is that the water manager does not know and cannot reliably determine the exact nature of the water year (magnitude and timing of inflow) during the winter drawdown phase. Thus, the default is to follow average winter lake elevation targets recommended either by the Canada - British Columbia Okanagan Basin Agreement (OBA) or learned and handed down from previous water managers (Table 2.2).

Table 2.2 shows that the all-year average drawdown of Okanagan Lake between October 15 and May 31 is approximately 0.28m (0.19m from October 15 to January 31). Between May 31 and June 30, Okanagan Lake increases in elevation by approximately 0.25m. This highlights the significance of spring runoff. One way to think about the variation in these numbers, is to recognise that 1 standard deviation in lake elevation at the end of June is +/- 0.24 m. (This reflects cumulative uncertainty in all dates prior to June 30, not just variation at the end of June). This value is significant considering the knife-edge flood damage that begins to accumulate shortly after Okanagan Lake exceeds the full pool elevation (342.53 m) typical of this time of year. In other words, in practice, there really isn't such thing as an "average" year.

Detailed strategies for coping with wet, dry and average water years are discussed in Chapter 4.

Table 2.2. Okanagan Lake water elevation targets by time of year, including all-year average values. Bold values represent targets for the winter drawdown phase, a time when there is little reliable information for inflow forecasts. The italicised values represent "the critical window", a time-period during which water managers should try to lower Okanagan Lake elevation.

Date	Target (m)	30 Year Average Target Elevation (m)
October 15	241.52 (241.5)	241.75
November 15	241.8	241.75
December 15	241.8	241.74
January 31	241.77	241.69
February 28	241.7	241.72
March 27	241.55	241.66
April 30	241.5	241.65
May 31	241.47 (241.5)	241.72
June 30	241.42 (241.5)	241.81
July 31	241.5	241.85
August 31	241.7	241.75
December 31	241.65	241.65

On the following page, Figure 2.2 provides a generalised timeline summarising the key events and considerations during a water year.

Okanagan Lake/River Water Management

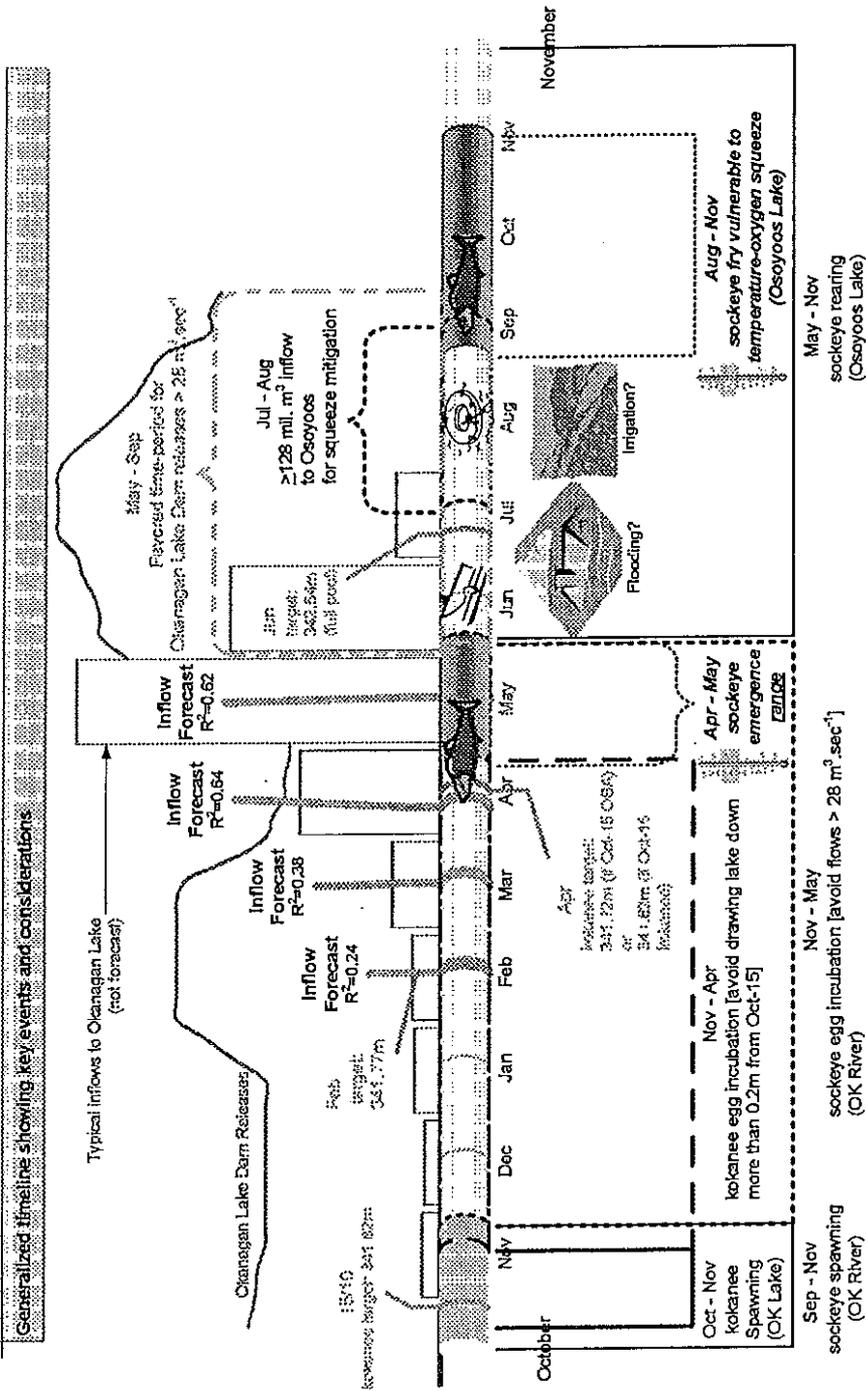


Figure 2.2. Timeline for the annual management cycle of Okanagan basin, illustrating flood management, fisheries, irrigation and recreation considerations. The timing of various life-history intervals for kokanee and sockeye are not fixed—they vary year to year. A stylised Okanagan Lake dam release pattern is shown in red. The monthly net inflows (vertical bars) refer to actual average net inflows on a given month (not the inflow forecast). This pattern is highly variable year to year. The inflow forecasts for February, March, April and May refer to the dates of those provided by the River Forecast Centre. Figure 2.1 provides the geographic context.

Net inflow to Okanagan Lake

The timing and magnitude of spring inflows to Okanagan Lake are the two biggest uncertainties in fish/water management in the Okanagan basin. The River Forecast Centre (RFC) estimates from snowpack measurements are helpful, but because they use limited data to forecast inflows over several months, they are not exact. This is demonstrated by comparing the forecast flows to the actual flows that occurred from 1974 to 2002 (Figure 2.3). The RFC estimates are least reliable in February (lowest R^2 value) and most reliable in April and May (highest R^2 values).

Data back to 1921 show the large interannual variability in net inflow to Okanagan Lake (Figure 2.4), and within each of these years, there is also considerable seasonal variability (Figure 2.5). The combination of interannual and seasonal variability in net inflows is the primary reason for the wide envelope observed in historical lake elevations (Figure 2.6) and in Okanagan Lake dam release patterns (Figure 2.7).

The OKFWM system helps to address the uncertainties by projecting the consequences to Okanagan basin objectives according to both a low (mean - 1SE) and a high (mean + 1SE) RFC forecast. **It is critical for the water manager to know whether the low or the high forecast is the best one to follow. This involves leveraging real-time inflow information to update these prior expectations,** a task that is possible using the OKFWM system. In practice, this involves comparing matched time period forecasts of net inflows with actual net inflows and making assumptions about whether the trend observed to date is expected to continue and whether the average, low or high inflow forecast is most representative.

There are no hard and fast rules, but in general, if the water year is noticeably drier than forecast, then the low RFC forecast should receive more weight. If the water year is wetter than forecast, then the high RFC forecast should receive more weight.

Once the water year advances to April and May, it is possible to update the mean RFC inflow estimates with real-time inflow data. This is an advanced technique involving OKFWM's weekly net inflow report, and should only be performed by a senior hydrologist or other competent individuals. **The point is, ignoring real-time inflow data (i.e., strict anchoring to RFC inflow forecasts) once the snowpack is no longer accumulating (generally April and May) will result in poorer water management performance.**

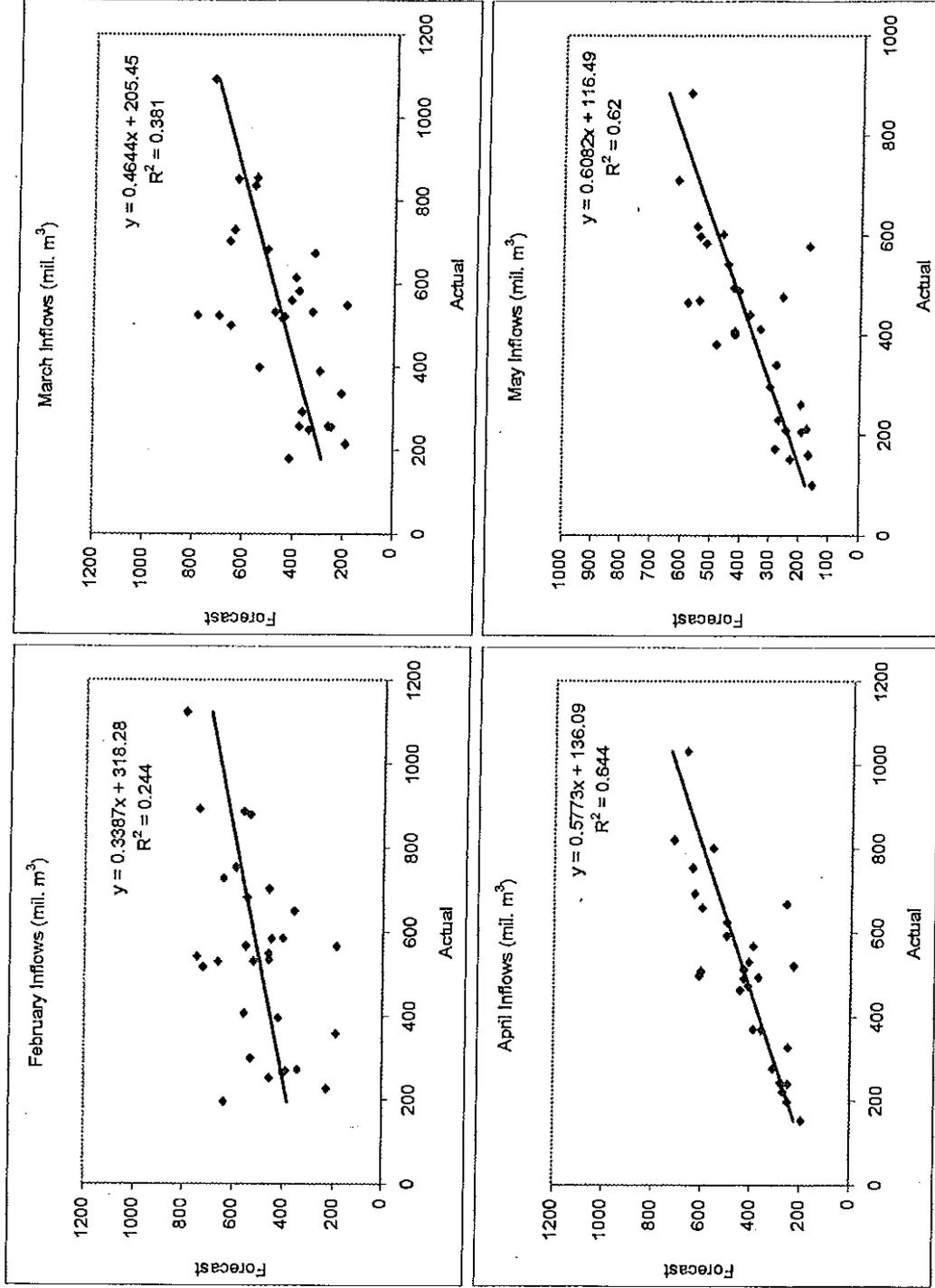


Figure 2.3. Comparison of the River Forecast Centre's net inflow forecasts with actual net inflows (1974 to 2002).

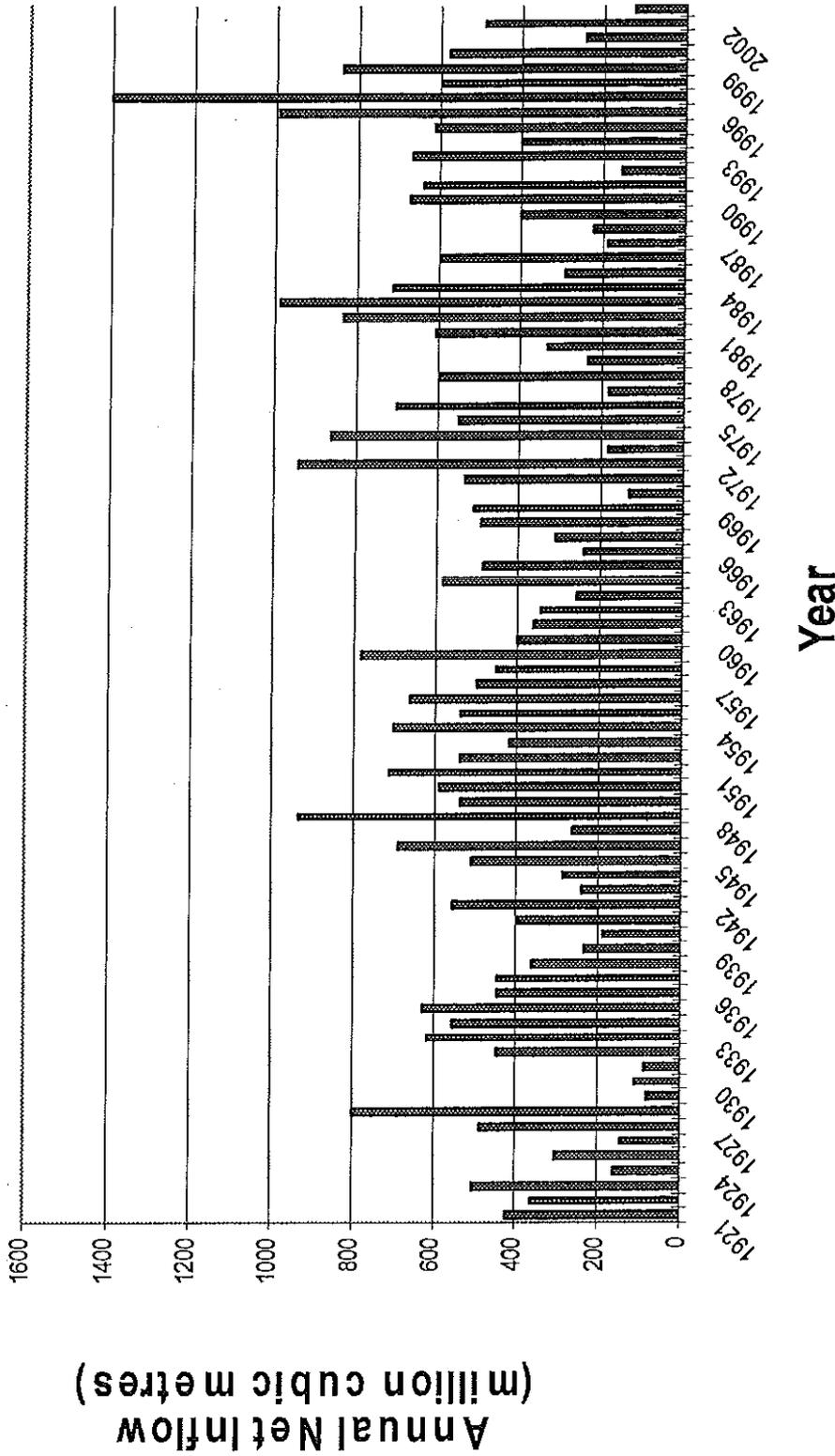


Figure 2.4. Okanagan Lake annual net inflows, 1921 to 2003.

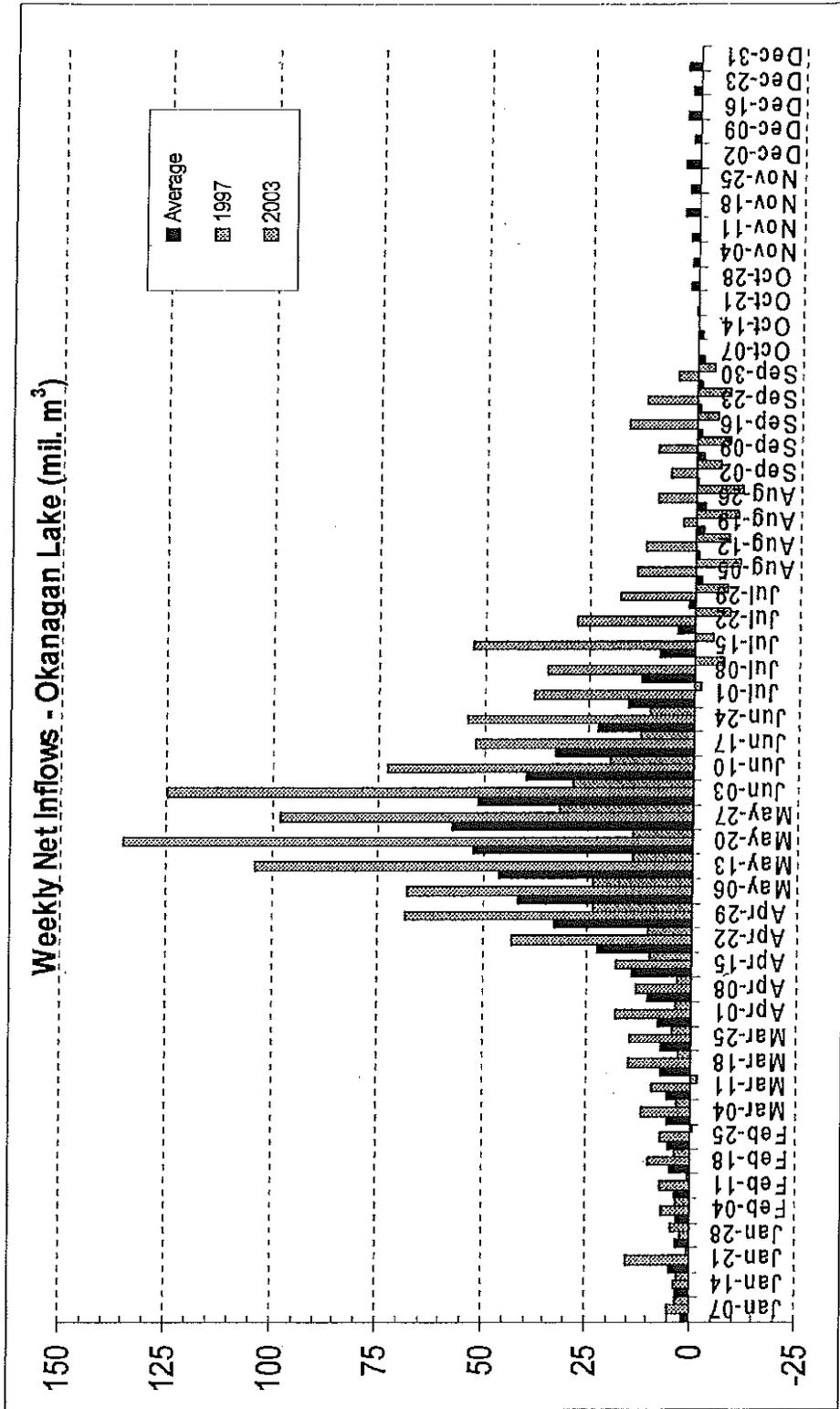


Figure 2.5. Mean and extreme year examples of the pattern of weekly net inflow to Okanagan Lake.

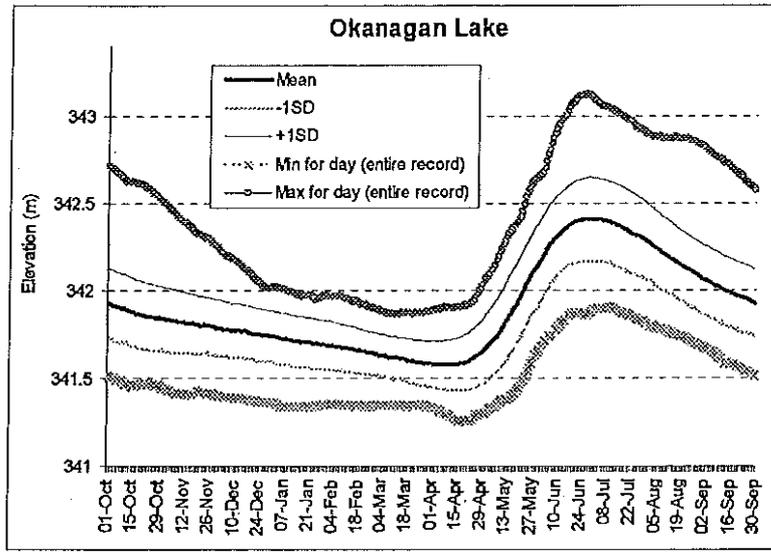


Figure 2.6. Mean and historical variation in Okanagan Lake water elevation (to September 2004). SD = standard deviation. (Note: min/max do not represent continuous time series—they are all-year daily extremes).

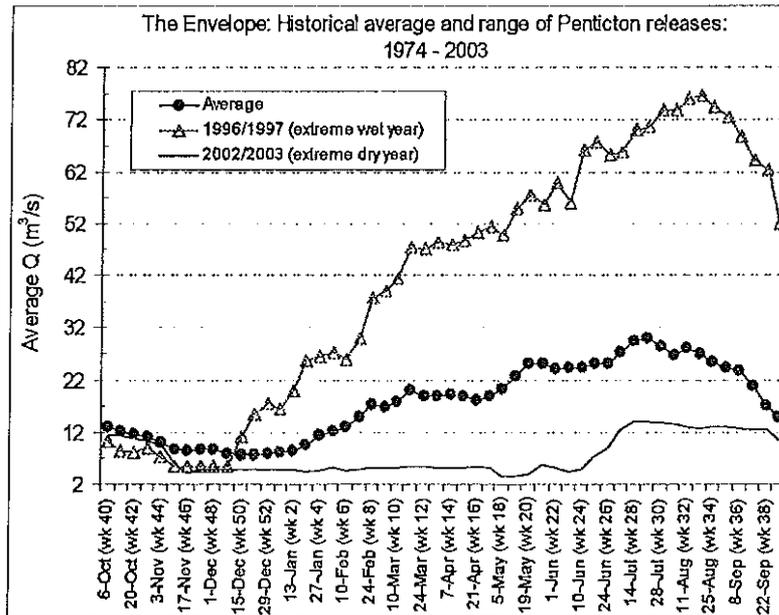


Figure 2.7. Mean and extreme year variation in Okanagan Lake dam outflow at Penticton. Q = discharge in $m^3 \cdot sec^{-1}$.

Relationship of net inflow to releases at Okanagan Lake dam

Individuals new to Okanagan Lake water management commonly ask: "What change should I expect in Okanagan Lake water elevation for a given outflow from Okanagan Lake dam?"

The answer depends on the actual net inflows that occur during the period when a particular lake elevation or river discharge target is being sought. Recognising this and the variability in inflows just presented, the following rules of thumb along with Table 2.3 are helpful:

Lowering Okanagan Lake's elevation

- If net inflows were exactly 0, Okanagan Lake could be lowered by approximately 1 cm by releasing $1.3 \text{ m}^3 \cdot \text{sec}^{-1}$ over 30 days.
- Stated more practically, Okanagan Lake could be lowered by approximately 1 cm by releasing net inflow plus $1.3 \text{ m}^3 \cdot \text{sec}^{-1}$ for 30 days.

Similarly, Okanagan Lake could be lowered by approximately:

- 2 cm by releasing net inflow plus $2.63 \text{ m}^3 \cdot \text{sec}^{-1}$ for 30 days.
- 3 cm by releasing net inflow plus $3.94 \text{ m}^3 \cdot \text{sec}^{-1}$ for 30 days.
- 4 cm by releasing net inflow plus $5.26 \text{ m}^3 \cdot \text{sec}^{-1}$ for 30 days.
- 5 cm by releasing net inflow plus $6.57 \text{ m}^3 \cdot \text{sec}^{-1}$ for 30 days.
- 5 cm by releasing net inflow plus $13.2 \text{ m}^3 \cdot \text{sec}^{-1}$ for 15 days.
- 5 cm by releasing net inflow plus $39.4 \text{ m}^3 \cdot \text{sec}^{-1}$ for 5 days.
- Under average October to January net inflows (approximately $3.5 \text{ m}^3 \cdot \text{sec}^{-1}$), the lake elevation could be lowered by almost 43 cm by running Okanagan Lake dam at its maximum design capacity of $60 \text{ m}^3 \cdot \text{sec}^{-1}$ for 30 days.
- Under average February to June inflows (approximately $38 \text{ m}^3 \cdot \text{sec}^{-1}$), the lake elevation would be lowered by just 16 cm by running Okanagan Lake dam at maximum release capacity of $60 \text{ m}^3 \cdot \text{sec}^{-1}$ for 30 days (*subject to the assumed inflow of $38 \text{ m}^3 \cdot \text{sec}^{-1}$).

Raising or maintaining Okanagan Lake's elevation

- Following typical releases from October through March ($6\text{-}22 \text{ m}^3 \cdot \text{sec}^{-1}$) and typical net inflows, Okanagan Lake should be expected to rise by approximately 0.77 m between April and June with releases from $22\text{-}26 \text{ m}^3 \cdot \text{sec}^{-1}$ and average net inflows for April through June of 449 million m^3 .
- *Hypothetically*, if Okanagan Lake dam releases were set to $0 \text{ m}^3 \cdot \text{sec}^{-1}$ for the entire water year and all-year average net inflows continued, Okanagan Lake's elevation would increase by approximately 1.62 m. (Conversely, lowering lake elevation by 1.62 m would require a one-month release of $213 \text{ m}^3 \cdot \text{sec}^{-1}$.)
- If all-year average net inflows occurred each month and releases were approximately $17.7 \text{ m}^3 \cdot \text{sec}^{-1}$ per month, there would be no net increase in Okanagan Lake's elevation by years end (though the level of winter drawdown would be excessive and summer full pool elevation would not be reached).

Table 2.3. All-year average net inflow by month to Okanagan Lake. In practice, these values are *highly* variable, especially between March and July. Note: the maximum design release capacity of Okanagan Lake dam at Penticton is $60 \text{ m}^3 \cdot \text{sec}^{-1}$. (At flood lake elevations, Okanagan Lake dam is capable of releasing $77\text{-}78 \text{ m}^3 \cdot \text{sec}^{-1}$).

Month	$\text{m}^3 \cdot \text{sec}^{-1}$
January	1.84
February	1.84
March	1.84
April	1.84
May	1.84
June	1.84
July	1.84
August	-1.84
September	-1.52

Water management guidelines: "Cheat Sheet"

The following material offers a quick reference for the major guidelines described earlier. These do not replace or substitute for the detailed knowledge and context specific discussions required to balance objectives. **If followed in isolation of year-specific information on inflows, water temperatures, and kokanee and sockeye brood strength, these guidelines may produce avoidable flooding or fisheries losses.**

Guideline 1: Do not fill Okanagan Lake above 342.75 metres.

Guideline 2: Avoid drawing down Okanagan Lake below 341.5 metres.

Guideline 3: Minimise the drawdown of Okanagan Lake between the time of peak kokanee shore spawning and the date of 100% fry emergence (~March/April). i.e., minimise de-watering of kokanee eggs and fry subject to guidelines 1 (above), and 8 and 9 (described below).

Guideline 4: Do not exceed $65 \text{ m}^3.\text{sec}^{-1}$ releases at Okanagan River, Penticton, to minimise the number of buildings flooded at and downstream of Penticton.
(*Note:* Okanagan Lake dam at Penticton is capable of water releases upwards of $78 \text{ m}^3.\text{sec}^{-1}$ under flood elevations. The $60 \text{ m}^3.\text{sec}^{-1}$ design level has been exceeded several times in the past).

Guideline 5: Provide summer flows for river recreation if possible (i.e., maintain flows of $20\text{-}30 \text{ m}^3.\text{sec}^{-1}$ in July through August), subject to satisfying ALL other guidelines.

Guideline 6: Adult sockeye migration—maintain flows at Oliver between $8.5\text{-}12.7 \text{ m}^3.\text{sec}^{-1}$ during Aug 1-Sept 15 to allow "easy" passage, subject to guidelines 1 and 2.

Guideline 7: Adult sockeye spawning—maintain flows between $9.9\text{-}15.6 \text{ m}^3.\text{sec}^{-1}$ during September 16-October 31 to maximise "good" spawning habitat, subject to guidelines 1 and 2.

Guideline 8: Sockeye egg and alevin incubation—keep flows between $5.0\text{-}28.3 \text{ m}^3.\text{sec}^{-1}$ between November 1 and the anticipated date of 100% emergence (~ April/May). i.e., incubation flows must be greater than or equal to 50 % of spawning flows & must not exceed $28 \text{ m}^3.\text{sec}^{-1}$ to avoid redd desiccation & scouring (respectively), subject to guidelines 1 and 2.

Guideline 9: Sockeye fry emergence and migration—maintain flows between $5.0\text{-}28.3 \text{ m}^3.\text{sec}^{-1}$ during February 16-April 30, subject to guidelines 1 and 2.

Guideline 10: Maintain adequate sockeye rearing habitat in Osoyoos Lake—under drought and early onset of temperature/oxygen "squeeze" (i.e., >93 consecutive days of Osoyoos Lake inflow water temperatures >17 Celsius), provide July-September cumulative flow above 145 to 167 million m^3 (~ $18\text{-}22 \text{ m}^3.\text{sec}^{-1}$) to avoid high mortality of rearing fry, subject to guideline 2.

Table 2.4 summarises some appropriate overall strategies based on net February 1 to July 31 inflows. Hyatt and Alexander (2005) provide evidence in support of these strategies. The primary challenge is *knowing* the true net inflow early enough for it to matter. We offer no hard and fast rules for this trick!

Table 2.4. Appropriate release strategies in accordance with *actual* net February 1 to July 31 inflow category. These strategies are discussed in chapter 4 as well as in Hyatt and Alexander (2005).

February 1 - July 31 Net Inflow Category	Recommended Release/Leakage Strategy
High	Reduce releases to meet the minimum required flow. If the minimum required flow is not met, then the minimum required flow should be met by increasing releases to meet the minimum required flow.
Medium	Reduce releases to meet the minimum required flow. If the minimum required flow is not met, then the minimum required flow should be met by increasing releases to meet the minimum required flow.
Low	Reduce releases to meet the minimum required flow. If the minimum required flow is not met, then the minimum required flow should be met by increasing releases to meet the minimum required flow.
Very Low	Reduce releases to meet the minimum required flow. If the minimum required flow is not met, then the minimum required flow should be met by increasing releases to meet the minimum required flow.
Very High	Reduce releases to meet the minimum required flow. If the minimum required flow is not met, then the minimum required flow should be met by increasing releases to meet the minimum required flow.

CHAPTER 3

Scope & Biophysical Basis of OKFWM Submodels

This chapter does not attempt a detailed explanation of the scope, objectives, data sources, functional relationships, algorithms and performance measures for OKFWM's five coupled biophysical submodels. This material is covered in depth in the Record of Design for OKFWM (see Alexander and Hyatt 2005). However, a thumbnail sketch of some of the cause and effect relationships is provided below for illustration. Readers wishing to go further are directed to the Record of Design.

The OKFWM tool is an internet-accessible, multi-user model for supporting decisions about water management in the Okanagan basin (Figure 3.1). Specifically designed for day-to-day use by water and fisheries managers, OKFWM provides a framework for choosing weekly water releases at Okanagan Lake dam. Using monthly inflow forecasts provided to Okanagan basin water managers by the Provincial Government's River Forecast Centre (RFC), these release decisions are then passed to the tool's five coupled biophysical models (Figure 3.2) to generate critical performance measures at a variety of lake and down-river sites.

In addition to holding parameters and lookup information for the tool's biophysical submodels, the databasc for the system is automatically updated each day with the actual recorded data for Okanagan Lake elevation, water temperatures and Okanagan River discharge at several sites. This real-time information feeds into the hydrology and water temperature components of the model to "self-correct" inflow forecasts and adjust forecasts for accumulated thermal units (ATUs) which determine the windows of vulnerability for developing sockeye and kokanee eggs.

The process of developing OKFWM has produced significant technical and cognitive advances in fish/water management in the basin. These advances would not have been possible without the unparalleled collaboration sustained by the Canadian Okanagan Basin Technical Working Group (COBTWG) and their partners over a 6-year period.

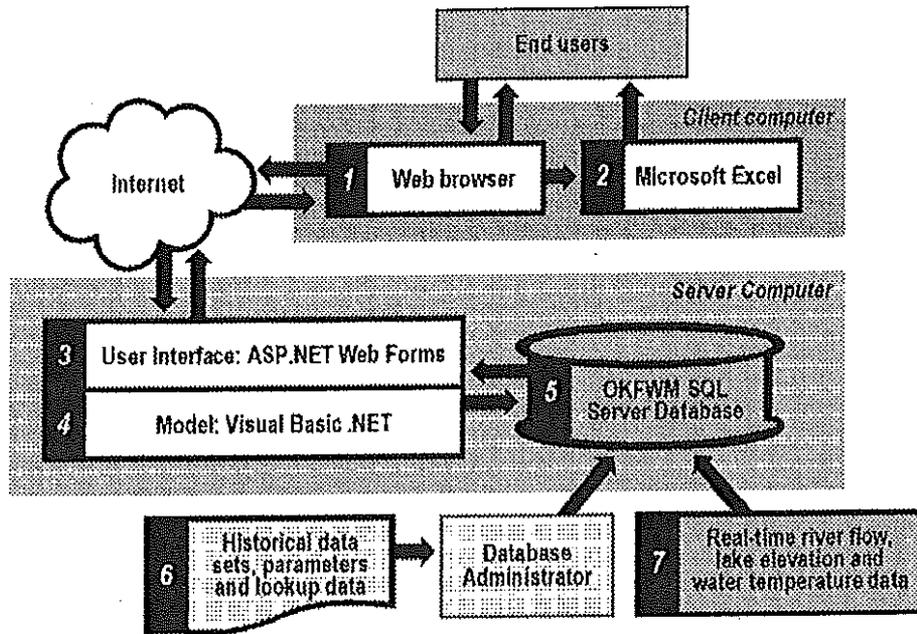


Figure 3.1. OKFWM system architecture. The system is built on the Microsoft .NET Framework, using ASP.NET for the web browser user interface (1, 3), VB.NET for application (submodel) logic (4) and Microsoft Excel for downloadable output reports (2). All data is housed in a single SQL Server 2000 relational database (5). A .NET Web service developed and managed by Environment Canada supplies the real time data to the OKFWM database (7). This data is further processed into daily average, minimum and maximum values by OKFWM.

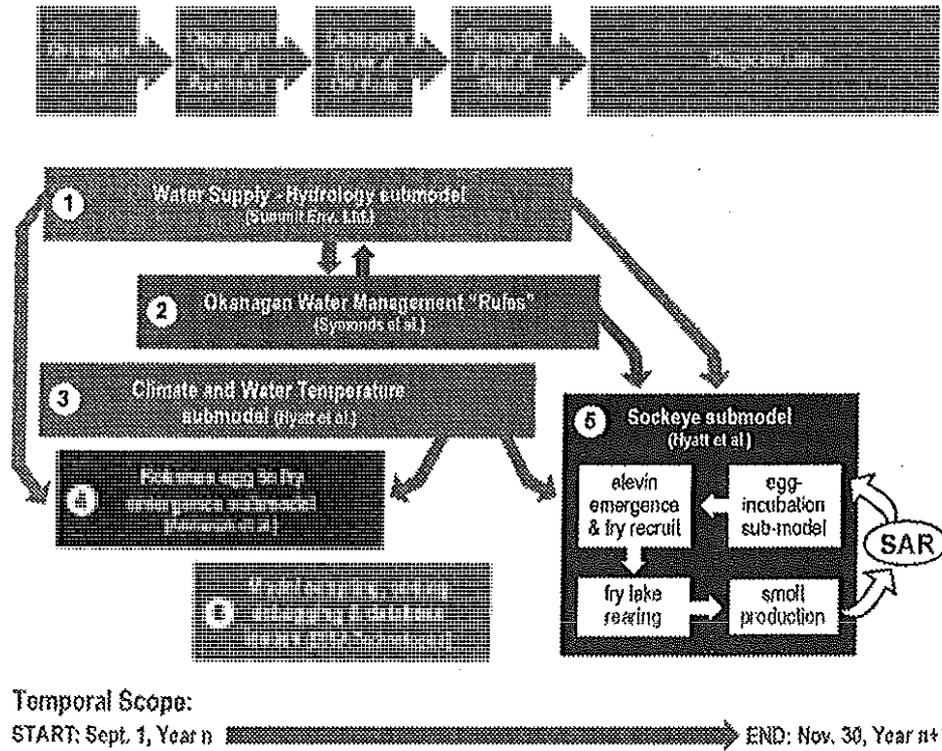


Figure 3.2. The OKFWM model is a coupled set of five biophysical submodels of key relationships (among climate/hydrology, water, fish and property) used to predict the consequences of water management decisions for fish and other water users. OKFWM may be used to explore water management decision impacts in-season, or in a retrospective or training mode looking back where the true daily historic inflows are known.

OKFWM submodels

All five submodels within the OKFWM system have been designed to make best use of empirical observations derived from locations (Okanagan Lake, Okanagan River), subjects (climate, hydrology, sockeye, kokanee), events (floods, drought) and processes (snowmelt, sockeye survival and growth, etc.) specific to the Okanagan basin. For example, predictions of sockeye egg losses associated with flood-and-scour or drought-and-desiccation events are based on functional relationships among discharge, bedload movement, desiccation and juvenile sockeye production outcomes observed for spawning beds in the Okanagan River. These empirical datasets used to inform functional relationships in OKFWM have been accumulated over several years to decades. Furthermore, OKFWM imports real-time/actual observations for several critical physical variables (lake elevations, river discharge and water temperature) on a daily frequency. These “true” observations are used in efforts to “self-adjust” projections of water temperatures and inflows. As a data rich model, expert opinion assumptions have been minimised, though certainly not eliminated.

Model predictions are not infallible and require ongoing efforts to verify achievement and maintenance of a satisfactory (i.e., useful) match between various OKFWM submodel predictions and corresponding empirical observations. Thus, OKFWM's predictions (e.g., year-specific sockeye and kokanee egg hatch and fry emergence times) require ongoing field verification for reliability given large annual variations in environmental conditions.

A brief overview of each of OKFWM's submodels and some of their critical functional relationships are provided below.

Temporal horizon and resolution

A fundamental concept in OKFWM is that of a "decision date". By design, the tool uses the best information available for any specified decision date. A decision date is the specific calendar date forward of which a user wishes to see a *forecast* of water release decision impacts. Events prior to this date have already happened, so a water manager is no longer able to influence them. Therefore, OKFWM ignores any water release decisions that may be specified prior to the decision date, and instead it shows the real-time lake elevations, river flows and water temperatures that actually occurred. These water values are obtained from field loggers operated by Environment Canada (Water Survey of Canada) and its partners (see Chapters 3 and 4 in Alexander and Hyatt 2005).

The temporal horizon for three of OKFWM's submodels is **October 1** of year n to **September 30** of year $n+1$ (12 months). Only the temperature and sockeye submodels extend to **November 30** of year $n+1$ (14 months). As an in-season management tool, OKFWM is not structured to perform multi-year simulations.

The temporal resolution of OKFWM involves mixed weekly and daily time-steps. *Prior to a given decision date*, all submodels operate on a daily time-step. When forecasting, the fundamental temporal resolution of OKFWM's submodels is weekly, except for the temperature submodel which provides forecasts on a daily resolution. An important feature of the water supply/hydrology submodel is the use of standardised (fixed) weeks. The water supply/hydrology submodel's forecasts of river flows in some cases provide minimum, average and maximum weekly values. Likewise, all water values are provided on a daily minimum and maximum basis within the real-time period. These daily minima and maxima are obtained on 15 minute to hourly intervals (the interval of measure by WSC loggers).

Water supply / hydrology

The role of the water supply / hydrology submodel within the overall OKFWM system is to identify the relative impact of water management decisions on: 1) Okanagan Lake elevations; and 2) Okanagan River discharge at several points of interest. Accordingly, the water supply/hydrology submodel uses forecasts of inflows, updated with real-time hydrologic data to determine lake elevation and river discharge consequences associated with alternative Okanagan Lake dam water releases.

The spatial extent of the water supply / hydrology submodel includes the entire watershed of Okanagan Lake and Okanagan River upstream of Osoyoos Lake and including the north basin of

Osoyoos Lake. However, submodel calculations are performed only at specific locations within the watershed:

- the shoreline and immediate surroundings of Okanagan Lake;
- Okanagan River at Penticton;
- Okanagan River at Okanagan Falls; and
- Okanagan River at Oliver.

OKFWM's water supply / hydrology submodel is the only one that implements user management actions: changes to the weekly water releases at Okanagan Lake dam. Other water control structures were considered (Skaha, Vaseux) but ignored, as Okanagan Lake dam dominates. Also, tributary inflows below Okanagan Lake dam are incorporated, but they are beyond management control. The special ability of the OKFWM tool to incorporate real-time hydrometric and water temperature data to self-adjust forecasts aids in modifying the schedule of releases as a water year progresses. These water release policies vary from year to year depending largely on the total volume and distribution of Okanagan Lake inflow.

Approximately 95% of the total annual inflow to Okanagan Lake occurs in the 6-month period between February 1 and July 31. The key annual indicator of the magnitude of this inflow is provided by the RFC at four intervals. These externally-derived forecasts of the total lake inflow from the RFC are made February 1, March 1, April 1, and May 1 and cover the period from the forecast date to July 31. These forecasts are provided to members of the OKFWM Operations Group in the form of an expected value, a high estimate and a low estimate (the high and low estimates represent the mean ± 1 standard error, respectively). These values are entered on the model's "Inflow" tab (see Chapter 6).

The authors of the submodel (Guy et al. 2005 as cited in Alexander and Hyatt 2005) developed the following procedures or algorithms:

- a means of disaggregating total seasonal Okanagan Lake inflow forecasts provided by the River Forecast Centre (RFC) (for the periods February 1 to July 31, March 1 to July 31, April 1 to July 31, and May 1 to July 31) into weekly estimates;
- an estimate of the weekly distribution of lake inflows for the remainder of the year (August 1 through January 31);
- a means of predicting future weekly changes in the elevation of Okanagan Lake, based on the forecasts of weekly lake inflow and a series of weekly outflows at Okanagan Lake dam at Penticton specified by the user;
- a means of predicting future weekly inflow from tributaries to the Okanagan River downstream of Penticton and upstream of Okanagan Falls, as well as the resulting weekly average and total discharge of the river at Okanagan Falls; and
- a means of predicting future weekly inflow from tributaries to the river downstream of Okanagan Falls and upstream of Oliver, as well as the resulting weekly average and total discharge of the river at Oliver.

These hydrological models form the backbone of forecast water supply assumptions in the OKFWM system and are used to calculate weekly values of inflow to Okanagan Lake, Okanagan Lake level, and discharge of Okanagan River at Penticton, Okanagan Falls and Oliver.

Water temperature

The role of the temperature submodel is to forecast water temperatures at several points of interest and replace and correct these forecasts as real-time water temperature information is made available during a water year. These water temperatures are used principally in the kokanee and sockeye submodels to determine peak spawn dates, fry hatch and emergence dates, and in the case of the sockeye submodel, fry rearing conditions in Osoyoos Lake. The water temperature submodel supplies a crucial biophysical linkage for determining “windows of vulnerability” to water management decisions for kokanee and sockeye, as well as the need for Osoyoos Lake flow mitigation to improve in-lake rearing conditions.

Specifically, three aquatic habitat locations were of interest: 1) Okanagan Lakeshore where kokanee spawn; 2) Okanagan River downstream of McIntyre Dam where adult sockeye spawn; and 3) Okanagan or Osoyoos Lake habitats where juveniles of both species rear. The northwest quadrant of Okanagan Lake was chosen by Ministry of Environment biologists as the most suitable for gauging temperatures that drive maturation of incubating shore-spawned kokanee eggs. For incubating Okanagan River sockeye salmon, temperatures taken near Okanagan Falls are used.

The submodel uses long-term air temperature records as its foundation to reconstruct historic seasonal water temperature regimes prior to 2002 for the aquatic locations relevant to Okanagan kokanee and sockeye salmon. After 2002, real-time water temperature values are obtained directly from field sites.

The authors of the temperature submodel (Hyatt et al. 2005 as cited in Alexander and Hyatt 2005) developed season-specific sets of linear and non-linear air-water temperature regression models for reconstructing past water temperature values (Table 3.1). Details are available in Alexander and Hyatt (2005).

Table 3.1. General method used for air-to-water temperature reconstructions at Okanagan Lake, Okanagan River near Oliver, and Osoyoos Lake.

Incubation period for water temperature	Regression model
Incubation period for kokanee eggs	Linear, 2 variable regression
Incubation period for sockeye eggs	Linear, 2 variable regression
Incubation period for sockeye fry	Linear, 2 variable regression

Kokanee

The role of the kokanee submodel is to identify the potential for shore-spawned egg mortality associated with fluctuations in Okanagan Lake levels during the incubation period. Kokanee populations below Okanagan Lake are not explicitly incorporated by the submodel, but they are assumed to benefit from downstream water management decisions in the same way as sockeye salmon. Further, the fate of kokanee fry post swim-up (emergence) in the in-lake phase is beyond the scope of the submodel.

Key limiting factors for the adult population abundance of shore-spawning kokanee are lake drawdown and lake carrying capacity. The OKFWM kokanee submodel simply considers the impacts of water storage and release decisions on egg survival, *not* in-lake kokanee survival which is dependent on many other factors unrelated to water management decisions at Okanagan Lake dam.

There have been some field investigations of the actual depth that shore-spawned kokanee eggs are deposited. Matthews and Bull (1981) found that the majority of eggs were located 10-30cm down in the substrate. Harris (1984) found alevins at 30cm below substrate. The most comprehensive investigation of egg deposition depth was made by Dill (*in* Ashley et al. 1998) who found eggs were usually at an average depth of 15cm below substrate. Alevins were found at two sites ranging in depth from 7.5-24cm depending on the depth of a fine silt layer below the rock substrate. The depth of egg deposition below substrate (e.g., 15cm) provides a “cushion” against some drawdown.

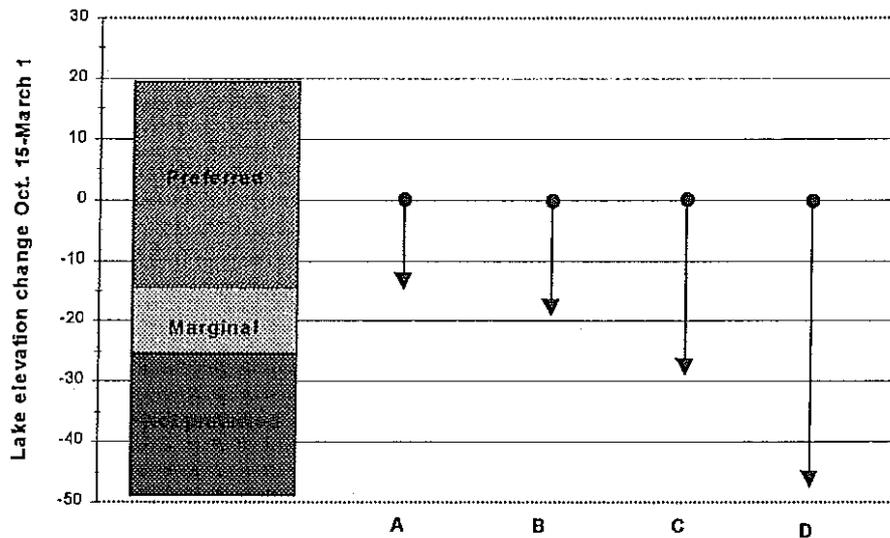


Figure 3.3. Generalised model showing acceptability of declining lake levels from October 15 to March 1. “A” indicates preferred lake drawdown, “B” represents a less acceptable drawdown, “C” is marginally acceptable, and “D” is not preferred.

Figure 3.3 provides the recommended lake drawdown guidelines to protect incubating kokanee eggs by illustrating the acceptability of various degrees of drawdown. The figure takes into account that the depth of spawning can occur in water less than 10cm but the majority at 25-75cm. Thus, a decline of only 15cm, which took place from October 15-March 1 in 2001-2002 would result in little, if any, impact. A 20cm change causes some minor egg loss while changes > 30cm cause unacceptably high losses.

Based on historical drawdown analyses, the preferred lake elevation at the onset of spawning (~ October 15 to 21) is 341.82m with the lake then being held as close to this level as is safe from a flood management perspective until emergence (~ mid-March to April, depending on water temperatures during incubation).

Egg emergence timing varies from year to year, but it is unlikely that the variation would be greater than two weeks from that illustrated in Figure 3.4 and Figure 3.5.

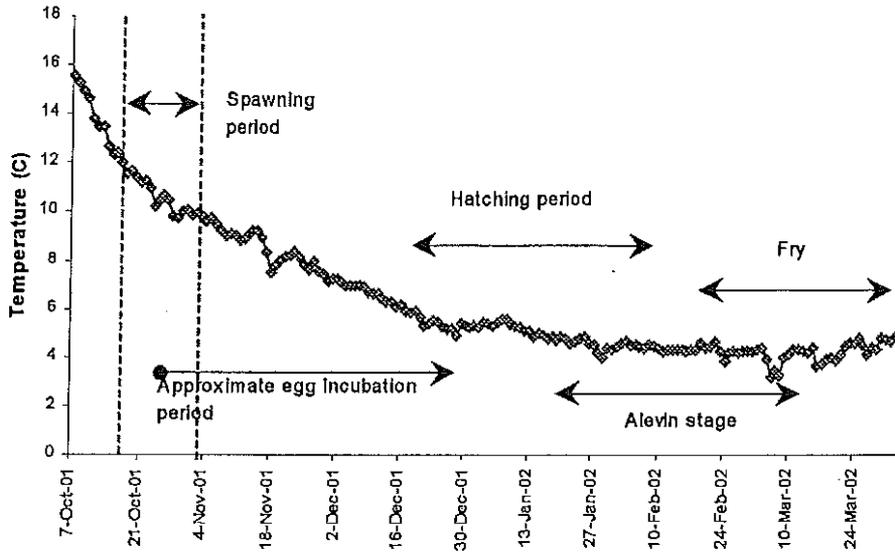


Figure 3.4. Mean daily surface water temperature (°C) recorded at Bertram Park, Okanagan Lake, October 2001 to April 2002. Note: kokanee shore spawning illustrated from October 16 to November 2, 2001 and range of developmental stages approximated.

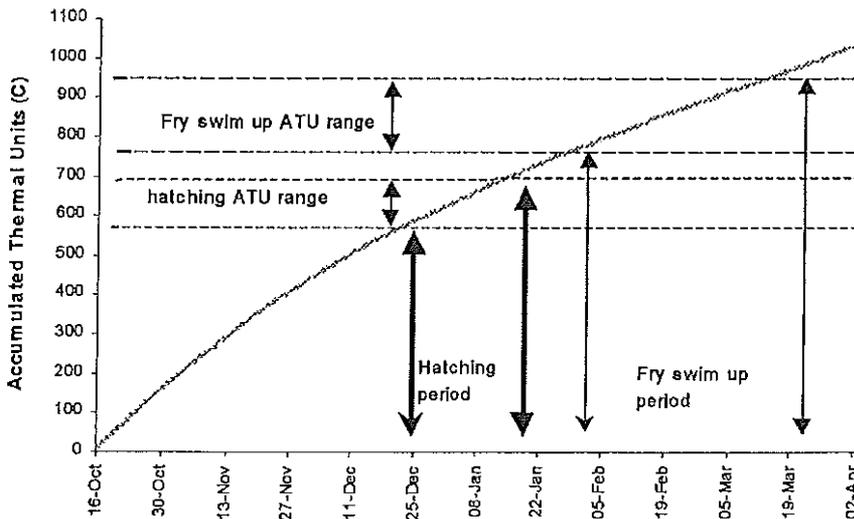


Figure 3.5. Accumulated thermal units (ATUs) experienced by 2001 Okanagan Lake shore spawning brood. Emergence and swim-up dates indicated are ranges based on 2001-2002 results and Smith (1978), Matthews and Bull (1981), Dill (1996, 1997, 1998) and G. Gale (pers, comm. 2002) using actual 2001-2002 temperatures from Bertram Park site.

Considering the analyses above, especially more recent data for 2003-2005 (not shown), the Provincial Ministry of Environment recommends using water temperatures from the NW quadrant of Okanagan Lake when calculating accumulated thermal units (ATU). Also, in consideration of Figure 3.5, a 950°C ATU threshold is recommended for determining the date of 100% emergence.

Sockeye

The role of the sockeye submodel within the overall OKFWM system is to identify the relative impact of water release decisions on: 1) annual production variations of Okanagan River/Osoyoos Lake sockeye salmon; and 2) to explore the potential smolt production benefits that might be obtained by modifying these decisions. Accordingly, the sockeye submodel provides a framework for capturing information about variations in water supply years, alternative water management scenarios and the consequences for sockeye production (expressed in terms of annual fry recruitment and in smolt production per female from a given brood year of adults). The submodel does not consider subsequent mortality factors operating seaward of Osoyoos Lake after the juvenile overwintering period.

The existing OBA anticipates impacts of flow on sockeye life history events (migration, spawning, egg incubation, fry emergence) by assuming that events occur within a *fixed* calendar-interval every year. Given the availability of year-specific spawning, flow and temperature data, today's water managers have much better information at their fingertips to refine weekly water release decisions.

The sockeye submodel uses flows in the Okanagan River (between Okanagan Lake and Osoyoos Lake) during spawning (September-October) to determine the capacity of spawning habitat for Osoyoos Lake sockeye spawners. Flows and water temperatures during incubation (November-May) are used to determine egg-to-fry losses associated with either desiccation or fry stranding events (e.g., Figure 3.6) or redd scour (Figure 3.7).

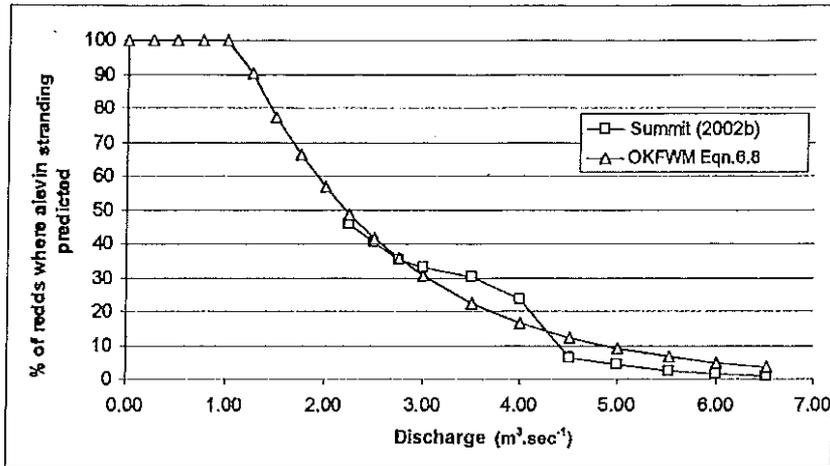


Figure 3.6 Discharge variations and predicted losses of alevins to stranding in the Okanagan River and the function used in OKFWM's sockeye submodel to represent the empirical field observations. Summit (2002b) refers to the foundation field study report that characterised the level of dewatering and stranding mortality. OKFWM Eqn 6.8 refers to an equation in OKFWM's Record of Design (see Alexander and Hyatt 2005).

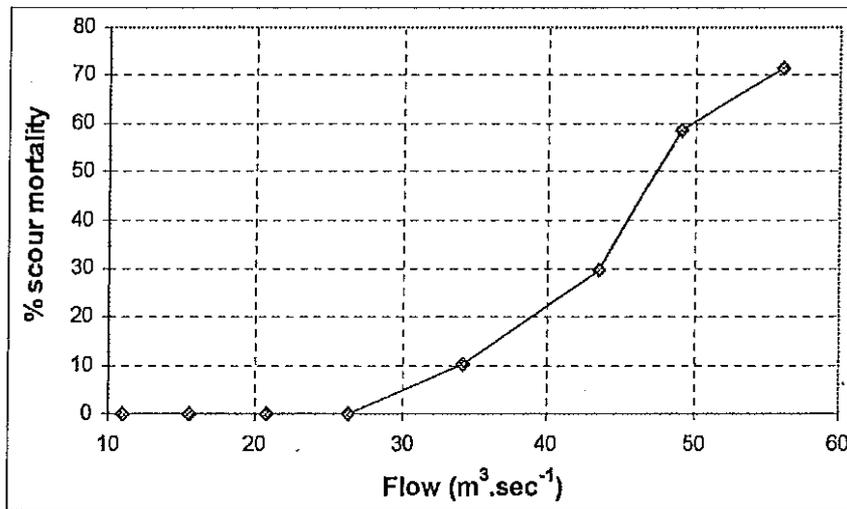


Figure 3.7. Relationship between % bed scour and flow. Source: Summit (2002c).

Estimates of the assumed start and end dates for sockeye life history stages that are vulnerable to scour or desiccation mortality in any given year are determined as follows:

1. Accumulate daily thermal units for each weekly egg cohort starting on the last day of the week in which the eggs were spawned. Daily water temperatures used for this purpose are provided by the temperature submodel. For historical water years, use actual (if available) or reconstructed mean daily water temperature at Okanagan Falls to

characterise the thermal regime experienced by developing eggs and alevins. However, the model uses a mixture of past and future water temperatures to estimate hatch and emergence dates for any current year in which incubation and emergence remains incomplete.

2. Accumulate ATUs for each cohort until they exceed the threshold for 100% hatch (525 ATUs, Beacham and Murray 1990). The week in which this happens becomes the hatching week for that cohort.
3. Continue to accumulate ATUs for each cohort until it exceeds the threshold for 100% emergence (875 ATUs, Andrusak and Matthews, as cited in Alexander and Hyatt (2005)). The week in which this happens becomes the emergence week for that cohort.

Egg desiccation and scour are evaluated for each week between the egg deposition week and egg hatching week; alevin desiccation and scour are evaluated for each week between hatch week and emergence week.

The acceptability of different levels of sockeye egg or alevin mortality owing to flow management-induced desiccation or scour are provided in Table 3.2. These thresholds are based on expert judgement and were approved by the Canadian Okanagan Basin Technical Working Group (COBTWG) Steering Committee in 2004.

Table 3.2. Thresholds used to define hazard ratings for sockeye submodel.

Parameter	Green	Yellow	Red
Desiccation mortality (eggs)	< 10%	10% - 15%	> 15%
Desiccation mortality (alevins)	< 10%	10% - 15%	> 15%
Scour mortality (eggs)	< 10%	10% - 15%	> 15%
Scour mortality (alevins)	< 10%	10% - 15%	> 15%

During the summer, Osoyoos Lake develops high temperatures in the epilimnion (> 17°C) and hypoxia in the hypolimnion (< 4 ppb O₂). This occurs subsequent to 100% fry emergence, but it has a major influence on the quantity and quality of habitat that is suitable for rearing by juvenile sockeye (Figure 3.8). Field observations have demonstrated that both the south and central basins of Osoyoos Lake become wholly unsuitable for occupation by juvenile sockeye during most of the late spring through to the fall growing season. Thus, the north basin of Osoyoos Lake appears to support virtually all of the fry-to-smolt production originating from Osoyoos Lake each year, but even this portion of the lake is subject to a late-season, temperature and oxygen “squeeze” (Figure 3.8).

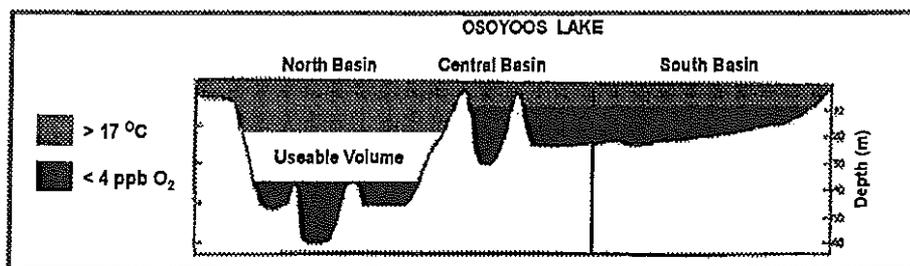


Figure 3.8. Stylised representation of the temperature-oxygen “squeeze” that commonly develops in Osoyoos Lake between September and November. *Source:* Hyatt et al in prep.

The useable volume (in millions m^3) of lake rearing habitat available in the north basin of Osoyoos Lake on a particular day is assumed to be a function of the cumulative number of days that Osoyoos Lake surface water temperatures equal or exceed $17^\circ C$ during the rearing period. To make this calculation, the temperature-oxygen squeeze period is assumed to end November 30.

After approximately 118 days of surface temperatures greater than $17^\circ C$, the useable rearing volume in the north basin of Osoyoos Lake is zero. This implies that there is *nowhere* in the lake that has suitable temperature and oxygen conditions for sockeye fry, and thus very high rates of density independent mortality. The sockeye submodel assumes that onset of temperature-oxygen squeeze mortality will be triggered before this extreme. This is based on observations (Hyatt and Rankin in prep) of actual losses of juvenile sockeye in the central basin of Osoyoos Lake in 1998. These data showed that accelerated mortality occurred before the limnetic zone reached zero rearing volume (results not shown). Thus, based on expert judgement, a useable rearing volume of 40 million m^3 is recommended as the trigger point of switching from density-dependent to density-independent mortality (Figure 3.9). At 40 million m^3 , all sockeye fry will be confined to a roughly 5m vertical depth interval in the hypolimnion. This occurs after 93 days of surface water temperatures equal to or greater than $17^\circ C$. On days when this is the case, a constant density-independent survival rate is applied for that day, equal to 0.9894. This rate of survival is approximately 10 times less than the rate of density-dependent survival.

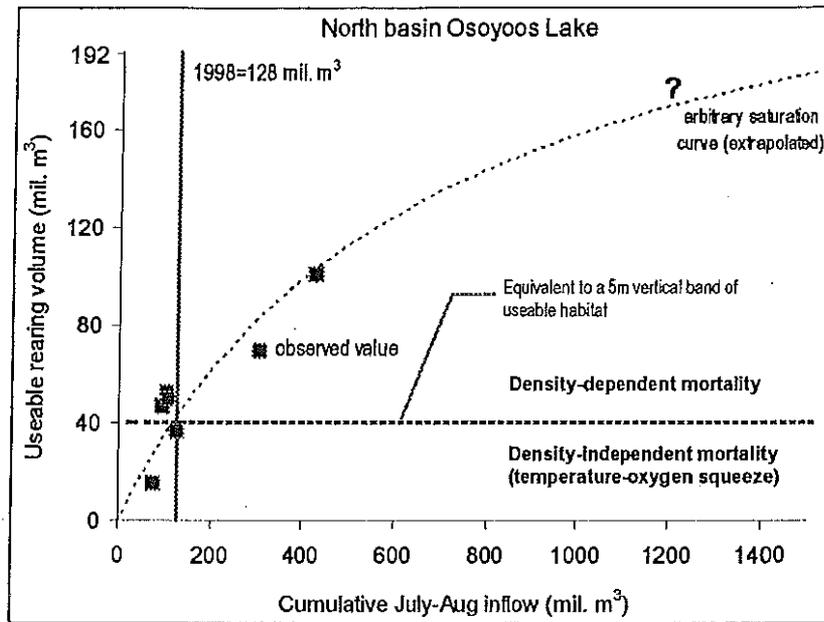


Figure 3.9. Observed values for cumulative inflows in relation to useable (habitable) rearing volumes in the north basin of Osoyoos Lake, showing the transition between density-dependent and density-independent (induced by the temperature-oxygen squeeze) mortality.

It is hypothesised that cumulative flows to Osoyoos Lake during July and August can be used to mitigate a potential temperature-oxygen squeeze event. The threshold cumulative inflow for this mitigation is 128 million m³ (Figure 3.9). An alternative hypothesis is that the cumulative inflow to Osoyoos Lake of 145 to 167 million m³ between July 1 and September 30 would also prevent severe density independent “squeeze” mortality. The mitigation threshold is based on expert judgement and was approved by the Canadian Okanagan Basin Technical Working Group (COBTWG) Steering Committee in 2004, with the alternative hypothesis supplied in the summer of 2006.

Socio-economic water management rules

The role of the socio-economic water management rules submodel is to identify the relative impact of Okanagan Lake water elevations and Okanagan River discharge on: 1) flood related property damage; 2) water supply availability for agricultural irrigation and community/domestic uses; 3) navigation problems at docks and marinas; and 4) local recreation opportunities in the Penticton channel. Accordingly, the submodel uses outputs from the water supply/hydrology submodel along with information obtained from engineering specifications, maps, economic assessments and interviews with property managers, realtors and other business people to specify acceptable and unacceptable “rules” for lake elevations and flows at select points of interest (details in Alexander and Hyatt 2005).

For each of the socio-economic relations, “preference zones” were then specified in terms of the independent variable used in the relation (usually Okanagan Lake elevation or Okanagan River

discharge). As with other submodels in the OKFWM system, the three “preference zones” identified for each socio-economic impact were defined as follows:

Zone	Impact
High	High
Medium	Medium
Low	Low

Some of these relations are relevant only at certain times of the year, whereas others are relevant at any time during the year. The relations were determined through:

- a subjective assessment of the relative impacts of lake levels and flows, and an assessment of the boundary conditions (i.e., flows and lake levels corresponding to maximum and minimum impacts), contributed by the Provincial Ministry of Environment staff in Penticton; and
- follow-up work based on this and the 1974 OBA, gathering up-to-date information to estimate impacts in absolute terms.

The following socio-economic relations were developed for this submodel:

- the impact of high and low water levels on Okanagan Lake on: a) irrigation infrastructure (Table 3.4); and b) water supply infrastructure for domestic consumption and other purposes (Table 3.5);
- the flooding impact of high levels in Okanagan Lake on lakeshore properties (Table 3.6);
- the impact of Okanagan Lake levels above and below the normal lake level range on recreation, navigation and tourism (Table 3.7; Table 3.8);
- the impact of low flows in Okanagan River on: a) water intakes used for agricultural irrigation purposes (Table 3.9); and b) water intakes used for domestic consumption and other purposes (Table 3.12);
- the flooding impact of high flows in Okanagan River on properties along the river (Table 3.11; Table 3.12; Table 3.13); and
- the impact of low Okanagan River flows on river-related recreation businesses (Table 3.14).

These various relations and threshold guidelines place a considerable number of constraints on how the distribution of releases from Okanagan Lake dam should be managed.

It is important to point out that not all of these considerations have equal significance for water managers. The ranking in Table 3.3 is consistent with the overall tone of discussions surrounding these issues by Fish/Water Management Tools (FWMT) stakeholders between 2001 and 2005. However, the ranking is highly dependent on individual values/interests and so Table 3.3 is not a consensus statement. In practice, there are many “if then” rules associated with balancing these objectives alongside fisheries values. This guide makes no attempt to list the multiple possibilities. Balancing and ranking of objectives are topics that must be handled in-season, with frequent and routine communication between senior water and fisheries managers. Further, these rules and rankings should not be expected to remain static over time – highlighting the need for a

Table 3.5. Risk zones, expressed in terms of Okanagan Lake elevation, for inoperable community and domestic water supplies due to exposure or flooding.

Zone	Range of the Independent Variable
Green (preferred)	$E_i > 340.7$
Yellow (low to moderate risk)	$340.7 \geq E_i \geq 341.75$
Red (high risk)	$E_i < 341.75$

Table 3.6. Risk zones, expressed in terms of Okanagan Lake elevation, for lakeshore flood damage.

Zone	Range of the Independent Variable
Green (preferred)	$E_i > 341.7$
Yellow (low to moderate risk)	$341.7 \geq E_i \geq 342.75$
Red (high risk)	$E_i < 342.75$

Table 3.7. Risk zones, expressed in terms of Okanagan Lake elevation, for sailboat navigation problems at marinas around Okanagan Lake.

Zone	Range of the Independent Variable
Green (preferred)	$E_i > 341.90$
Yellow (low to moderate risk)	$341.90 \geq E_i \geq 341.70$
Red (high risk)	$E_i < 341.70$

Table 3.8. Risk zones, expressed in terms of Okanagan Lake elevation, for unusable docks around Okanagan Lake.

Zone	Range of the Independent Variable
Green (preferred)	$E_i > 342.0$
Yellow (low to moderate risk)	$342.0 \geq E_i \geq 342.75$
Red (high risk)	$E_i < 342.75$

Table 3.9. Risk zones, expressed in terms of Okanagan River discharge, for inoperable irrigation water supplies due to exposure or flooding.

Zone	Range of the Independent Variable
Green (preferred)	$Q_i > 100$
Yellow (low to moderate risk)	$100 \geq Q_i \geq 125$
Red (high risk)	$Q_i < 125$

Table 3.10. Risk zones, expressed in terms of Okanagan River discharge, for inoperable community and domestic water supplies due to exposure or flooding.

Zone	Range of the Independent Variable
Green (preferred)	$Q_{OR} < 50$
Yellow (low to moderate risk)	$50 \leq Q_{OR} \leq 60$
Red (high risk)	$Q_{OR} > 60$

Table 3.11. Risk zones, expressed in terms of Okanagan River discharge at Penticton, for flooding along Okanagan River between Okanagan and Skaha lakes.

Zone	Range of the Independent Variable
Green (preferred)	$Q_{OR} < 50$
Yellow (low to moderate risk)	$50 \leq Q_{OR} \leq 60$
Red (high risk)	$Q_{OR} > 60$

Table 3.12. Risk zones, expressed in terms of Okanagan River discharge at Okanagan Falls, for flooding along Okanagan River between Skaha and Vaseux lakes.

Zone	Range of the Independent Variable
Green (preferred)	$Q_{OR} < 65$
Yellow (low to moderate risk)	$65 \leq Q_{OR} \leq 70$
Red (high risk)	$Q_{OR} > 70$

Table 3.13. Risk zones, expressed in terms of Okanagan River discharge at Oliver, for flooding along Okanagan River between Vaseux and Osoyoos Lakes.

Zone	Range of the Independent Variable
Green (preferred)	$Q_{OR} < 60$
Yellow (low to moderate risk)	$60 \leq Q_{OR} \leq 65$
Red (high risk)	$Q_{OR} > 65$

Table 3.14. Risk zones, expressed in terms of Okanagan River discharge, for revenue loss to a river tubing business at Penticton.

Zone	Range of the Independent Variable
Green (preferred)	$Q_{OR} < 50$
Yellow (low to moderate risk)	$50 \leq Q_{OR} \leq 60$
Red (high risk)	$Q_{OR} > 60$

CHAPTER 4

Water Management Strategies

In the winter of 2003/2004, the Canadian Okanagan Basin Technical Working Group (COBTWG) led a rigorous trial of OKFWM by training three individuals unfamiliar with Okanagan Lake and River water management (Hyatt and Alexander 2005). This exercise showed that these “apprentice” fish/water managers were able to competently balance objectives (or make things no worse than they had been) once they had used the tool to simulate the management of 2 to 3 complete water years (January 1 to September 30 in the training mode of OKFWM). This amounted to a highly effective training investment of just 10 to 14 hours that otherwise would have required three or four *years*.

OKFWM Works: Results of a 25-year retrospective analysis

To quantify the potential benefits of routine application of OKFWM for in-season management, a formal retrospective analysis was completed between December 2003 and February 2004. The retrospective analysis was used to identify potential fish production benefits while concurrently balancing flood control and water supply objectives (Hyatt and Alexander 2005).

The research question addressed by this analysis was: *“If you had used OKFWM between 1974 and 2003 to balance objectives, what water release decisions would have been made and how might this have changed the abundance of sockeye smolts leaving Osoyoos Lake?”* To answer this question, several steps were completed:

1. Training three “apprentice” fish/water managers to use the OKFWM system. These apprentice managers were given grounding in the temporal and location specific trade-offs at the heart of water management in the basin. They then performed retrospective water year management alongside two more experienced water managers (all focusing on different water years). Hence, the analysis incorporated results over a range of experience by water managers. Some group discussion was allowed to simulate the collaborations that take place in-season between engineers, hydrologists and fisheries biologists.
2. Using the OKFWM model to re-create the history of weekly to daily water management decisions made since 1974. Care was taken to randomly assign water years to apprentice managers and to make these 25 years unidentifiable. In addition to “blinding” the water years, simulations used only the information that was available at the time (i.e., the past inflow forecasts and not the actual inflows). New simulated lake levels and river discharges were calculated knowing the actual daily net inflows to Okanagan Lake and actual daily tributary inflows that occurred in each of these years. These were applied once users “locked in” a particular water release policy, usually in increments of several

days to two weeks at a time. Once “locked in,” apprentice water managers could not go backwards and change their decisions.

3. Running the actual seasonal water storage and release decisions for each of the 25 years through OKFWM to identify sockeye production outcomes expected based on the biophysical model guidelines. This ensured internal consistency in comparisons between actual and recreated results.
4. Calculating the sockeye smolt production with and without use of the OKFWM model.

The analysis suggests that routine use of OKFWM by fish-and-water managers may yield an average annual increase in Okanagan sockeye smolt abundance by as much as 55% (median improvement 12.3%) without significantly increasing socio-economic losses associated with other water use interests (Figure 4.1). This encouraging result owes to improved understanding of fundamental ecological processes controlling juvenile production, the application of real-time data to inform physical and biological parameters, and a heightened awareness of trade-offs—all features seamlessly captured within the OKFWM tool.

Although 25 years of retrospective analysis observations have provided encouraging evidence for the potential value of OKFWM, retrospective results are nevertheless theoretical (model based). A true test of the OKFWM tool’s value must be based on credible assessments of OKFWM’s contribution to shaping fish-and-water management decisions to achieve increases in sockeye smolt production in both current and future years. Moreover, a multi-year monitoring and evaluation program will be required to corroborate the magnitude of annual sockeye production benefits associated with the use of OKFWM.

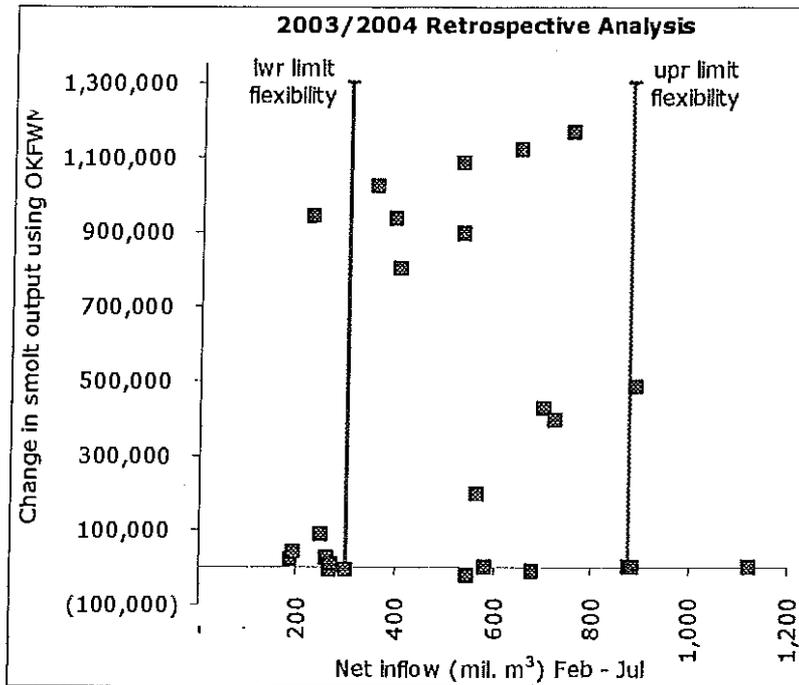


Figure 4.1. Change in sockeye smolt production owing to routine use of OKFWM between 1974 and 2003 as a function of water supply year (net inflow in millions of cubic meters between February 1 and July 31). Beyond certain thresholds of inflow, some years are too dry or too wet to permit enough flexibility for smolt production gains (without seriously affecting other important objectives). Lwr = lower; Upr = upper.

Key lessons from retrospective analysis: new strategies

Every water year is unique in terms of the combination of starting lake elevation, net inflow, distribution of this inflow (diffuse or compressed) and winter/spring water temperatures. The level of challenge and fine tuning required is generally greater in above average to high inflow years. However, dry years, if not too severe, can force a delicate balancing act early in the year to hold enough water should a pulse release for Osoyoos Lake sockeye be considered. Furthermore, the prioritisation among objectives will also strongly influence the water release strategy that is pursued. In short, there is no single "best" release strategy.

While the release strategy and Okanagan Lake response will vary each year, Figure 4.2 shows the all-year average water releases from Okanagan Lake dam and the approximate Okanagan Lake elevation response. Though a misnomer, let's call it the "standard operational plan" (SOP). The SOP entails a slow increase of flows to drawdown Okanagan Lake in advance of the bulk of spring freshet inflow, then further modest increases to ensure the lake peaks at around 342.53m in late June, and finally drawdown to around 341.9 m by October (Figure 4.2).

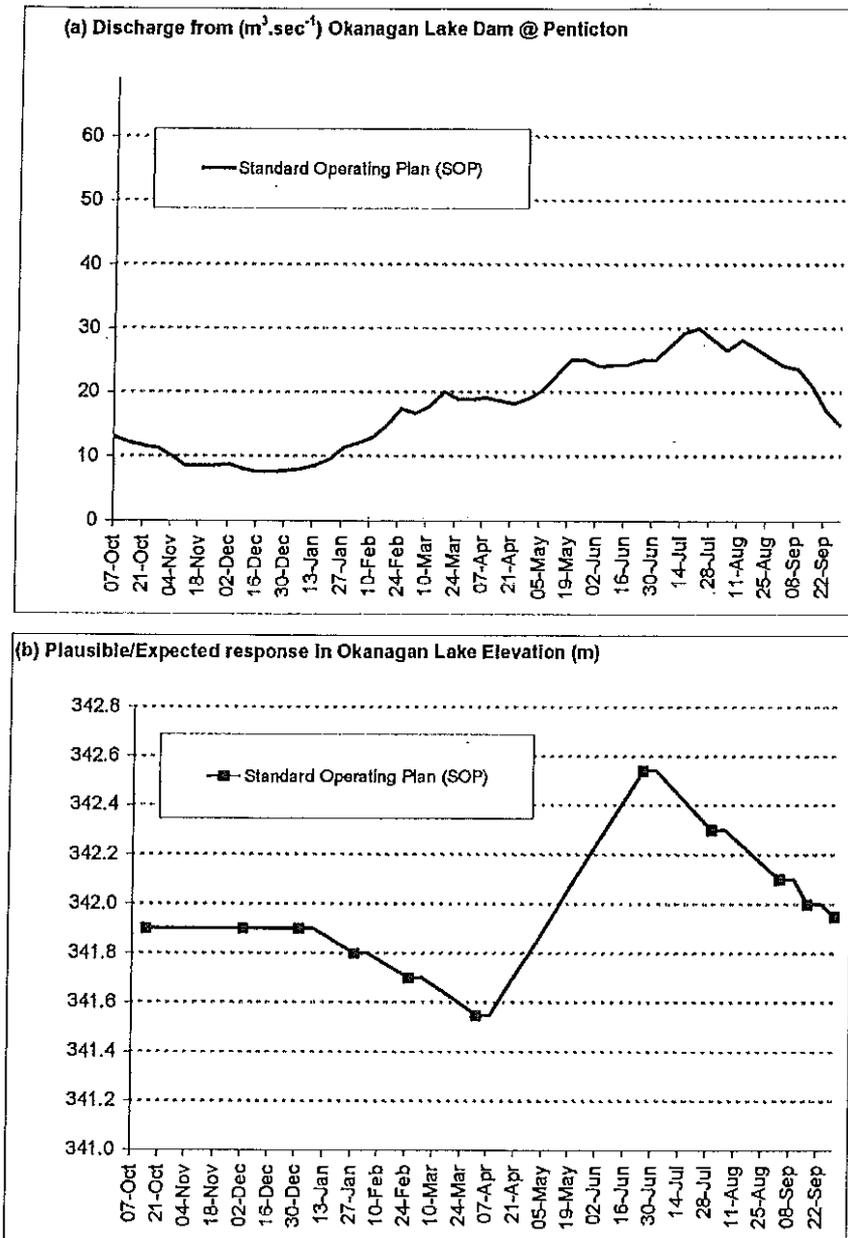


Figure 4.2. “Effective” standard operating plan (SOP) for Okanagan Lake dam at Penticton, if the magnitude and distribution of the all-year average net inflow occurred and the Okanagan Basin Implementation Agreement was followed.

The Fish/Water Management Tools (FWMT) program has revealed various strategies that can be applied to maximise fish survival in average to wet years and in dry years. The work by the COBTWG has also shown that when February 1 to July 31 net inflows approach 825 million m³

or fall below 310 million m³, flow management considerations may no longer be tipped in favour of meaningfully improving juvenile fish survival (Hyatt and Alexander 2005). Historically, net inflows are rarely in this range, but knowledge of these extremes is of paramount practical significance for water release decision-making at Okanagan Lake dam.

Average to wet years

There are two operational strategies that are more “fish-friendly” in above average to high (but not extremely high) net inflow years: 1) a ‘*winter pulse, hold, then flush*’ approach; or 2) a ‘*hold-and-flush*’ approach (Figure 4.3).

In above average and high inflow years, the *winter pulse, hold, then flush* approach provides a better opportunity to protect incubating sockeye eggs while avoiding late spring/early summer flooding. However, “knowing” whether a year will be wet enough to warrant this kind of release action in January or February is a highly uncertain science. So adopting this strategy requires judgement based on experience with snowpacks and looking at early trends in real-time data. Also, a risk with this approach is that it can generate in-lake de-watering mortality of shore-spawned kokanee eggs if the February to March drawdown exceeds 20 to 25 cm (Andrusak and Matthews, as cited in Alexander and Hyatt 2005). Note: the proportionate magnitude of losses and threat to the kokanee population as a whole from these “red hazard” losses is less than the loss that would be experienced by Okanagan River sockeye under the equivalent “red hazard” condition during their incubation (Hyatt and Alexander 2005). This statement is provided for context and is not meant as a consensus statement on fisheries values.

If net inflows are expected to be *not too great*, the best option from a sockeye and kokanee perspective is to hold onto the water until late in the emergence period and then to “let it rip” (i.e., > 50 m³.s⁻¹ at Okanagan Lake dam, Penticton). The advisability of a pure *hold-and-flush* approach depends on how wet the late spring is likely to be. If the magnitude of net inflow in May through July happens to be less than expected or its distribution is more diffuse (and downstream tributary inflows are below average) the water manager will avert sockeye scour, kokanee de-watering and lake/down-river flooding. Given this strategy and these assumptions (and there are several), a fish/water manager would achieve the penultimate “win-win”.

Results from Hyatt and Alexander (2005) suggest the *hold-and-flush* strategy is a good one if the net February 1 to July 31 inflows are in the 550-775 million m³ range (because at this magnitude of inflow, “letting it rip” will not approach or exceed Okanagan Lake dam’s design outflow capacity of 60 m³.s⁻¹) nor produce in-river flooding. However, a *hold-and-flush* approach was clearly shown to be foolhardy if net inflows exceeded the 825-850 million m³ level (Hyatt and Alexander 2005). Essentially, if faced with ~ 825+ million m³ of water, the outlet works at Okanagan Lake dam at Penticton cannot cope with the magnitude of releases that would be needed to move this volume of water out of Okanagan Lake to meet elevation targets post-sockeye incubation, sometime in mid-April or early May.

Though more fish-friendly, as net inflow increases, the *winter pulse, hold, then flush* and *hold-and-flush* strategies inevitably entail some corresponding increase in flood risk¹ leading to certain massive flooding when February 1 to July 31 net inflows are in excess of 825 million m³ (Hyatt and Alexander 2005).

¹ However, as long as not heavily concentrated in time, this additional risk appears to be insignificant for net Feb 1 to July 31 inflows in the range of 500 million m³ to 675 million m³. Beyond ~ 675 million m³, the incremental increase in flood risk—while potentially acceptable—becomes a more significant consideration.

Extreme wet years

When approaching/exceeding 825 million m³ in net inflow (between February 1 to July 31), the flexibility to hold off large releases during the egg incubation period is no longer feasible. In this case, large releases of water (often upwards of 45-70 m³.s⁻¹) should be considered starting as early as March 1 (or even mid February) *regardless* of egg/alevin scour mortality impacts (Hyatt and Alexander 2005). Okanagan Lake dam has a limited release capacity, which equates to very different rates of freshet inflows and lake outflows (e.g., >250 m³.s⁻¹ entering lake, ~ 60-70 m³.s⁻¹ leaving lake). Therefore, in these extremely high inflow years, the slow response of lake elevation to outflow means that water managers who wait until mid-April or May to start ramping up releases for Okanagan Lake drawdown will run out of time and experience *massive* lakeshore and river flooding.

Dry years

The COBTWG's retrospective analysis suggested a third "fish-friendly" option in the case of dry years. In dry years, in-river egg desiccation mortality and especially density-independent temperature/oxygen squeeze mortality in Osoyoos Lake are likely to dramatically limit smolt production. In extreme dry years, supplying the water necessary to mitigate these effects would draw Okanagan Lake down well below tolerable levels. However, for water years in the ~ 310-420 million m³ range, 'summer pulse' flows, totalling about 145 to 167 million m³ or more, during July through September may be able to alleviate temperature/oxygen squeeze mortality (Kim Hyatt, Fisheries and Oceans Canada, *personal communication*).

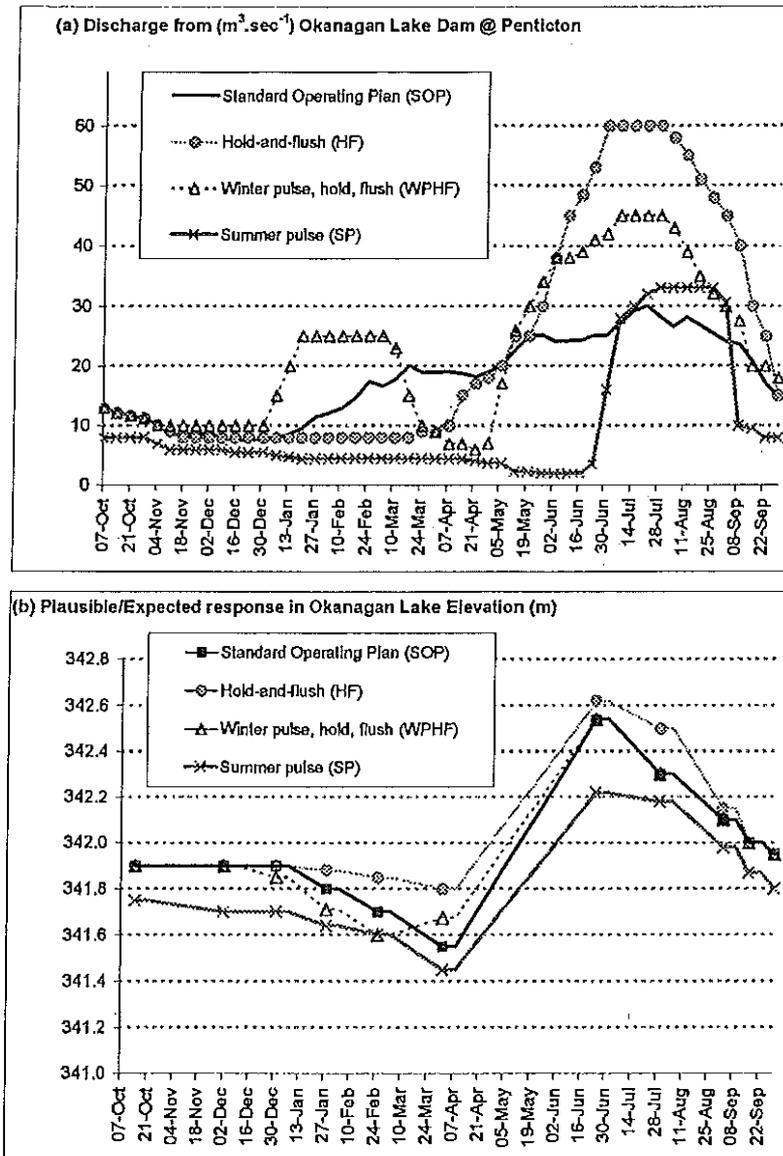


Figure 4.3. Stylised alternative release strategies for Okanagan Lake dam at Penticton (panel a). The exact numeric values that should be used will vary depending on the magnitude and pattern of net inflows. In particular, the numeric values shown for Okanagan Lake elevation (panel b) are only approximate, and they should not be expected in practice as results will vary depending on starting lake elevation, inflow magnitude and distribution. The Okanagan Lake elevation profiles in panel b are provided to show a plausible response pattern.

CHAPTER 5

Using OKFWM in Training Mode

This chapter is designed for an apprentice to begin using the OKFWM software program in the retrospective or **training mode**. It is called 'retrospective' because the software uses real data on Okanagan Lake elevation, river flow and water temperature, but the data are from a year that has already passed. While 'retrospective' refers to events that have occurred in the past, OKFWM randomly adds *y* years to this historical calendar date, so that a user is not able to go back in time and figure out details of that past year. So, February 14, 2073 in training mode may actually have been February 14, 1977. This disguising of dates ensures the apprentice cannot refer back to historical climate information for the year and know ahead of time what to expect. This makes it impossible to "cheat".

The goal of this chapter is to lead the apprentice, step by step, through a single year (the blinded year 2047) to demonstrate how to use the software, how decisions affect consequences, and how to read the output. This is just an example created by a first time user to orient the apprentice to the software and does not illustrate best balance inflows and outflows to manage the Okanagan water system. The apprentice will need to complete several practice years in the training mode and experience the effects of his or her decisions on dry, wet and average years to gain a solid grounding in OKFWM. The beauty of OKFWM's training mode is that the apprentice can gain the experience of making water release decisions for several years in the timeframe of a couple of days without bearing the burden of real world responsibility that goes with these decisions.

For step-by-step instructions about using the real-time, in-season mode of OKFWM, skip ahead to Chapter 6.

Before you begin

- Be familiar with the information in Chapter 2 and keep handy a copy of the Water Management Guidelines ("Cheat Sheet" on page 32).
- Be sure to have several uninterrupted hours available. Especially when you are new to OKFWM, you will find that you're making a lot of changes to the variables and re-running the program frequently.
- You need a computer with Internet Explorer™. Note: OKFWM has not been tested with other web browsers such as Netscape, Mozilla Firefox or Safari. The software is not guaranteed to work correctly with these browsers.
- Refer to the short glossary of terms on pg. 85 for definitions of terms you encounter as you work through this chapter.

Step 1: Log into system and create a working scenario

1.1 Open Internet Explorer™.

1.2 Enter the following url (Internet address) into the address bar.²



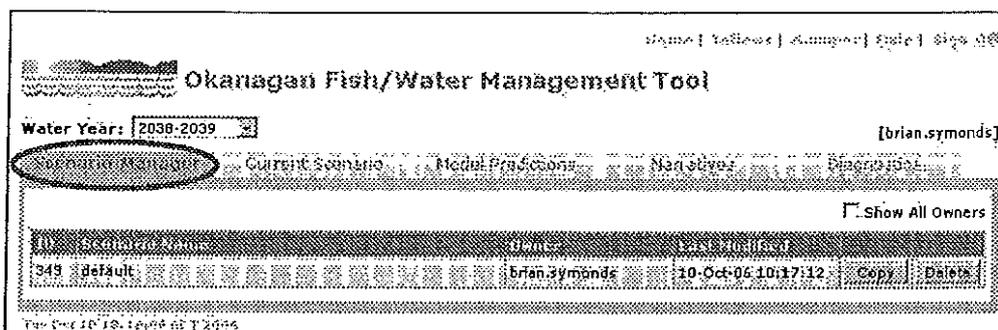
1.3 Type your user name and password:

A screenshot of the login page for the Okanagan Fish/Water Management Tool. The page has a title bar that says "Okanagan Fish/Water Management Tool". Below the title bar is a "Sign In" section. The text "Welcome to OKFWM - Please sign in" is displayed. There are two input fields: "User Name:" with a placeholder "firstname.lastname" and "Password:" with a masked password "*****". A "Submit" button is located below the password field. Below the input fields is a link that says "Need an account?". At the bottom of the page, there are four logos: Douglas County Public Utility District, Okanagan Nation Alliance, Fisheries and Oceans Canada, and BC Ministry of Water Land and Air Protection.

Note: If you do not have access to the system, choose the "Need an account?" link. Submit a password and the OKFWM administrator will contact you with a user name. (Allow 2-5 business days).

² Note: this url is planned to change sometime in 2006 or early 2007. The planned domain and address at that time will be "www.ok.fwmt.net/training" though not yet confirmed.

1.4 Once logged in, you will see a screen that resembles this:



This is OKFWM's main window, which consists of a navigation bar (upper right corner), a "Water Year" drop-down box, and a set of tabs.

The tabs on the main screen are:

- *Scenario Manager* – view, copy and delete scenarios

Definition: A "Scenario" is the set of assumptions on events that take place during a water year (October 1-September 30) in the Okanagan basin. The scenario includes information on net inflows to Okanagan Lake, water releases through Okanagan Lake dam and fisheries variables. You begin each water year with very little known information, and as you advance through the year, more and more information becomes available.

- *Current Scenario* – edit and run scenarios
- *Model Predictions* – view run results
- *Narratives* – post decision rationale comments and share files with other users
- *Diagnostics* – disabled in retrospective mode³

The "Water Year" drop-down box contains a long list of water years, starting with 1973-74 and running through to 2098-2099, and is used to filter scenarios and narratives. It is disabled on all other tabs.

The navigation bar contains a number of links that perform a variety of navigation and administrative functions. These are:

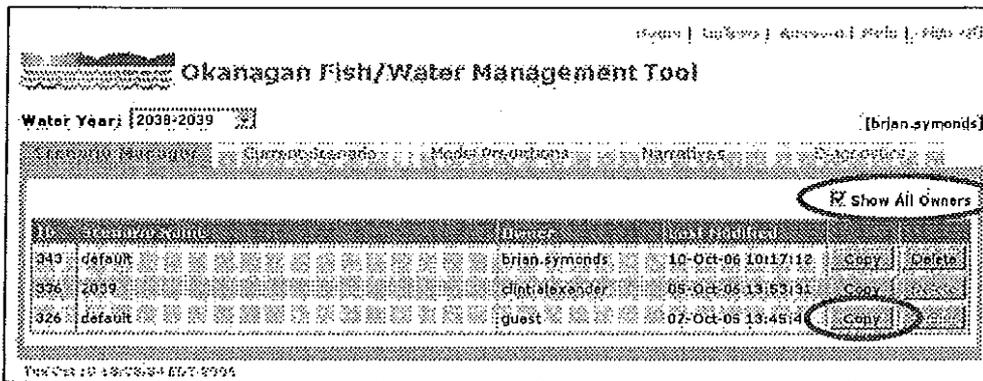
- **Home** – switches to the *Scenario Manager* tab
- **Inflows** – displays inflow estimate data from the BC River Forecast Centre (see Step 7 below, pg. 78)
- **Account** – change password / provides technical assistance contact information
- **Help** – access to on-line documentation about OKFWM / provides technical assistance contact information
- **Sign Off** – ends the OKFWM session

³ The purpose of the *Diagnostics* tab in in-season mode (where it is enabled) is to provide users with access to real-time data and information relevant to OKFWM runs (see pg. 104). Because training mode scenarios are set in the future, real-time information does not exist, so the tab is disabled.

1.5 Choose an existing scenario in the *Scenario Manager* tab (circled in red above). When you first log on, the existing scenario will likely be named “default” or given the name of the future water year.

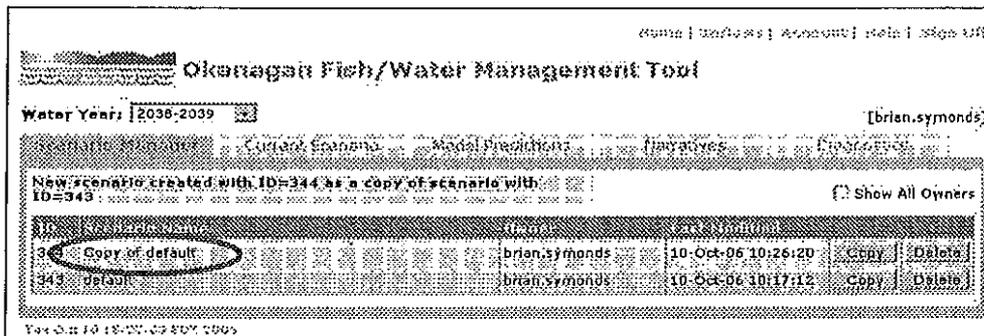
- a) To choose an existing scenario, start by filtering the available scenarios by selecting a “Water Year” from the drop-down box at the top of the screen. Only those scenarios defined for the selected water year will be listed. The screen image above shows one scenario for the water year 2038-2039. Click the blue hyperlink under “Scenario Name”.
- b) To create a new scenario (e.g., a copy of Default so you don’t alter the template), click the “Copy” button at the right of the screen (see image below).

Note: In some cases, a default scenario may not be available (i.e., no scenarios listed under Scenario Name). When this happens, click the “Show All Owners” option at top right (see image below). This allows you to view scenarios created and shared by other users. Copy one of these.



Note: You may only Delete (and modify) scenarios that you own. Above, the user id is “brian.symonds”, and he owns only one of the scenarios. However, you are free to Copy any of the other shared scenarios. You may want to do this to see how other people are managing water flows, for example.

1.6 Open the scenario you have just copied by clicking on the blue hyperlink. In the example below, we are opening “Copy of default”.



1.7 Opening a scenario takes you to the *Current Scenario* tab, as below. In Step 2, you will use the "Edit" button to change the content of your scenario.

Home | Help | Account | Login | Sign Out

Okanagan Fish/Water Management Tool

Water Values: 13/13/2009 [brian.symonds]

Scenario Manager | **Current Scenario** | Initial Predictions | Nutrients

Scenario ID: 344 Scenario Name: New apprentice - training year 1 Owner: brian.symonds
Last Modified: 10 Oct 09 11:05:42

Run Edit Advance Date

Description: default values for model parameters Share with Other Users: No

Decision Date: 01-Jan-2039

Run Mode: Retrospective - forecast inflows

Hydrology

Minimum Outflow (m³/s): 5.55 Use Outflow Constraints: Yes
Outflow Constraints: [No future constraints] Show Historical Outflows

Kobanoo

Peak spawn date: 21-Oct
Cum. thermal units for 100% fry emergence (°C-days): 950
Lake drawdown considered to be "preferred" (cm): 15
Lake drawdown considered to be "not preferred" (cm): 25

Rockeys

Peak spawn date: Use temperature threshold rule (~12°C)
Number of spawners on spawning grounds: 22500
Proportion females: 0.52
Proportion of spawners - age 1,1: 0.2
- age 1,2: 0.75
- age 1,3: 0.05

NEW Cum. thermal units for 100% fry hatching (°C-days): 525
NEW Cum. thermal units for 100% fry emergence (°C-days): 875
Total Phosphorus concentration during spring (µg/L): 12
Mysis density in spring (#/m² of lake surface): 10
NEW Osoyoos Lake habitable volume causing squeeze (millions m³): 40
NEW Cum. inflow alleviating Osoyoos squeeze (millions m³): 157

Tom 5:28:19 4/04/05 BDI COCE

Step 2: Re-name your scenario and select a year

2.1 Click the “Edit” button, and you will see the following screen:

The screenshot shows the 'Okanagan Fish/Water Management Tool' interface. At the top, there are navigation links: Home, Inflows, Account, Help, and Stop. The main title is 'Okanagan Fish/Water Management Tool'. Below this, there is a 'Water Year' field set to '2038-2039' and a user name '[brian.symonds]'. A menu bar includes 'Scenario Managers', 'Current Scenarios', 'Model Predictions', 'Networks', 'Inflows', and 'Outflows'. The 'Current Scenarios' section shows a scenario with ID '344 (Editing)' and name 'New apprentice - training year 1'. It includes an 'Update' button (circled in red) and a 'Cancel' button. The 'Scenario Name' field is highlighted in red and contains the text 'New apprentice - training year 1'. The 'Description' field contains 'default values for model parameters'. The 'Decision Date' is set to '1 Jan 2039', with '2039' circled in red. The 'Run Mode' is 'Retrospective - forecast inflows'. The 'Hydrology' section shows 'Minimum Outflow (m³/s): 5.55' and 'Outflow Constraints: [No future constraints]'. There are checkboxes for 'Use Outflow Constraints' (checked) and 'Show Historical Outflows'. At the bottom, there are 'Add' and 'Initialise' buttons.

2.2 Re-name your scenario in the “Scenario Name” field. On the screen above, we’ve typed “New apprentice - training year 1”.

2.3 Select the water year that you want to try. On the screen above, we’ve selected “2039” as the Decision Date year. By design, you cannot change the month and day here (in retrospective mode, this is done by using the “Advance Date” button). By default, the month and day are set to January 1.

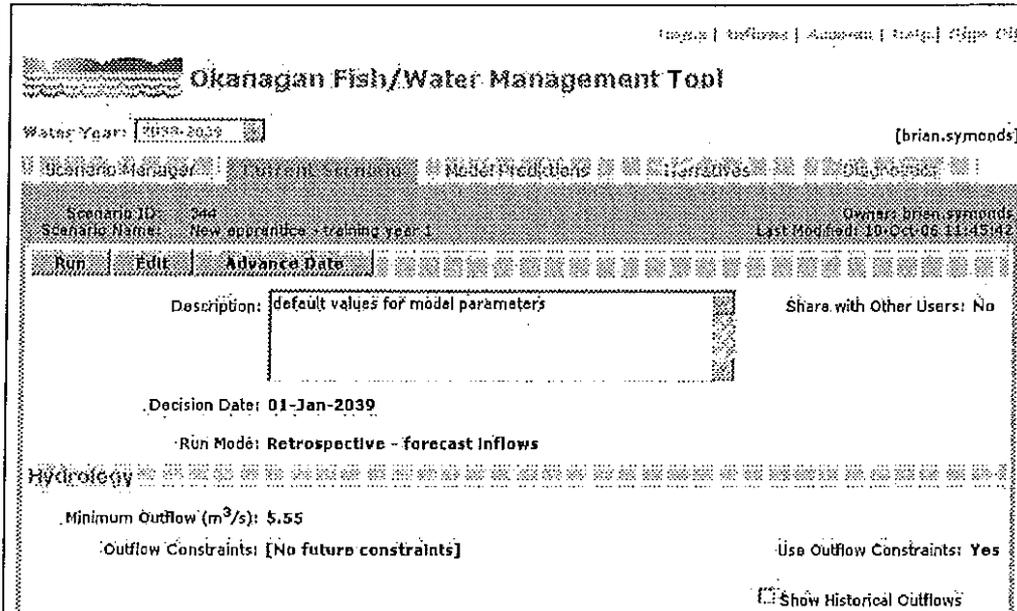
Definition: The Decision Date is the day forward from which you must make decisions about weekly water releases at Okanagan Lake dam. OKFWM will show you what has already happened up until this date and will forecast what is likely to happen afterwards based on the releases you choose and a variety of other data.

Note: The data and information with which you work in this training run are real, but the year has been disguised or blinded. Hence, the future years.

2.4 To apply the changes you have made to Scenario Name and Decision Date, click “Update”.

Tip: Whenever you make changes in the “Edit” function, you must click “Update” for the changes to take effect.

2.5 You now have a screen that resembles this:



Step 3: Add outflow constraints

3.1 Click “Edit” again.

3.2 Under the “Hydrology” section of the screen, click the “Initialize” button, as shown below. To the right, the box labelled “Use Outflow Constraints” will automatically be ticked—leave it ticked.

Home | Inflows | Parameters | Help | Sign Out

Okanagan Fish/Water Management Tool

Water Year: [brian.symonds]

Scenario ID: 344 (Editing) Owner: brian.symonds
 Scenario Name: New apprentice - training year 1 Last Modified: 10 Oct 06 11:17:46

Scenario Name: Share with Other Users

Description:

Decision Date:

Run Mode: Retrospective - forecast inflows

Hydrology

Minimum Outflow (m³/s):

Outflow Constraints:

Use Outflow Constraints
 Show Historical Outflows

3.3 A grid with four columns has now appeared, as below. For each week, an outflow volume is already filled in (this is the flow at Okanagan Lake dam). These flows are the average for that week from a data set that includes 1974-present (referred to in this chapter as the "all-year average"). The numbers represent an "in the ballpark" starting point for how you should manage outflows during the year. For now, leave these numbers as they are; later, you will need to change them.

Home | Inflows | Account | Help | Sign Off

Okanagan Fish/Water Management Tool

Water Year: 2038-2039 [brian.symonds]

Scenario Manager | Current Scenario | Model Predictions | Historicals

Scenario ID: 344 (Editing) | Owner: Brian Symonds
 Scenario Name: New apprentice - training year 1 | Last Modified: 10-Oct-06 11:45:42

Update | Cancel

Scenario Name: New apprentice - training year 1 Share with Other Users

Description: default values for model parameters

Decision Date: 1 Feb 2039

Run Mode: Retrospective - forecast inflows

Hydrology

Minimum Outflow (m³/s): 5.55

Outflow Constraints:

Week #	Week Ending	Flow (m ³ /s)	
1	07-Jan	9	<input type="checkbox"/>
2	14-Jan	9	<input type="checkbox"/>
3	21-Jan	10	<input type="checkbox"/>
4	28-Jan	12	<input type="checkbox"/>
5	04-Feb	11	<input type="checkbox"/>
6	11-Feb	12	<input type="checkbox"/>
7	18-Feb	15	<input type="checkbox"/>
8	25-Feb	17	<input type="checkbox"/>
9	04-Mar	16	<input type="checkbox"/>
10	11-Mar	16	<input type="checkbox"/>

Use Outflow Constraints

Show Historical Outflows

3.4 The water year runs from October 1 (week ending October 7) to September 30. All training years begin on January 1, which means you can only make changes to the Okanagan Lake dam outflow from January 1 forward. The average weekly releases that have already occurred during the current water year, i.e., prior to the week of January 1, can be displayed by checking the "Show Historical Outflows" box to the right of the grid (as below). Historical flows will appear in grey, indicating they cannot be edited.

Hydrology

Minimum Outflow (m³/s):

Outflow Constraints:

Week #	Week Ending	Flow (m ³ /s)	<input type="checkbox"/>
40	07-Oct	12.20	<input type="checkbox"/>
41	14-Oct	9.43	<input type="checkbox"/>
42	21-Oct	9.71	<input type="checkbox"/>
43	28-Oct	9.60	<input type="checkbox"/>
44	04-Nov	9.60	<input type="checkbox"/>
45	11-Nov	4.99	<input type="checkbox"/>
46	18-Nov	4.84	<input type="checkbox"/>
47	25-Nov	4.79	<input type="checkbox"/>
48	02-Dec	4.81	<input type="checkbox"/>
49	09-Dec	5.52	<input type="checkbox"/>
50	16-Dec	5.59	<input type="checkbox"/>
51	23-Dec	5.59	<input type="checkbox"/>
52	31-Dec	5.47	<input type="checkbox"/>
1	07-Jan	9	<input type="checkbox"/>
2	14-Jan	9	<input type="checkbox"/>
3	21-Jan	10	<input type="checkbox"/>
4	28-Jan	12	<input type="checkbox"/>
5	04-Feb	11	<input type="checkbox"/>
6	11-Feb	12	<input type="checkbox"/>

Use Outflow Constraints

Show Historical Outflows

3.5 Your grid now contains the average outflow volume for weeks 1 to 39, plus historical flows if you chose to display them. Click "Update" at either the top or the bottom of the screen.

Note: You will notice that it's also possible to change variables under the "Kokanee" and "Sockeye" submodel headings. Leave these variables at the default values during the training mode. When you begin using the real-time mode, you will need to change these values according to information supplied to you by Okanagan fisheries biologists.

Step 4: Run the model

Before you can begin changing the Outflow Constraints, you need to have a general idea of what the Okanagan basin water system looks like and how OKFWM presents the results. To do this, you will need to run the model with the all-year average (default) outflows.

4.1 In the *Current Scenario* tab, click the “Run” button, as below.

The screenshot shows the 'Okanagan Fish/Water Management Tool' interface. At the top, there are navigation links: Home | Inflows | Advance | Help | Log Off. Below the title bar, there is a 'Water Year' dropdown set to '2038-2039' and a user name '[brian.symonds]'. A tabbed interface is visible with 'Current Scenario' selected. Below the tabs, there is a table of scenarios. The first row is highlighted and contains the following information:

Scenario ID:	344	Owner:	brian.symonds
Scenario Name:	New approach - training year 1	Last Modified:	10-Oct-06 11:29:41

Below the table, there are buttons for 'Run', 'Edit', and 'Advance Date'. The 'Run' button is circled in red. To the right of the 'Run' button, there is a 'Description' field containing 'default values for model parameters' and a 'Share with Other Users' checkbox which is unchecked. At the bottom of the scenario details, there is a 'Decision Date' field set to '01-Jan-2039' and a 'Run Mode' field set to 'Retrospective - forecast inflows'.

4.2 You will see a screen saying “OKFWM model is now running”.

4.3 After 2-5 minutes, the screen will change and say “OKFWM model run complete... generating run results.”

4.4 After a few more minutes, you will see the following screen, which is in the Model Predictions tab:

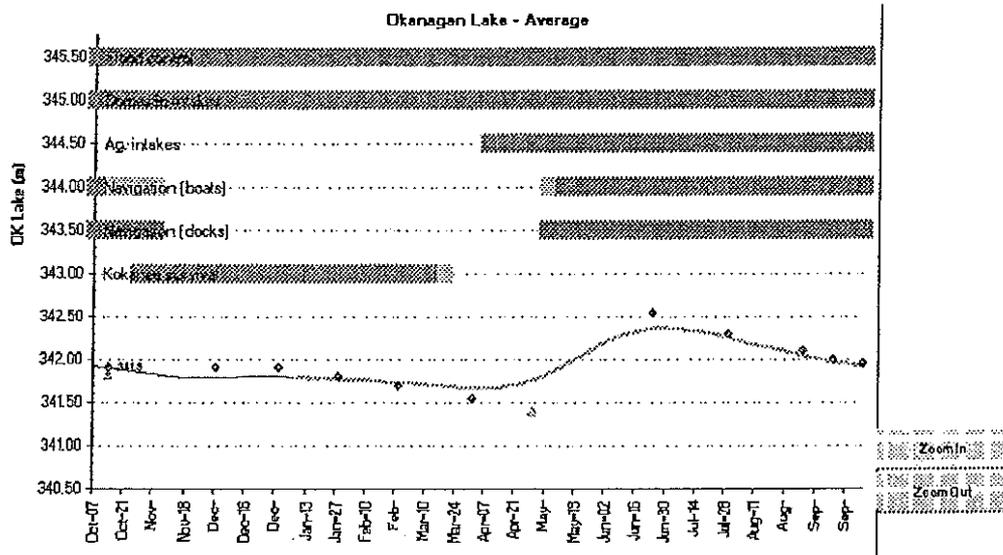
4.5 For now, you will concentrate on the first data output named “Multi-objective hazard assessment [state-of-the-science considerations]”. Click the hyperlink to open the hazard report.

Step 5: Review the hazard report

5.1 The hazard assessment data report opens in an Excel window. If you are prompted about the use of macros, click “Enable Macros”. You can either view the report in the browser that it opened in, or you can save the report and view it in Excel.

Tip: If Internet Explorer stops responding when you click “Open”, try clicking on the hazard report link with your right mouse button and selecting “Save target as.” You can then save the report to your computer and open it in Excel.

5.2 In the “Graphs(Avc)” Excel tab, the first graph you see is titled “Okanagan Lake – Average”, as below.

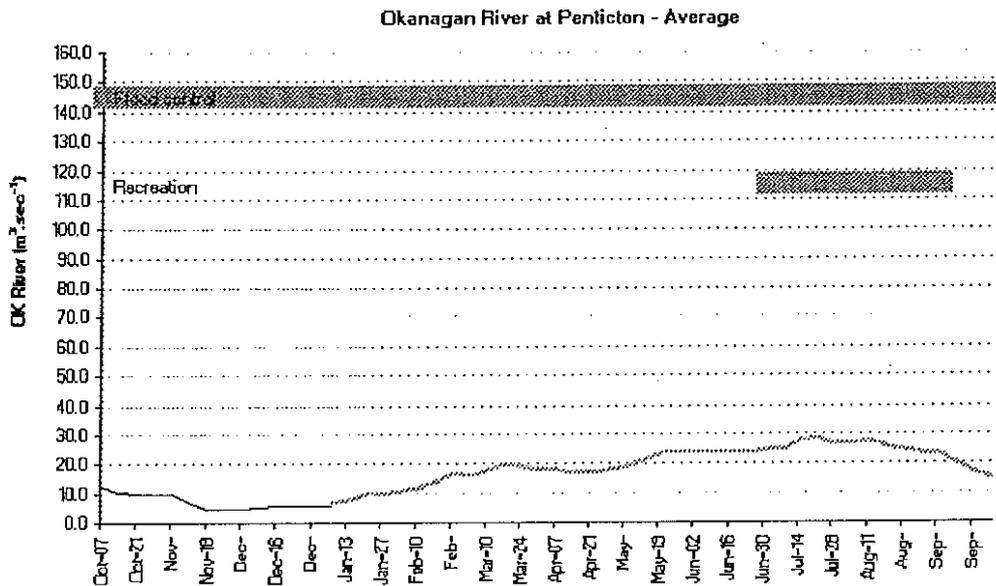


- 5.3 Look at the line that is black and then becomes blue. This is the elevation (water level) of Okanagan Lake. For the week ending October 7, lake elevation was 341.90 metres. The black line shows all the known information in the 2038-39 water year—in other words, the lake elevation that has already been observed from October 1 to December 31. The blue line is a forecast of lake elevation for the remainder of the water year. OKFWM determines the forecast line based on the weekly Outflow Constraints you supplied that are in the Hydrology grid (in Current Scenario tab).
- 5.4 The green diamond symbols indicate the Okanagan Basin Agreement targets for lake elevation throughout the water year (see pg. 119). The yellow triangles indicate alternative lake elevation targets based on kokanee considerations (October triangle) and for extreme wet year flood protection (April-May triangle).
- 5.5 The horizontal coloured bars indicate that lake elevation is acceptable (green), marginal (yellow) or not acceptable (red) for whichever objective is indicated. There are five objectives to consider: flood control, domestic and agricultural water intakes, navigation and kokanee survival. From left to right, the bars indicate the length of time when the objective must be considered. On this graph, the bars pertain only to conditions in Okanagan Lake.

Note: Use the "Zoom In" button to get a closer look at the graph and the "Zoom Out" button to return to the original view.

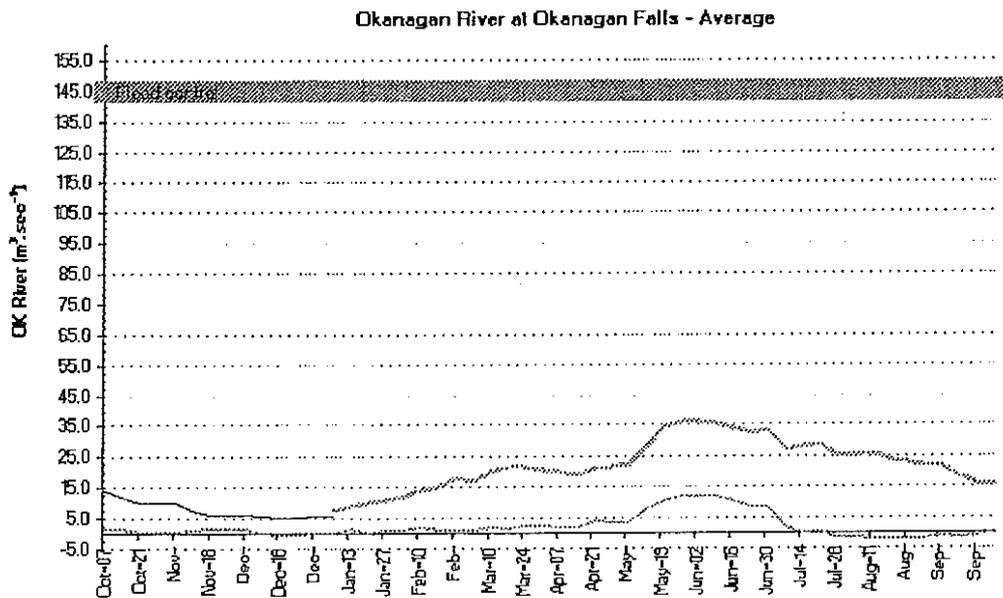
Tip: One of the tabs in the Excel file is labelled "Hazard Definitions." This contains a table with information about what the green, yellow and red bars mean for each objective. The table is also on pg. 125 of this report.

- 5.6 Scroll down from the Okanagan Lake graph and you see a graph for "Okanagan River at Penticton – Average":



5.7 The black and blue lines show the actual and planned discharge in Okanagan River below Okanagan Lake dam at Penticton, respectively. This is the water flow you can change in the Outflow Constraints data grid on the Current Scenario screen. There are two objectives to consider at this location: flood control and recreation.

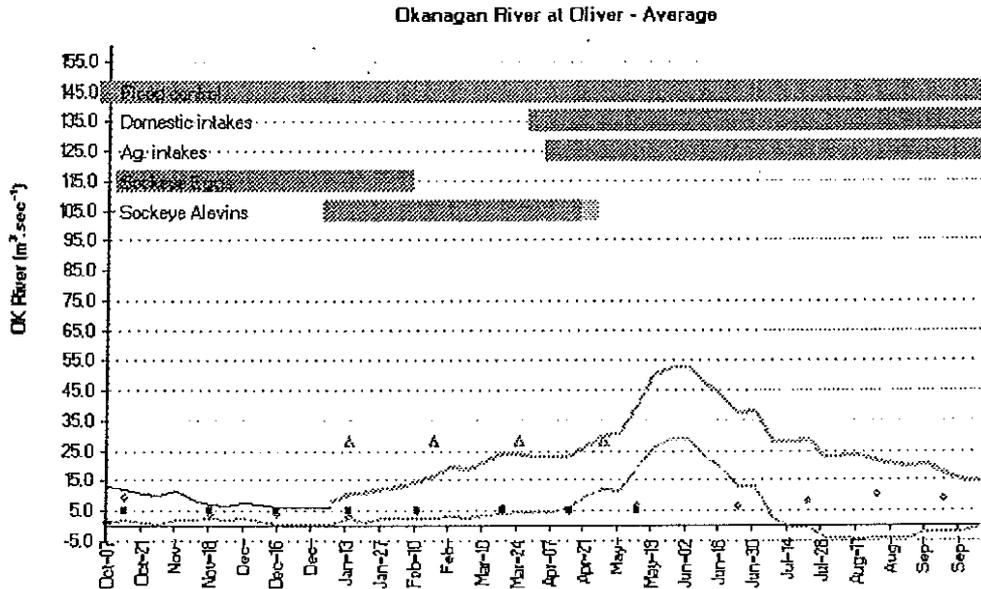
5.8 Scroll down to the graph for "Okanagan River at Okanagan Falls - Average":



5.9 The black and blue lines show the actual and forecast discharge in Okanagan River at Okanagan Falls, respectively. The orange line indicates the net inflow to Okanagan River from tributaries between Penticton and Okanagan Falls. As with mainstem river

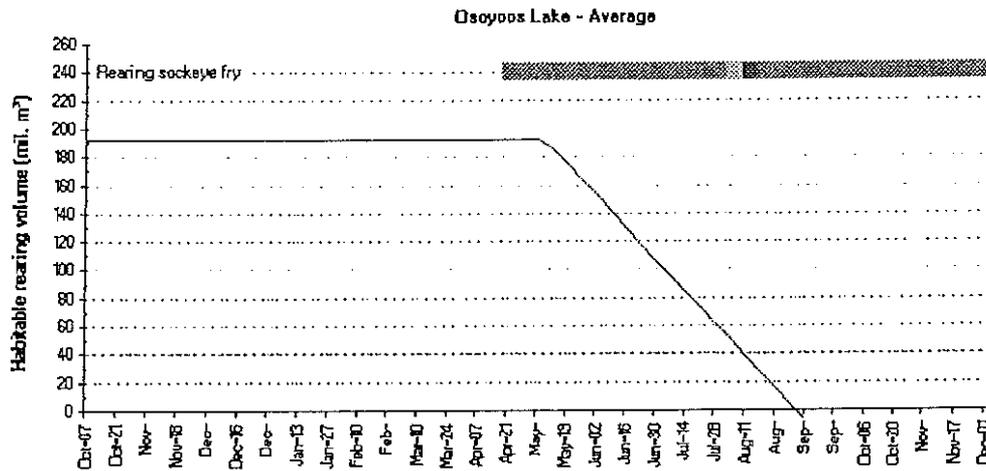
flows, the portion of the line underneath the black line gives actual net inflow, while the portion underneath the blue line gives the forecast net inflow. These tributaries are unregulated and are important sources of variation at sites Downstream from Penticton. There is only one objective to consider at this location: flood control.

5.10 Scroll down to the graph for "Okanagan River at Oliver – Average":



5.11 The black and blue lines show the actual and forecast discharge in Okanagan River at Oliver. The orange line indicates the net inflow to Okanagan River from tributaries between Penticton and Oliver. These tributaries are unregulated. The yellow triangles indicate the Okanagan Basin Agreement targets to minimise scour of sockeye eggs and alevins (water flow above the target will cause scour). The small purple squares show the flow below which sockeye eggs and alevins are likely to be de-watered. The small yellow diamonds indicate minimum flow targets set by the BC-Washington Cooperative Plan. There are five objectives to consider at this location: flood control, domestic and agricultural water intakes, and sockeye eggs and alevins.

5.12 Scroll down to the graph for "Osoyoos Lake – Average":



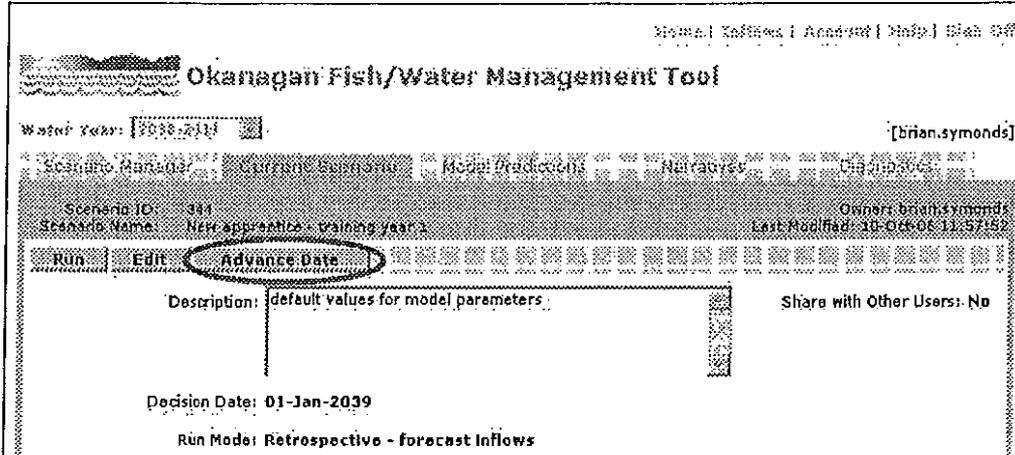
5.13 The solid brown line indicates the volume of habitable or uscable water available to rearing sockeye fry in Osoyoos Lake (water of <17°C and >4ppb oxygen). The red dashed line indicates the volume of water at which a temperature-oxygen “squeeze” is hypothesised to occur—this is reflected in the green-yellow-red hazard bar. There is one objective to consider at this location: rearing habitat for sockeye fry.

5.14 You will also see a histogram with blue bars (not shown here) below the Osoyoos Lake graph. This shows the cumulative inflow to Osoyoos Lake between July and September. Once it passes approximately 157 million m³, issues related to squeeze mortality are hypothesised to be fully mitigated (i.e., a red bar after habitable volume falls below threshold point will turn back to green).

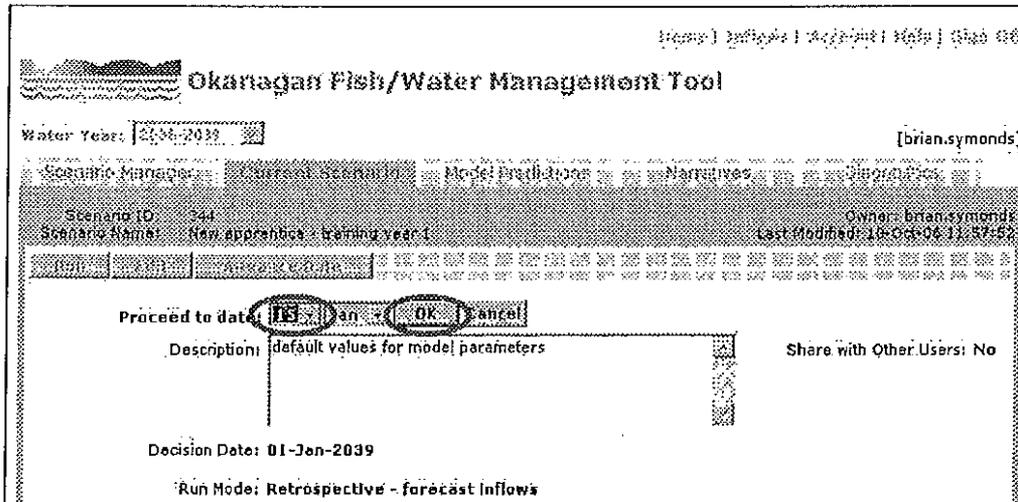
Note: The hazard report has additional tabs, with one containing the data used to create the graphs you’ve just looked at. You don’t necessarily need to look at these numbers in training mode, but they may be useful when you are more comfortable with the information.

Step 6: Advance decision date

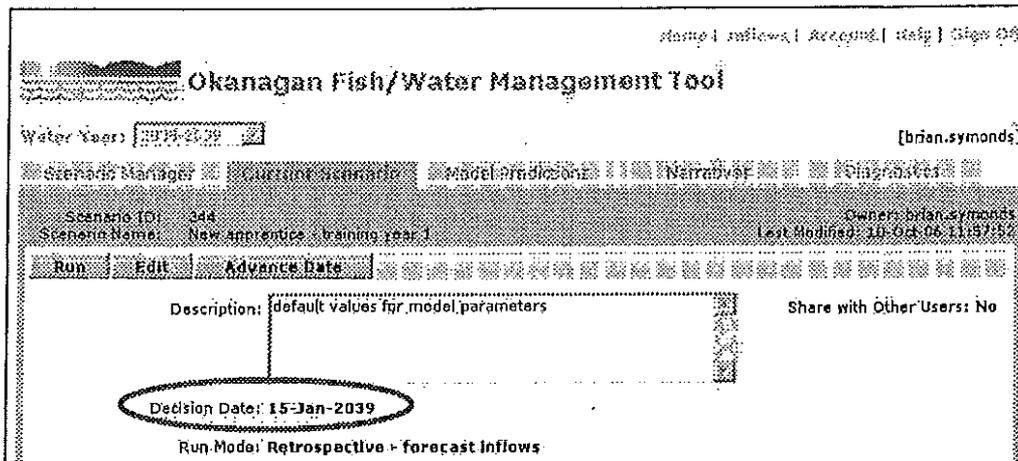
- 6.1 Return to Current Scenario by clicking the *Current Scenario* tab.
- 6.2 Click "Advance Date":



- 6.3 The Decision Date boxes will be highlighted in pink and you will have the option to change the month and day.
- 6.4 Choose a new Decision Date—generally, you want to advance by only 1 or 3 weeks at most, as after you have done so, you cannot go back. Because we don't yet have any inflow forecasts from the year 2038-39 (inflow forecasts begin on February 1 with data from the River Forecast Centre), we've advanced by 2 weeks:



- 6.5 Click OK and you will receive a pink highlighted message stating: "Please confirm that you want to advance the date more than 1 week." Click OK again.
- 6.6 You now receive a second pink message stating that advancing the Decision Date is irreversible. Once you advance, you cannot go back. Click OK, and you will now have an updated Decision Date (as below):



This means that OKFWM took your Okanagan Lake dam releases between the old and new Decision Dates, and applied them to the actual daily net inflows over that period to create a *new history of actual Okanagan Lake elevations and downriver flows!*

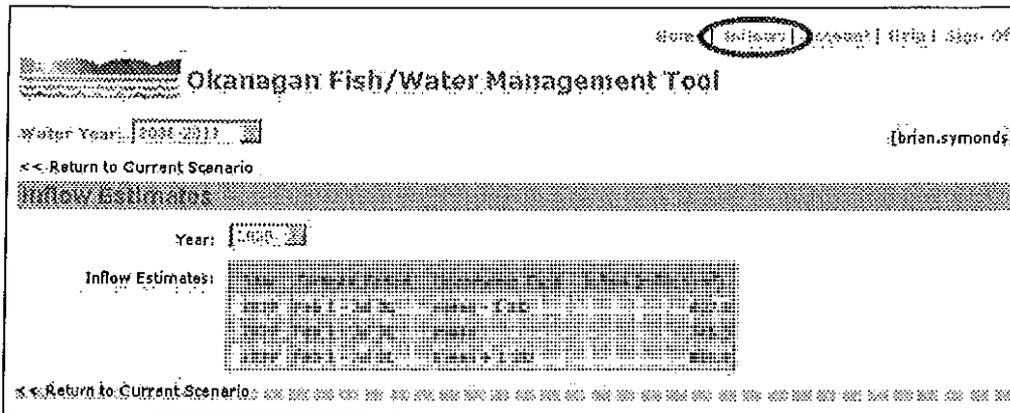
- 6.7 Click "Run" to generate a new set of results with the January 15 decision date.
- 6.8 Open the hazard report, and you will see that the black line has advanced 2 weeks to the right. The January 1-14 data are now known.

Step 7: Run the model with River Forecast Centre (RFC) inflow estimates

The River Forecast Centre (BC Ministry of Environment) produces net inflow estimates on February 1, March 1, April 1 and May 1. The estimates are for the net volume of water that will enter Okanagan Lake between the forecast date and July 31.

In the navigation bar at the top right of the screen, there is a link labelled "Inflows" (see image below). Clicking on this link will display the data from the RFC. With your Decision Date set in January, the Inflow Estimates grid is empty. By advancing the Decision Date to February 1, OKFWM will reveal the first of RFC's inflow estimates as it runs the model. This generally produces a significant change in the water supply outlook.

- 7.1 Return to the *Current Scenario* tab and advance the Decision Date, as you did in Step 6, to February 1.
- 7.2 Click on the Inflows link and look at the RFC data for February 1:



7.3 The grid has three rows of data, each for the period of February 1-July 31. The data rows are the mean water inflow to Okanagan Lake, the mean minus one standard deviation, and the mean plus one standard deviation.

Note: The ± 1 SD information is used by OKFWM to generate additional hazard reports so that you can view a range of possibilities. This is useful because the inflow estimates, particularly early in the season, are made using preliminary snowpack information. You will want to consider what will happen in the Okanagan water system if the mean estimate is too high or too low.

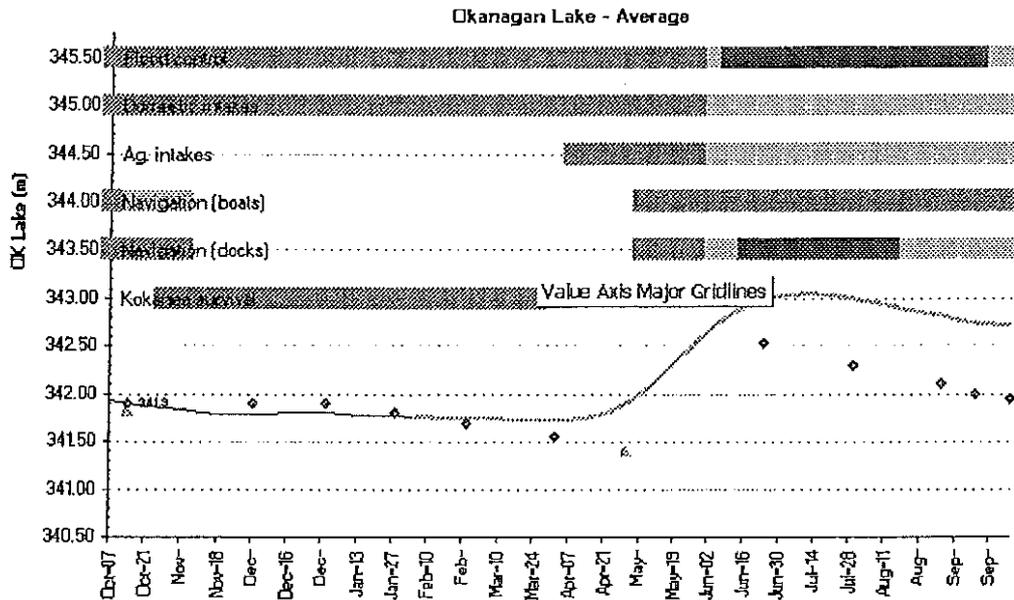
7.4 You can also begin to characterise the water year based on the Inflow Estimates. In the data grid above, the mean inflow to Okanagan Lake from February 1-July 31 is estimated at 746.3 million m^3 . This is a large volume of water (refer to Table 2.4 for the range of inflow volumes that can occur).

7.5 Return to Current Scenario tab and Run the model again. The model will use the average weekly outflow constraints in the Hydrology grid along with the RFC estimates (you do not need to specify that the RFC estimates be used—the model will automatically use RFC estimates when they become available).

7.6 Open the hazard report. You now have three tabs with graphs: one each for the mean (“Ave”), mean +1SD (“High”), and mean -1SD (“Low”) data. Look at the “Graphs (Ave)” tab.

7.7 As before, the black line on each graph has advanced to the new Decision Date revealing the consequences of using that period’s Okanagan Lake dam releases. The blue line is an updated forecast of expected Okanagan Lake elevations and River flows based on the RFC inflow estimate, tributary inflow estimates in accordance with your Okanagan Lake dam outflow constraints forward of the updated Decision Date.

7.8 You see immediately that under this hypothetical flow scenario, there is catastrophic flooding of property around Okanagan Lake from June through September (see below). Several of the other objectives have extensive yellow or red bars as well. Scroll down and look at the results in each graph.

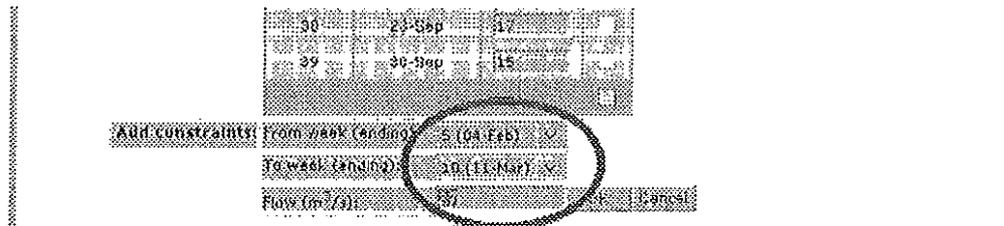


Step 8: Change the outflow constraints to balance objectives

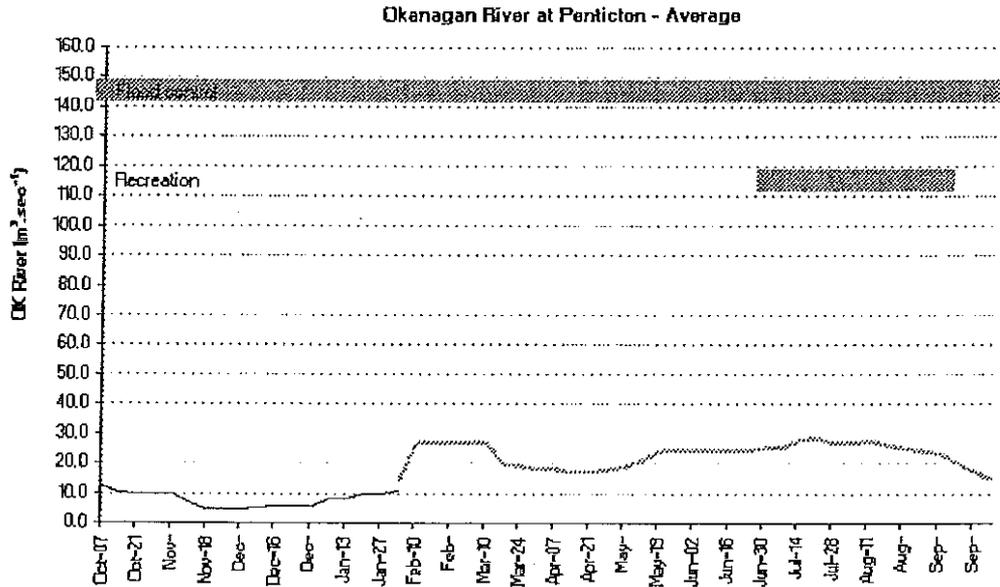
To reduce the projected lakeshore flooding and other negative outcomes, return to OKFWM and begin changing the outflow constraints. This is when you truly begin “gaming” in OKFWM.

Remember: Refer to the Water Management Guidelines (“Cheat Sheet”) as you change outflow constraints.

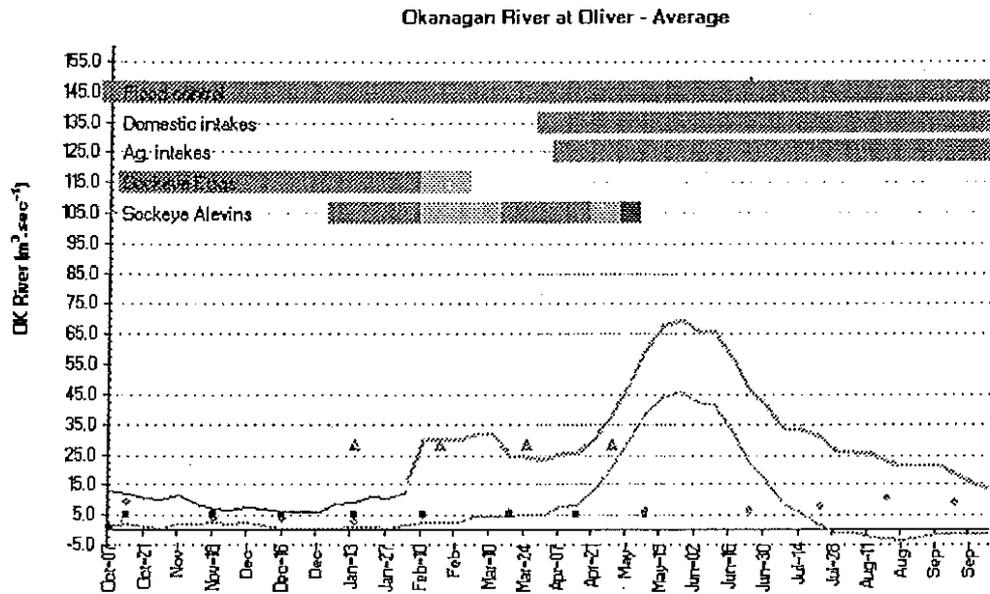
- 8.1 Return to Current Scenario and click “Edit”. Scroll to the end of the Hydrology grid of Outflow Constraints.
- 8.2 Click the “Add” button, which will bring up three boxes highlighted pink. Choose a date range to adjust outflows and type the desired volume in the bottom box. In the screen below, we’ve decided to increase outflow between February 01 and March 11 to $27 \text{ m}^3 \text{ sec}^{-1}$. (In practice, one would want to specify a date range from the week prior to the current Decision Date, through to September 30.)



- 8.3 Click OK and then scroll to the top of the grid where you'll see that the outflow entries for the six weeks specified are now 27 m³ sec⁻¹. (Another, and often more practical way to change outflows is to type directly into the box for each week you want to change.)
- 8.4 "Update" the changes and click "Run". The model will use the RFC estimates, as in the previous run, and the new weekly outflow constraints in the Hydrology grid.
- 8.5 Open the hazard report and look at the "Graphs (Ave)" tab.
- 8.6 The black line remains at February 1 because you did not advance the Decision Date. On each of the river flow graphs, you see the effect of increasing outflow at Pentiction to 27 m³ sec⁻¹ – the blue line increases to a plateau for six weeks:

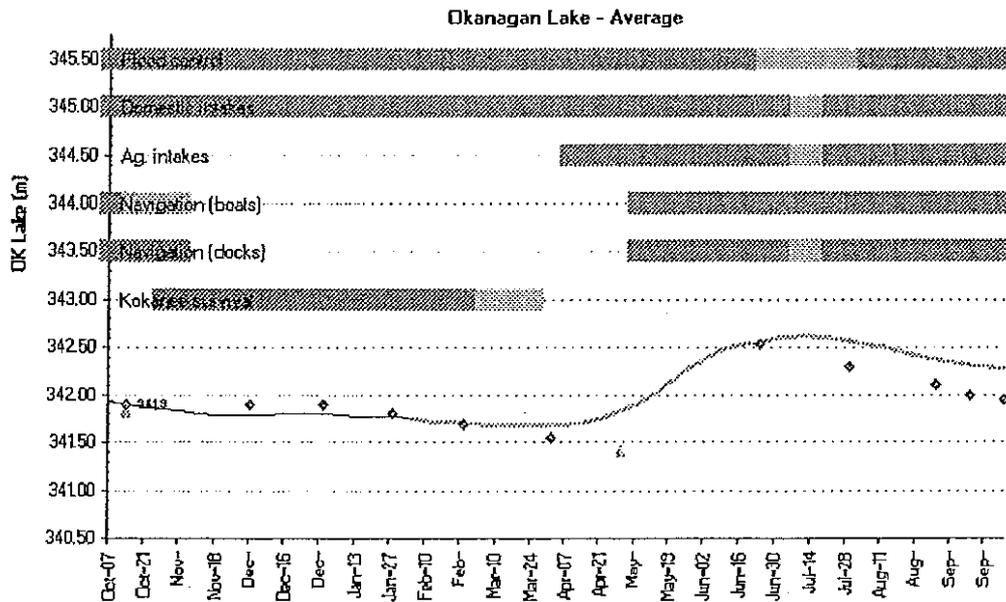


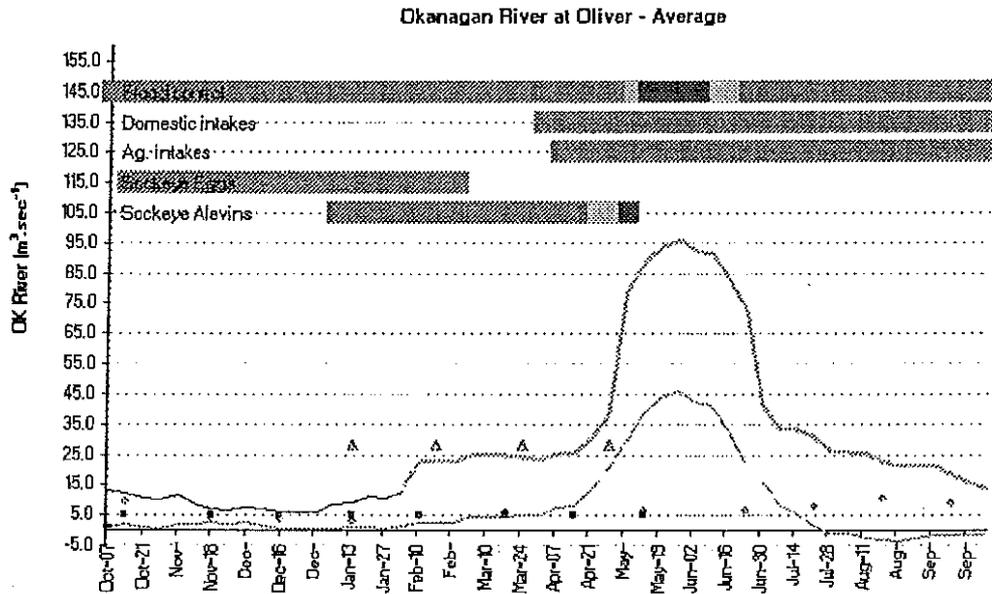
- 8.7 The effect of the change has shortened the length of time that the Okanagan Lake flooding bar is red, but there is still massive lakeshore flooding occurring. Water intakes, navigation and kokanee also continue to be affected. The new changes have also raised flow at Oliver high enough to scour sockeye eggs and alevins in February (see below).



8.8 Examine each graph and then return to Current Scenario to make more changes.

8.9 Try this: Change the February 01 to March 11 weeks to $20 \text{ m}^3 \text{ sec}^{-1}$ and change the May 01 to June 24 weeks to $50 \text{ m}^3 \text{ sec}^{-1}$. Run the model again. Now, the flooding around Okanagan Lake is less severe and you are not scouring the sockeye in February. However, there is flooding occurring around Oliver (largely owing to an expectation of high tributary inflow), and there are problems for sockeye later in the spring.





- 8.10 Continue to tweak the outflows, re-run the model, and examine the output graphs until you are satisfied that you've balanced the objectives as well as you can. Clearly—this was not achieved in the first-pass examples shown above!!
- 8.11 When you are satisfied, advance the Decision Date by one to two weeks (but more than two weeks is not advisable) and run the model again. Continue the back and forth process.

Remember: Once you advance the Decision Date you cannot go back!

Step 9: Narratives

At any time throughout the training session, you can share your findings, time period specific decision rationale and save copies of OKFWM output reports (i.e., expected outcomes) by posting messages and files on the *Narratives* tab. The *Narratives* tab serves as a decision rationale and message centre for OKFWM users. Narratives are displayed by water year. Select the water year for which you wish to view narratives from the "Water Year" drop-down box at the top left corner of the OKFWM main window.

For more information about narratives, how to create and manage them, and some suggested best practices, see Step 11 of Chapter 6 (pg. 111).

Final notes

- The changes you made to outflow constraints in the last several steps are not necessarily the best ones to have made. They were used simply to demonstrate how to make the changes and how changes can affect the objectives.
- As you continue through the water year, you will also want to examine the High and Low output graphs (based on the mean RFC estimate ± 1 SD).
- If you want information about the other output reports generated by OKFWM, go to Steps 6 and 9 in Chapter 6.
- Different years in training mode present different challenges: wet years, dry years, average years. You should work your way through several of them to experience a range of conditions and begin to build a strong foundation of knowledge about how the Okanagan basin water system responds throughout the year.
- Don't hesitate to seek advice and guidance from somebody who is experienced at using OKFWM to help balance fish and water management objectives in the Okanagan basin.

Glossary

All-year average – The flows for a particular week of the year that are the average of all data collected from 1974 to present.

Current scenario – The tab in OKFWM that houses the data you can manipulate.

Decision date – The calendar date you must make a decision about the future pattern of discharge to release from Okanagan Lake dam – think of it as being “today”. OKFWM will show you what has already happened up until “today” and will forecast what is likely to happen after “today” based on a variety of data.

Hazard report – The main report produced by OKFWM. It presents a series of graphs showing how well you meet the various objectives with “traffic light” indicators.

Inflow estimates – The estimated volume of water that will enter Okanagan Lake between the forecast date and July 31. The River Forecast Centre (BC Ministry of Environment) produces inflow estimates on February 1, March 1, April 1 and May 1. The estimates are shown by OKFWM under the tab labelled “Inflow Estimates”.

Lake elevation – The geodetic water level on Okanagan Lake.

Model predictions – The tab in OKFWM that lists various Excel and other output reports available after the model has run.

Objectives – The variables that you are trying to balance in Okanagan basin. These variables include flood control, kokanee egg and alvin survival, sockeye egg, alvin and fry survival, water intakes, navigation, and recreation.

Outflow constraints – The weekly discharge out of Okanagan Lake through the dam at Penticton (Okanagan Lake dam). The outflow is constrained by the design capacity of the dam ($60 \text{ m}^3 \cdot \text{sec}^{-1}$), lake elevation (at flood stage can exceed $60 \text{ m}^3 \cdot \text{sec}^{-1}$, approaching $78 \text{ m}^3 \cdot \text{sec}^{-1}$) and the discretion of the water manager.

Retrospective – The term used to describe OKFWM’s use of historical data on lake levels, snowpack volumes, water inflows and outflows, and fish survival. The data are from a year that has already passed, and the year is blinded or disguised so that it cannot be identified. The retrospective mode of OKFWM is also referred to as the training mode.

Scenario – An set of assumptions on the events that take place during a water year (October 1-September 30) in the Okanagan basin. The scenario includes information on water releases through Okanagan Lake dam, RFC inflow estimates and values for various fisheries variables such as peak spawning dates and the threshold total of accumulated thermal units for fry emergence.

Scenario manager – The tab in OKFWM where you can select, copy, and delete scenarios made available by other users.

Water year – The 12-month period during which water flow decisions are made. In the Okanagan basin, the water year runs from October 1 to September 30. Note that in training mode, OKFWM begins on January 1, which is three months into a water year.

CHAPTER 6

Using OKFWM for in-season management

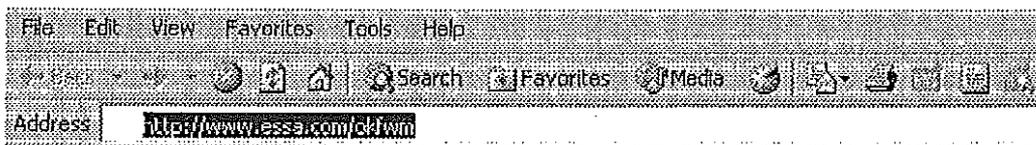
OKFWM can operate in two modes: (1) training or retrospective mode, and (2) in-season management mode. This chapter gives steps for using the in-season management mode; for the retrospective mode, see Chapter 5.

Note: A number of screen images in this chapter have been recently updated to reflect changes in the OKFWM interface. Consequently, the Last Modified date may not seem to be consistent with the information in the scenario being shown.

Step 1: Log into system and create a working scenario

On a computer with an internet connection, open Internet Explorer™. Note: OKFWM has not been tested with other web browsers such as Netscape or Mozilla Firefox. Thus, system behaviour cannot be guaranteed on these platforms.

Enter the following url into the address bar.⁴

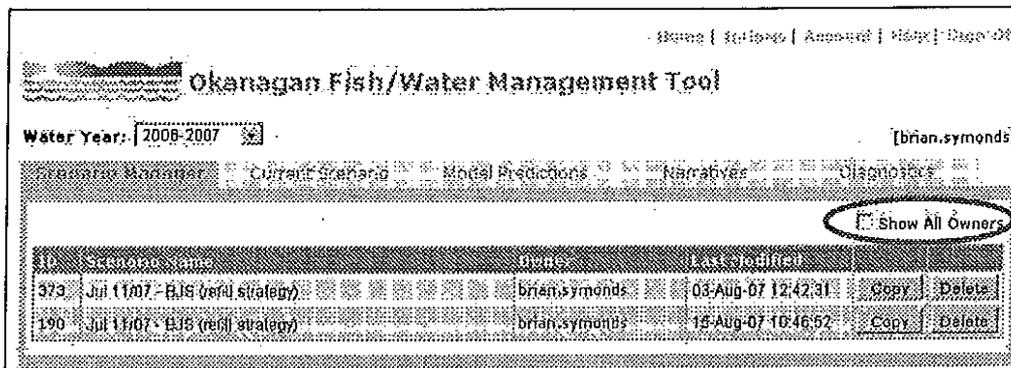


Type your user name and password.

Note: If you do not have access to the system, choose the "Need an account?" link. Submit a password and the OKFWM administrator will contact you with a user name. Allow 2-5 business days.

⁴ Note: this url is planned to change sometime in 2006 or early 2007. The planned domain and address at that time will be "www.ok.fvmt.net" though this is subject to change.

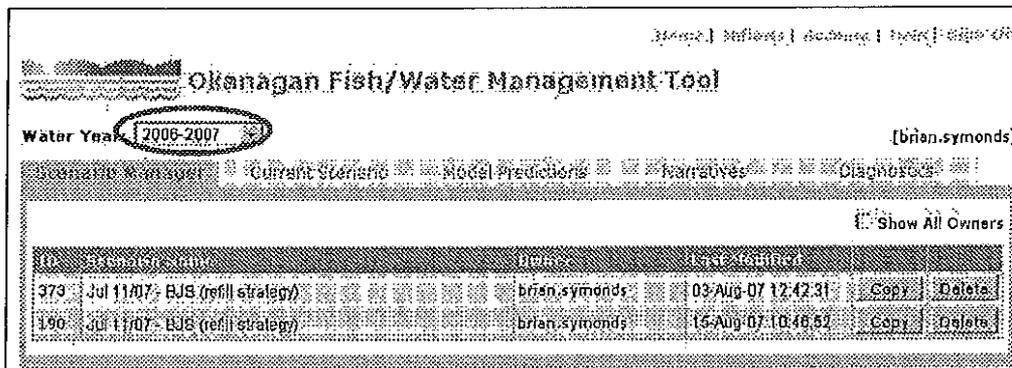
Once logged in, you will see the *Scenario Manager* tab, where you can open or copy an existing Scenario.



Check the “Show All Owners” box to see both your own scenarios and the scenarios others have marked for sharing with other users.

Step 2: Orient in time – set correct “decision date”

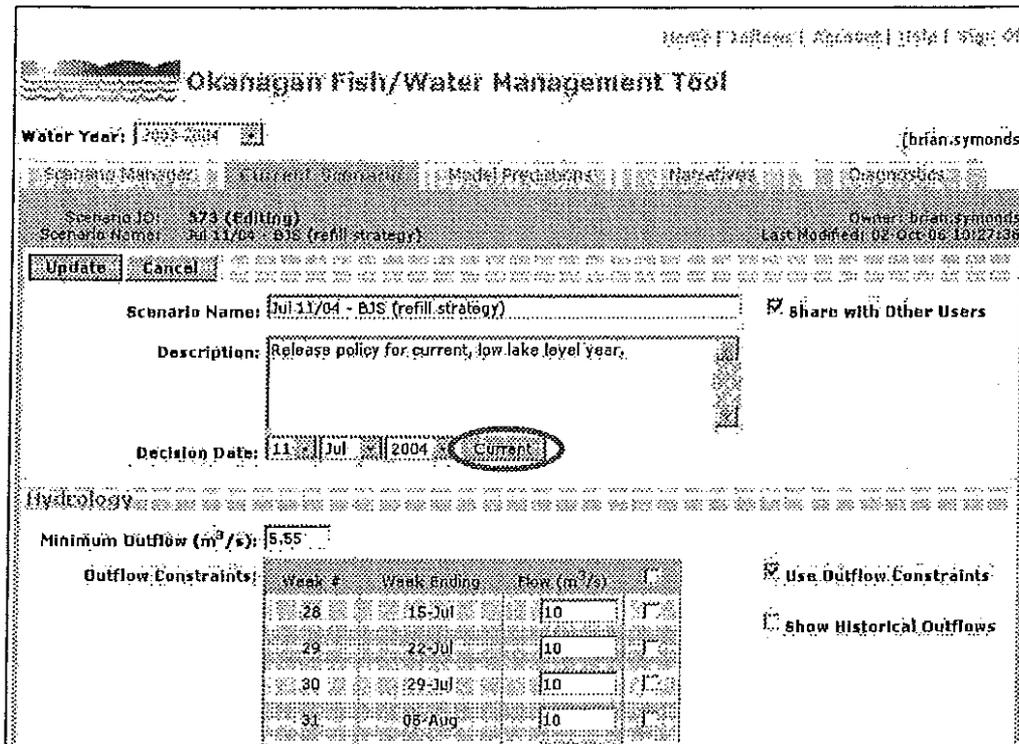
Once you have logged in, choose a working scenario. To do this, start by filtering the available scenarios by selecting a “Water Year” from the drop-down box at the top of the screen. Only those scenarios defined for the selected water year will be listed. The screen image below shows two scenarios (with hypothetical dates) for the water year 2006-2007.



Left-click on your chosen scenario. This action will open the scenario in the *Current Scenario* tab. From this tab, you can edit and run your scenarios.

Note that the information in the *Current Scenario* tab for in-season mode will be different than it was in retrospective mode (which reflects an entirely different suite of scenarios), including up-to-date real-time information. In particular, the in-season mode *Current Scenario* tab will have neither an “Advance Date” button nor “Decision Dates” that resemble future years like 2039.

With your scenario open in the *Current Scenario* tab, set the “Decision Date” to the date for which the most recent real-time data exist. To do this, click the “Edit” button and then click “Current” as shown in the image below:⁵



The result will depend on the actual calendar date. In this example, the user, ‘brian.symonds’, clicked the “Current” button on July 12, 2004. Because real-time data are available on a 24-hour lag, this action yields the previous day’s date.

The resulting table of values will show each week in the water year from the first week ending after the decision date, in this case July 15, to the end of the water year.

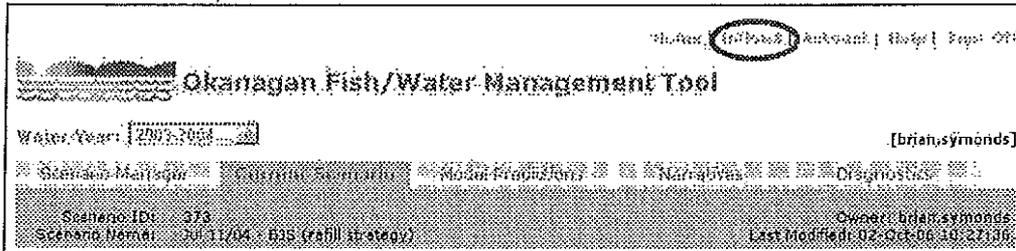
You can display all weeks in the water year by clicking in the “Show Historical Outflows” checkbox. The flow values listed for weeks prior to the decision date represent actual flows from the beginning of the water year, and cannot be edited or deleted. Actual flow data show you what trajectory you are on and provide useful context for outflows to use in the near term.

⁵ Most of the following screen images show older, existing, scenarios as these provide more realistic examples and provide clearer illustrations of procedures.

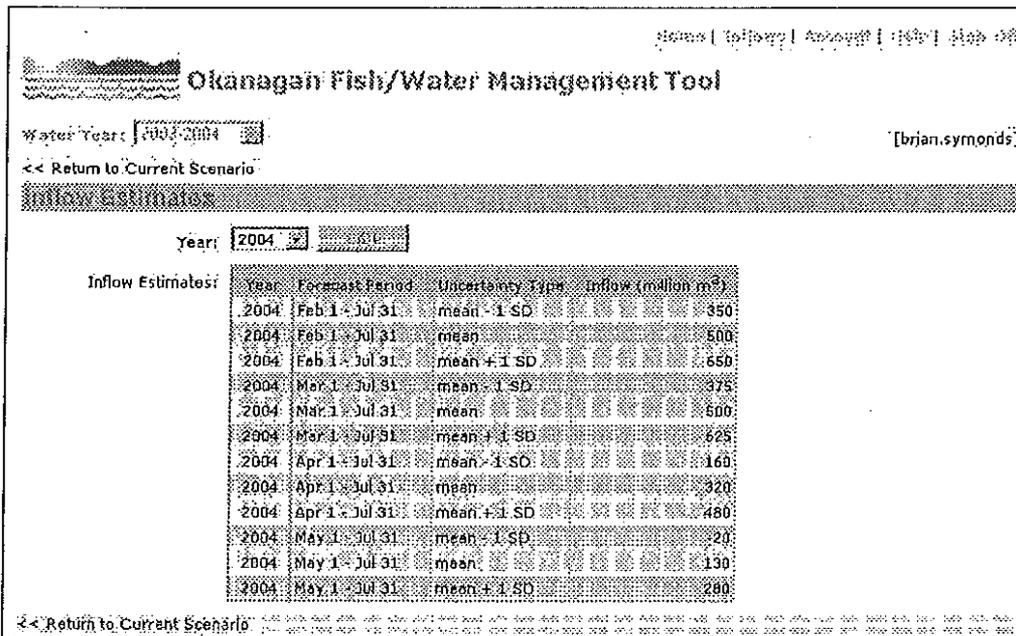
Step 3: Verify presence of or add River Forecast Centre (RFC) inflow estimates

Before adjusting “Outflow Constraints” or other parameter values or running the model from the *Current Scenario* tab, it is critical to ensure that valid *Inflow Estimates* exist for the time period of interest and that these inflow estimates match those supplied by British Columbia’s River Forecast Centre. If the inflow estimates do not match the BC River Forecast Centre values, it is important to document the decision rationale for changing them, using the *Narratives* tab.

Check inflow estimates by clicking on the “Inflows” link on the navigation bar at the top right of your screen:



This action switches the view to show inflow estimates for the selected water year. The result should look something like this:



As described earlier in this guide, net inflow estimates to Okanagan Lake are provided on or shortly after February 1, March 1, April 1 and May 1 of each year by the River Forecast Centre (www.env.gov.bc.ca/rfc/river_forecast/bulletin.htm)⁶. In the example above, the Decision Date was July 11, 2004. Therefore, all four sets of these estimates should already be present.

If the RFC inflow estimates do not appear or you are uncertain about how to obtain them, consult a member of the Canadian Okanagan Basin Technical Working Group (COBTWG) Fish/Water Management Tools (FWMT) Operations Group.

These values are automatically provided to the senior provincial government water managers who operate Okanagan Lake dam. It is recommended that the provincial government representative with the most hydrology and flood management expertise enter these inflow estimates into OKFWM. Once entered, they should not be changed without posting the decision rationale for the change to the *Narratives* tab, and notifying FWMT Operations Group members via email.

If, for instance, you chose a future decision date like February 1, 2007, you might find that the *Inflow Estimates* look as follows:

Okanagan Fish/Water Management Tool

Water Year: 2005-2006 [brian.symonds]

<< Return to Current Scenario

Inflow Estimates

Year: 2007 [Edit]

Year	Forecast Period	Uncertainty Type	Inflow (million m ³)
2007	Feb 1 - Jul 31	mean	
2007	Feb 1 - Jul 31	mean + 1 SD	
2007	Mar 1 - Jul 31	mean - 1 SD	
2007	Mar 1 - Jul 31	mean	
2007	Mar 1 - Jul 31	mean + 1 SD	
2007	Apr 1 - Jul 31	mean - 1 SD	
2007	Apr 1 - Jul 31	mean	
2007	Apr 1 - Jul 31	mean + 1 SD	
2007	May 1 - Jul 31	mean - 1 SD	
2007	May 1 - Jul 31	mean	
2007	May 1 - Jul 31	mean + 1 SD	

<< Return to Current Scenario

You would need to obtain the February 1 to July 31 low (mean - 1 Standard Deviation), mean, and high (mean + 1 Standard Deviation) inflow estimates from the River Forecast Centre and enter them, *before you can use OKFWM with a decision date between February 1 and February 28*. Once the current decision date reaches March 1, you would need an additional 3 inflow estimates from the River Forecast Centre before running OKFWM for decision dates between March 1 and March 31. *Failing to do so will generate an error during a model run.*

If you need to enter or change RFC estimates, click the “Edit” button (image below).

⁶ Should this government branch decide to re-name or re-invent itself, the URL will likely change/be invalidated. Updated links to these important external web resources are maintained under OKFWM’s *Diagnostics* tab.

Home | Inflows | Accept | Help | Sign Off

Okanagan Fish/Water Management Tool

Water Year: [brian.symonds]

<< Return to Current Scenario

Inflow Estimates

Year:

Next, click the “Edit” button associated with the time-of-year inflow estimate row in the grid that you wish to edit.

Home | Inflows | Budget | Help | Sign Off

Okanagan Fish/Water Management Tool

Water Year: [brian.symonds]

Inflow Estimates (Editing)

Inflow Estimates:

Year	Forecast Period	Uncertainty Type	Inflow (million m ³)	
2007	Feb 1 - Jul 31	mean		<input type="button" value="Edit"/>
2007	Feb 1 - Jul 31	mean + 1 SD		<input type="button" value="Edit"/>
2007	Mar 1 - Jul 31	mean - 1 SD		<input type="button" value="Edit"/>
2007	Mar 1 - Jul 31	mean		<input type="button" value="Edit"/>
2007	Mar 1 - Jul 31	mean + 1 SD		<input type="button" value="Edit"/>
2007	Apr 1 - Jul 31	mean - 1 SD		<input type="button" value="Edit"/>
2007	Apr 1 - Jul 31	mean		<input type="button" value="Edit"/>
2007	Apr 1 - Jul 31	mean + 1 SD		<input type="button" value="Edit"/>
2007	May 1 - Jul 31	mean - 1 SD		<input type="button" value="Edit"/>
2007	May 1 - Jul 31	mean		<input type="button" value="Edit"/>
2007	May 1 - Jul 31	mean + 1 SD		<input type="button" value="Edit"/>

Edit estimate: 2007 | Feb 1 - Jul 31 | mean + 1 SD | 0 |

Enter an inflow value. Click the “OK” button to save inflow estimate entries, or “Cancel” to abandon your changes.

Step 4: Set year-specific parameter values

The *Current Scenario* tab includes a number of parameters that you can manipulate under the Kokanee and Sockeye submodel headings⁷. These are in addition to the “Outflow Constraints”, which you will work with in a later step (and described in Chapter 5).

⁷ OKFWM’s database has numerous other parameters for these submodels, but they are not available for user gaming.

Home | Settings | Help | About | Sign Out

Okanagan Fish/Water Management Tool

Water Year: **2002-2004** [brian.symonds]

Scenario Manager | Current Scenario | Model Predictions | Narratives | Diagnostics

Scenario ID: 377 Owner: brian.symonds
 Scenario Name: Jul 11/04 - B39 (refill strategy) Last Modified: 02-Oct-06 10:27:36

Run Edit

Description: Release policy for current, low lake level year. Share with Other Users: Yes

Decision Date: 11-Jul-2004

Hydrology

Minimum Outflow (m³/s): 5.55

Outflow Constraints: Use Outflow Constraints: Yes

Year #	Week Ending	Flow (m ³ /s)
28	15-Jul	10
29	22-Jul	10
30	29-Jul	10
31	05-Aug	10
32	12-Aug	10
33	19-Aug	10
34	26-Aug	10
35	02-Sep	25
36	09-Sep	25
37	16-Sep	25
38	23-Sep	15
39	30-Sep	10

Show Historical Outflows

Kokanee

Peak spawn date: 20-Oct
 Cum. thermal units for 100% fry emergence (°C-days): 950
 Lake drawdown considered to be "preferred" (cm): 15
 Lake drawdown considered to be "not preferred" (cm): 25

Sockeye

Peak spawn date: 19-Oct
 Number of spawners on spawning grounds: 31536
 Proportion females: 0.537
 Proportion of spawners - age 1.1: 0.007
 - age 1.2: 0.972
 - age 1.3: 0.021

NEW Cum. thermal units for 100% fry hatching (°C-days): 595
NEW Cum. thermal units for 100% fry emergence (°C-days): 875
 Total Phosphorus concentration during spring (µg/L): 12
 Mysis density in spring (#/m² of lake surface): 10
NEW Osoyoos Lake habitable volume causing squeeze (millions m³): 40
NEW Cum. inflow alleviating Osoyoos squeeze (millions m³): 157

Suitable default values are usually given, but these should be reviewed by kokanee and sockeye biologists at the beginning of, and during in-season management. Users should also look for "start-up" postings on the *Narratives* tab, where FWMT Operations Group biologists may have already posted the recommended parameter values. Values can be changed by clicking the "Edit" button, making the desired changes, and then clicking "Update" (images below).

Home | Admin | Account | Help | Sign Off

Okanagan Fish/Water Management Tool

Water Year: [brian.symonds]

Scenario Manager | Scenario Designer | Model Productions | Narratives | Diagnostics

Scenario ID: 373 Owner: brian.symonds
 Scenario Name: Jul 11/04 - BJS (refill strategy) Last Modified: 02 Oct 06 10:27:36

Run **Edit**

Kokanee

Peak spawn date:

Cum. thermal units for 100% fry emergence (°C-days):

Lake drawdown considered to be "preferred" (cm):

Lake drawdown considered to be "not preferred" (cm):

Sockeye

Peak spawn date: Use temperature threshold rule (~12°C)
 Specify

Number of spawners on spawning grounds:

Proportion females:

Proportion of spawners by age 1.1:

- age 1.2:

- age 1.3:

NEW Cum. thermal units for 100% fry hatching (°C-days):

NEW Cum. thermal units for 100% fry emergence (°C-days):

Total Phosphorus concentration during spring (µg/L):

Mysis density in spring (#/m² of lake surface):

NEW Osoyoos Lake habitable volume causing squeeze (millions m³):

NEW Cum. inflow alleviating Osoyoos squeeze (millions m³):

Update **Cancel**

Once established, these values should generally not be changed without cause. See Alexander and Hyatt (2005) for details on these assumptions. However, certain variables may change during a season, such as the "Peak spawn date", "Number of spawners on spawning grounds" and "Cum. thermal units" for hatching and emergence. Again, such changes will by best practices be posted on the *Narratives* tab.

Note: Changing these values within a scenario does *not* change the values associated with other user's scenarios. To harmonise assumptions, it is important that you notify all Operations Group members who use OKFWM of any global changes that should be made to fisheries parameters. Best practices for such changes are to put a message under the *Narratives* tab. If the information is deemed urgent, and requires immediate acknowledgement, then it should *also* (not instead of) be emailed, referencing the appropriate Narrative entry.

The screenshot shows the 'Okanagan Fish/Water Management Tool' interface. At the top, there are navigation links: 'Home | Settings | Reports | Help | Help 0/0'. The title bar reads 'Okanagan Fish/Water Management Tool'. Below the title, the 'Water Year' is set to '2003-2004' and the user is identified as '[brian.symonds]'. The 'Current Scenario' tab is selected, showing 'Scenario ID: 373 (Editing)' and 'Scenario Name: Jul 11/04 - BJS (refill strategy)'. The 'Description' field contains 'Release policy for current, low lake level year.' and the 'Decision Date' is set to '11 Jul 2004 Current'. In the 'Hydrology' section, 'Minimum Outflow (m³/s)' is '5.55' and 'Outflow Constraints' is '[No future constraints]'. There are buttons for 'Add' and 'Initialize' (circled), and checkboxes for 'Share with Other Users', 'Use Outflow Constraints', and 'Show Historical Outflows'.

Step 5: Get in the ballpark

5a. Initialize the Outflow Constraints

It is important that you identify a reasonable first approximation of weekly water releases at Okanagan Lake dam, Penticton to “get in the ballpark”. A highly experienced water manager familiar with the system will “know” what reasonable release values are for any particular week of the year, but newer users will not. (The guidelines on pg. 32 will prove valuable.) Outflow constraints can be applied to any week between the decision date and the end of the water year.

Therefore, an “Initialize” button is supplied in the Hydrology section of the *Current Scenario* tab. You may choose to use this button at any time, whether starting from a pristine state (i.e., no “Outflow Constraints” yet established) or whether “Outflow Constraints” already exist. If you click the “Initialize” button, it overwrites any existing constraints and replaces them with the

all-year average weekly release values at Penticton for all 52 weeks of the simulation year. The aim of this feature is to reduce the number of iterations (and thus simulation time) required to hone in on a release policy that *begins* to balance objectives.

Hydrology

Minimum Outflow (m³/s): 5.55

Outflow Constraints:

Week #	Week Ending	Flow (m ³ /s)	<input type="checkbox"/>
28	15-Jul	10	<input type="checkbox"/>
29	22-Jul	10	<input type="checkbox"/>
30	29-Jul	10	<input type="checkbox"/>
31	05-Aug	10	<input type="checkbox"/>
32	12-Aug	10	<input type="checkbox"/>
33	19-Aug	10	<input type="checkbox"/>
34	26-Aug	10	<input type="checkbox"/>
35	02-Sep	25	<input type="checkbox"/>
36	09-Sep	25	<input type="checkbox"/>
37	16-Sep	25	<input type="checkbox"/>
38	23-Sep	15	<input type="checkbox"/>
39	30-Sep	10	<input type="checkbox"/>

Add Delete Selected Initialize

Use Outflow Constraints

Show Historical Outflows

The next image shows the result of clicking "Initialize" when outflow constraints already exist:

Hydrology

Minimum Outflow (m³/s): 5.55

Outflow Constraints:

Week #	Week Ending	Flow (m ³ /s)	<input type="checkbox"/>
28	15-Jul	29	<input type="checkbox"/>
29	22-Jul	29	<input type="checkbox"/>
30	29-Jul	27	<input type="checkbox"/>
31	05-Aug	26	<input type="checkbox"/>
32	12-Aug	27	<input type="checkbox"/>
33	19-Aug	26	<input type="checkbox"/>
34	26-Aug	25	<input type="checkbox"/>
35	02-Sep	23	<input type="checkbox"/>
36	09-Sep	23	<input type="checkbox"/>
37	16-Sep	20	<input type="checkbox"/>
38	23-Sep	17	<input type="checkbox"/>
39	30-Sep	15	<input type="checkbox"/>

Add Delete Selected Initialize

Use Outflow Constraints

Show Historical Outflows

Note the values in the “Flow” column are now different than in the previous image which shows the values prior to clicking on “Initialize”.

Note: These constraints will *not* afford an optimal balance across objectives. They are merely a starting point – a way to avoid a ridiculous pattern of water releases.

5b. Work with the Outflow Constraints grid: Okanagan Lake dam releases

Hydrology

Minimum Outflow (m³/s): 5.55

Outflow Constraints:

Week #	Week Ending	Flow (m ³ /s)	<input type="checkbox"/>
27	08-Jul	10	<input type="checkbox"/>
28	15-Jul	10	<input type="checkbox"/>
29	22-Jul	10	<input type="checkbox"/>
30	29-Jul	10	<input type="checkbox"/>
31	05-Aug	10	<input type="checkbox"/>
32	12-Aug	20	<input type="checkbox"/>
33	19-Aug	30	<input type="checkbox"/>
34	26-Aug	20	<input type="checkbox"/>
35	02-Sep	25	<input type="checkbox"/>
36	09-Sep	10	<input type="checkbox"/>
37	16-Sep	10	<input type="checkbox"/>
38	23-Sep	9	<input type="checkbox"/>
39	30-Sep	9	<input type="checkbox"/>

Add Delete Selected Initialize

The Hydrology “Outflow Constraints” grid is the OKFWM component that you will update most frequently. The grid consists of: week number, week ending dates (ordered from October to September), weekly average Okanagan Lake dam outflows at Penticton (m³.sec⁻¹) and a check box column for specifying weeks to delete (i.e., weeks for which the user does not wish to specify an outflow that differs from the natural net inflow—the default for weeks that have not been assigned an Outflow Constraint). For example, you may wish to delete weeks for which you want outflow at the dam to equal inflow (resulting in stable lake levels), or future weeks that are beyond the timeframe for your scenario. You can also manually “Add” weeks to the grid, but more typically the “Initialize” button will be used for this purpose.

The Hydrology grid can show not only the weeks for which outflow constraints are to be applied (as in the screen image above), but it can also show historical (actual) outflows for the water year. Historical outflows help show you what trajectory you are on and provide context for flows in the near term. Historical flow values cannot be edited.

To add weeks and flows: Click the “Add” button at the bottom of the outflow constraints grid (image above) and you will see a display that resembles the following:

Hydrology

Minimum Outflow (m³/s): 9.55

Outflow Constraints:

Week #	Week Ending	Flow (m ³ /s)	<input type="checkbox"/>
27	08-Jul	10	<input type="checkbox"/>
28	15-Jul	10	<input type="checkbox"/>
29	22-Jul	10	<input type="checkbox"/>
30	29-Jul	10	<input type="checkbox"/>
31	05-Aug	10	<input type="checkbox"/>
32	12-Aug	20	<input type="checkbox"/>
33	19-Aug	30	<input type="checkbox"/>
34	26-Aug	20	<input type="checkbox"/>
35	02-Sep	25	<input type="checkbox"/>
36	09-Sep	10	<input type="checkbox"/>
37	16-Sep	10	<input type="checkbox"/>
38	23-Sep	9	<input type="checkbox"/>
39	30-Sep	9	<input type="checkbox"/>

Add constraints: From week (ending): 39 (07-Sep) To week (ending): 40 (07-Oct) Flow (m³/s): 0 OK Cancel

This feature allows you to choose one or more weeks and an outflow volume to add to the grid or to change outflow values for weeks already in the grid.

To edit flows for weeks within the text boxes: Highlight the flow to be changed and type the new value.

Outflow Constraints:

Week #	Week Ending	Flow (m ³ /s)	<input type="checkbox"/>
27	08-Jul	10	<input type="checkbox"/>
28	15-Jul	10	<input type="checkbox"/>
29	22-Jul	12.5	<input type="checkbox"/>
30	29-Jul	10	<input type="checkbox"/>
31	05-Aug	10	<input type="checkbox"/>

To delete specific weeks from the grid: Check the box to the right of the weeks you want to delete and click either “Delete Selected” or “Update”:

Outflow Constraints:			
Week #	Week Ending	Flow (m ³ /s)	<input type="checkbox"/>
27	08-Jul	10	<input checked="" type="checkbox"/>
28	15-Jul	10	<input checked="" type="checkbox"/>
29	22-Jul	12.5	<input type="checkbox"/>

If appropriate, you can select all weeks for deletion by clicking in the checkbox at the top of the grid (see red circled box in the screen image above). In practice however, deleting weeks is not necessary, nor is it a recommended practice.

Apply all of your changes by clicking the “Update” button:

Scenario Manager Current Scenario

Scenario ID: 190 (Editing)

Scenario Name: Jul 11/04 - B1S (refill strategy)

Important: OKFWM uses the best information available for a given decision date. For example, if the current decision date is July 22, and the outflow constraints grid specified release constraints for the weeks ending July 8 and July 15, these constraints would *not be used*. Instead, real-time information would be used to show what actually occurred during those weeks.

5c. Diagnostics

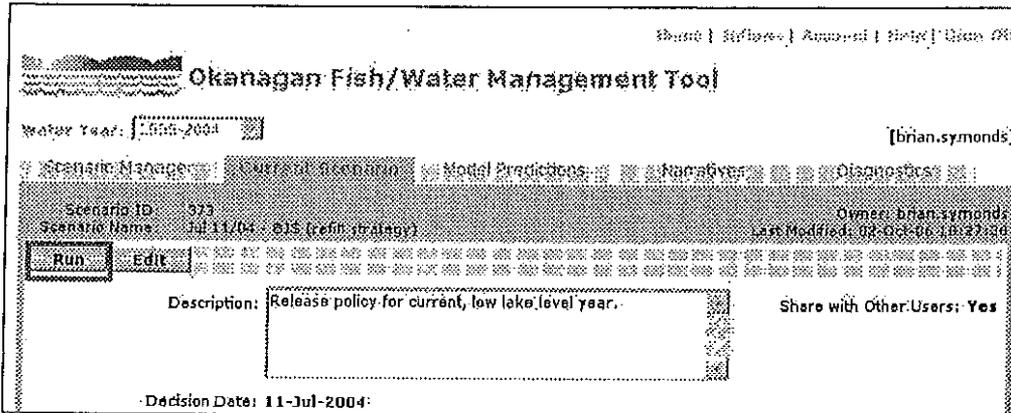
Another important resource for guiding decisions about outflow constraints is a set of diagnostics in the form of links to data and information about Okanagan water management that are external to the OKFWM system (*Diagnostics* tab). Diagnostics provide context for weighting decisions about things like flood risk vs. other considerations. They can be viewed without running the model. Five broad categories of information are available on OKFWM’s *Diagnostics* tab:

- (A) Snow pillow status and water supply forecast;
- (B) Local precipitation, weather forecasts and other real-time sources;
- (C) Okanagan Lake, River and Tributaries;
- (D) Weekly inflows, sockeye-kokanee emigration timing, cgg scour-desiccation, Osoyoos temp-O₂ squeeze; and
- (E) Other.

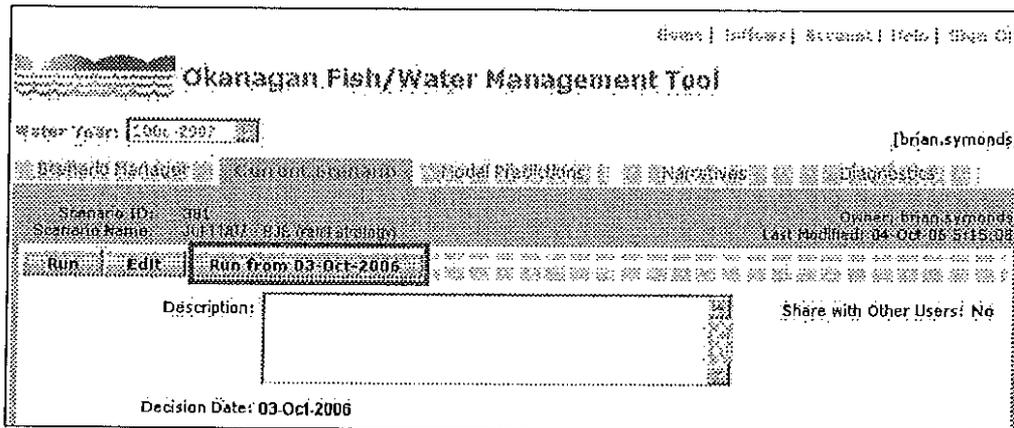
Diagnostic categories are presented on the tab in the order that users would typically review information when managing in-season.

Step 6: Perform model run to identify major trade-offs and begin to classify water year

At this point you have a working scenario, have updated the "Decision Date," have verified that the appropriate "Inflow Estimates" exist, and have chosen an initial set of "Outflow Constraints." OKFWM is now ready to run. Click the *Current Scenario* tab's "Run" button:



Alternatively, when working in the current water year, you can update and run the model in one step. To do this, click on the "Run from dd-mmm-yyyy" button (image below).

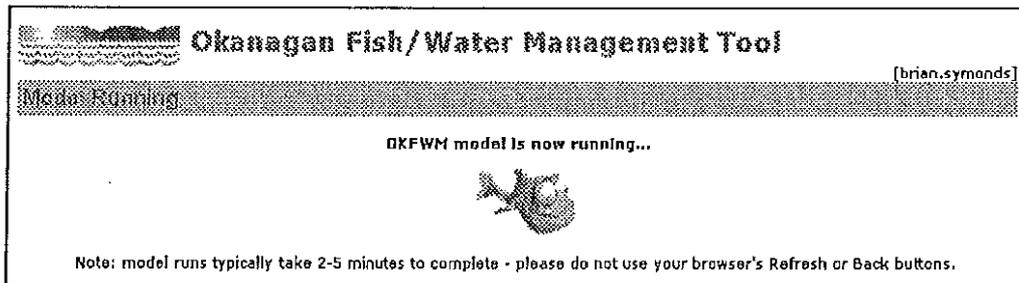


This action will run the model using the most current real-time data, based on a decision date determined from real-time downloads. Note that the "Run from dd-mmm-yy" button is only visible when you are viewing a scenario based on the current water year (retrospectively, this button does not make sense / have the necessary context).

Important: The date on the *Run from dd-mmm-yy* button should be no more than one to two days behind the actual calendar date. A date that is more than two or three days behind the actual calendar date usually indicates that there is a problem with the source data available for the model, e.g., trouble with field data loggers, technical problems with either Water Survey of Canada or the OKFWM server, etc. If this occurs, a Narrative entry should be posted noting the problem, and the OKFWM system administrator notified (see Help page for contact information).

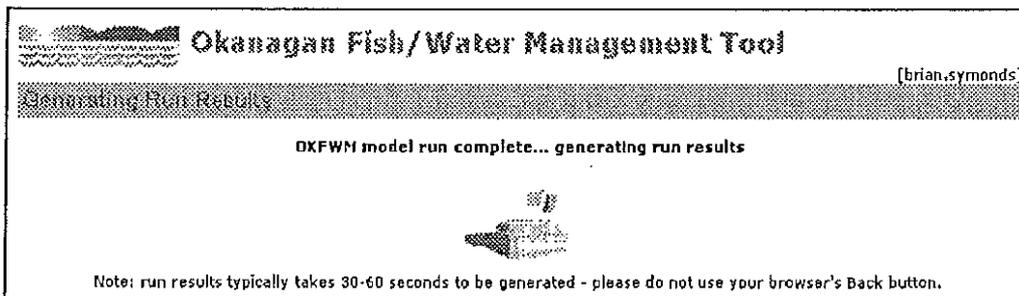
Another useful check, is to go to the "Actual Okanagan Lake Dam releases (hourly)" link on the Diagnostics tab, and ensure that the external Water Survey of Canada site is actually up to date for releases at Penticton. If not, then the problem resolution must be flagged up to the Water Survey of Canada's hydrometric web service administrator. This contact information is provided in the OKFWM Technical Administration document, and will be known by the OKFWM system administrator.

Run requests are sent to the OKFWM server computer, which performs the simulation and gathers real-time data. While this processing takes place, a screen resembling the following appears:



Note the comment: "please do not use your browser's Refresh or Back buttons".

Once model processing is complete and output has been written to the OKFWM database, OKFWM generates a series of downloadable output reports in Microsoft Excel™. While the server computer is generating these output files, a screen resembling the following appears:



When the run is complete and the results are ready for viewing, OKFWM automatically redirects you to the *Model Predictions* tab.

The entire process usually takes between 2 and 7 minutes depending on the decision date (time required to run the model increases as decision dates approach September), amount of concurrent activity or runs by other OKFWM users and background performance variation over the Internet.

Tip: Other computer tasks may be carried out while these runs are being performed. However, if you want to use the Internet, open a *second* instance of Internet Explorer. Otherwise, you may receive OKFWM run time errors.



Okanagan Fish/Water Management Tool

[Home](#) | [Refresh](#) | [Account](#) | [Help](#) | [Sign Off](#)

Water Year: 2008-2009

[brian.symonds]

Scenario Manager

Current Scenario

Model Predictions

Narratives

Discharge

Scenario ID: 374

Owner: brian.symonds

Scenario Name: Summer releases

Last Modified: 23-Sep-05 14:09:57

Run Started: 23-Sep-05 14:23:15

Run Completed: 23-Sep-05 14:24:30

Run Results:

- Multi-objective hazard assessment [state-of-the-science considerations].
- Net inflows (weekly) - includes cumulative inflow plot + statistical comparison with past years
- Net inflows (monthly) - can be compared with RFC inflow calculation methods
- Sockeye egg abundance over time (degradation and scour impacts).
- Sockeye lifetime abundance (cohort table)
- Kokanee emergence timing (showing Okanagan Lake ATUs) including lake elevation data
- Sockeye emergence timing (showing Okanagan River ATUs)
- Okanagan River (daily real-time and forecast flow data by station)
- Okanagan Lake (daily real-time and forecast lake elevation data)
- Compliance - Okanagan Basin Agreement (1970s compliance focused considerations)



There are three main classes of output on the *Model Predictions* tab: (1) primary hazard assessment of trade-offs over all locations; (2) hydrologic and fish population information; and (3) raw links to real-time data.

Water Years: 2002-2004

Scenario ID: 574
Scenario Name: Summer releases

Run Started: 23-Sep-05 14:23:15
Run Completed: 23-Sep-05 14:24:30

Run Results:

- Multi-objective hazard assessment [state-of-the-science considerations] **primary output**
- Net inflows (weekly) - Includes cumulative inflow plot + statistical comparison with past years
- Net inflows (monthly) - can be compared with REC inflow calculation methods
- Sockeye egg abundance over time (desication and scour impacts)
- Sockeye life-stage abundance (cohort table)
- Kokanee emergence timing (showing Okanagan Lake ATUs) including lake elevation data
- Sockeye emergence timing (showing Okanagan River ATUs)
- Okanagan River (daily real-time and forecast flow data by station)
- Okanagan Lake (daily real-time and forecast lake elevation data)
- Compliance - Okanagan Basin Agreement [1970s compliance focused considerations]

like primary output but not as scientifically grounded

real-time data links

output per sub-system/component

Brian Symonds

Again, in addition to the three main classes of OKFWM output, some very helpful contextual information sources in the form of external links are provided on the *Diagnostics* tab. These links give you quick access to a lot of the data used by OKFWM (but without the need to run the model to see the data). The links for "BC River Forecast Centre" and "Kelowna area precipitation" provide other potentially helpful information on forecast inflows and basin precipitation. The link for "Mission Creek inflows to Okanagan Lake" is quite useful, as this is the major tributary supplying surface run-off to Okanagan Lake. This can be used as an index of real-time tributary inflow to help scale releases at Okanagan Lake dam.

As you gain experience with fish/water management in the Okanagan, the relevance of these different sources of information will become clear.

Home | Inflows | Outputs | Help | Sign Off



Okanagan Fish/Water Management Tool

Water Year:
[brian.symonds]

Scenario Manager
Current Scenario
Model Predictions
Narratives
Diagnostics

A) Snow pillow status and water supply forecast:

- o Current snow conditions. {www.nwrfo.noaa.gov}
- o BC River Forecast Centre snow pillows via map or station list {www.env.gov.bc.ca/rfc}
- o BC River Forecast Centre bulletin (commentary) and outlook (if available) {www.env.gov.bc.ca/rfc}

D) Local precipitation, weather forecasts and other real-time sources:

- o Kelowna area precipitation {climate.weatheroffice.ec.gc.ca - climate station 1123965}
- o Kelowna 5-day weather forecast {www.theweathernetwork.com}
- o WeatherPro data - Mission Creek (air temp, cum. rain, SWE) {www.env.gov.bc.ca}
- o WeatherPro data - Brenda Mine (air temp, cum. rain, SWE) {www.env.gov.bc.ca}
- o RWIS station data (snow depths, freezing point, precip, air temps etc.) {saw-rwis.th.gov.bc.ca - requires login ID}
- o NOAA Northeast Pacific infrared satellite loop {www.ssd.noaa.gov}
- o NOAA monthly air temperature departures

C) Okanagan Lake, River and Tributaries:

- o Actual Okanagan Lake Dam releases (hourly) {scitech.pyr.ec.gc.ca - station 08NM050}
- o Okanagan Lake at Kelowna elevation (hourly) {scitech.pyr.ec.gc.ca - station 08NM083}
- o Okanagan River flow near Oliver (hourly) {scitech.pyr.ec.gc.ca - station 08NM085}
- o Mission Creek inflows to Okanagan Lake (hourly) {scitech.pyr.ec.gc.ca - station 08NM116}
- o Inkaneeep Creek inflows to OK River (gauge height only) {scitech.pyr.ec.gc.ca - station 08NM200}
- o Vaseaux Creek inflows to OK River (gauge height only) {scitech.pyr.ec.gc.ca - station 08NM246}

D) Weekly inflows, sockeye-kokanee emergence timing, egg scour-dessication, Dsoyoo temp-O₂ squeeze:

- o See: Model Predictions

E) Other:

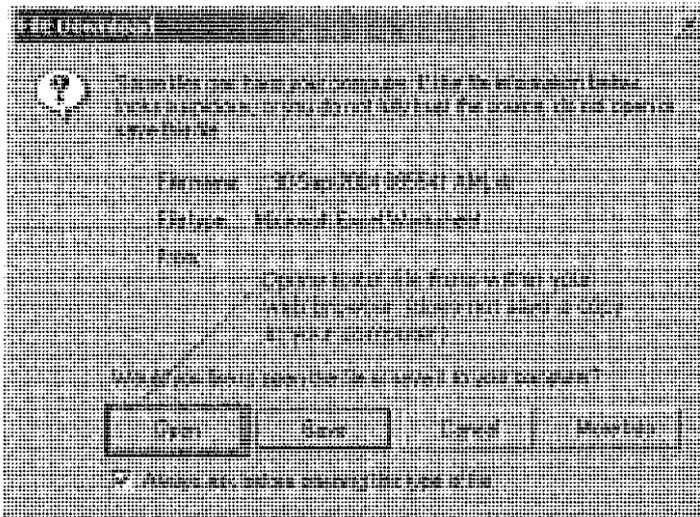
- o NorthWest Power & Conservation Council: Okanagan subbasin plan {www.nwcouncil.org}
- o Columbia Basin Research: fish status & trends {www.cbr.washington.edu}

Step 7: Review main hazard report output

From the *Model Predictions* tab, click the "Multi-objective hazard assessment" report:

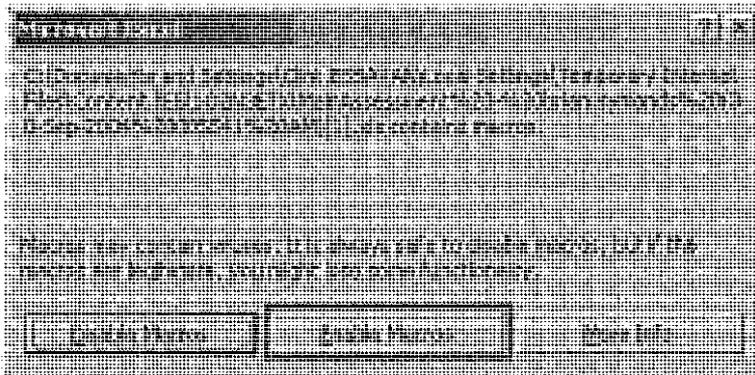
The screenshot shows the 'Okanagan Fish/Water Management Tool' interface. At the top, there are navigation tabs: 'Scenario Manager', 'Current Scenario', 'Model Predictions', 'Narratives', and 'Diagnosis'. The 'Model Predictions' tab is active. Below the tabs, the 'Scenario ID' is 374 and the 'Scenario Name' is 'Summer releases'. The 'Owner' is 'brian.symonds' and the 'Last Modified' date is '23-Sep-05 14:09:57'. The 'Water Year' is set to '2002-2003'. The 'Run Started' time is '23-Sep-05 14:23:15' and the 'Run Completed' time is '23-Sep-05 14:24:30'. The 'Run Results' section lists several reports: 'Multi-objective hazard assessment [state-of-the-science considerations]', 'Net inflows (weekly) - includes cumulative inflow plot + statistical comparison with past years', 'Net inflows (monthly) - can be compared with IFC inflow calculation methods', 'Sockeye egg abun', 'Sockeye lifestage', 'Kokanee emergence timing (showing Okanagan Lake ATUs) including lake elevation data', 'Sockeye emergence timing (showing Okanagan River ATUs)', 'Okanagan River (daily real-time and forecast flow data by station)', 'Okanagan Lake (daily real-time and forecast lake elevation data)', and 'Compliance - Okanagan Basin Agreement [1970s compliance focused considerations]'. A mouse cursor is hovering over the 'Net inflows (monthly)' report, and a tooltip box appears with the text: 'Right-click and choose "Open" to display in browser, or "Save Target As" to download.' There is a small graphic of a fish in the bottom right corner of the report area.

Depending on the version of Internet Explorer you use and its settings, this may result in the display of a dialogue resembling:



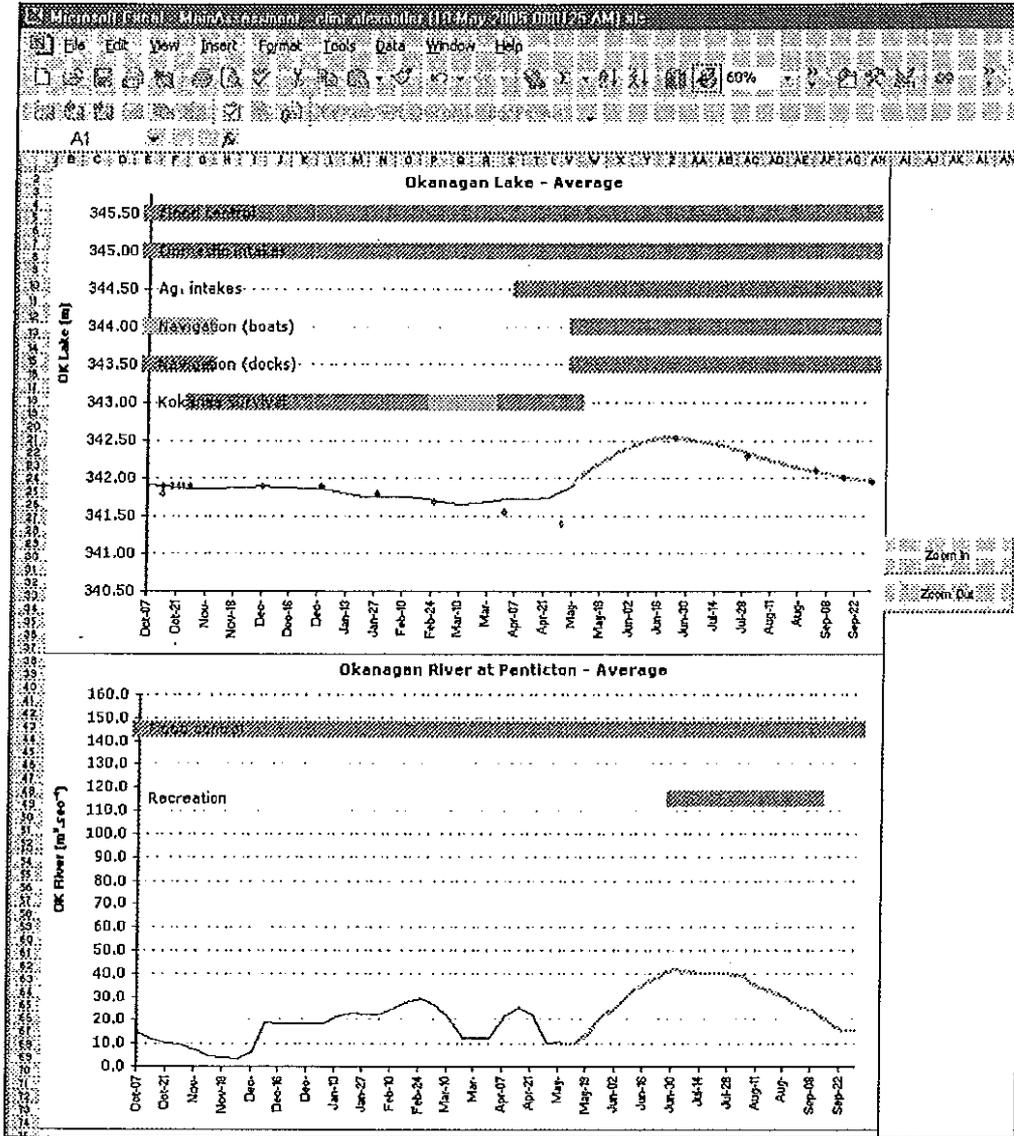
You may want to choose Open and preview the file to see if the outflow constraints you used provided a reasonable balance amongst objectives. Then, you can decide if it is worthwhile saving to your computer.

OKFWM uses Excel Visual Basic code to automate formatting of data supplied from the system's database. So, you will probably also receive a second dialogic resembling:



Choose "Enable Macros."

The multi-objective hazard report output will open in your web browser:



The information in this report is described in more detail starting on pg. 118, "Understanding OKFWM Hazard Assessment Reports".

Step 8: Adjust release constraints to better balance objectives and re-run simulation

In most cases, two or three additional runs will be necessary to *begin* to obtain a more reasonable balance amongst objectives (i.e., more “green”). Refer to the guidelines and strategies in Chapters 2, 3 and 4, and to the information available on the *Diagnostics* tab, as you adjust the Outflow Constraints.

To make adjustments:

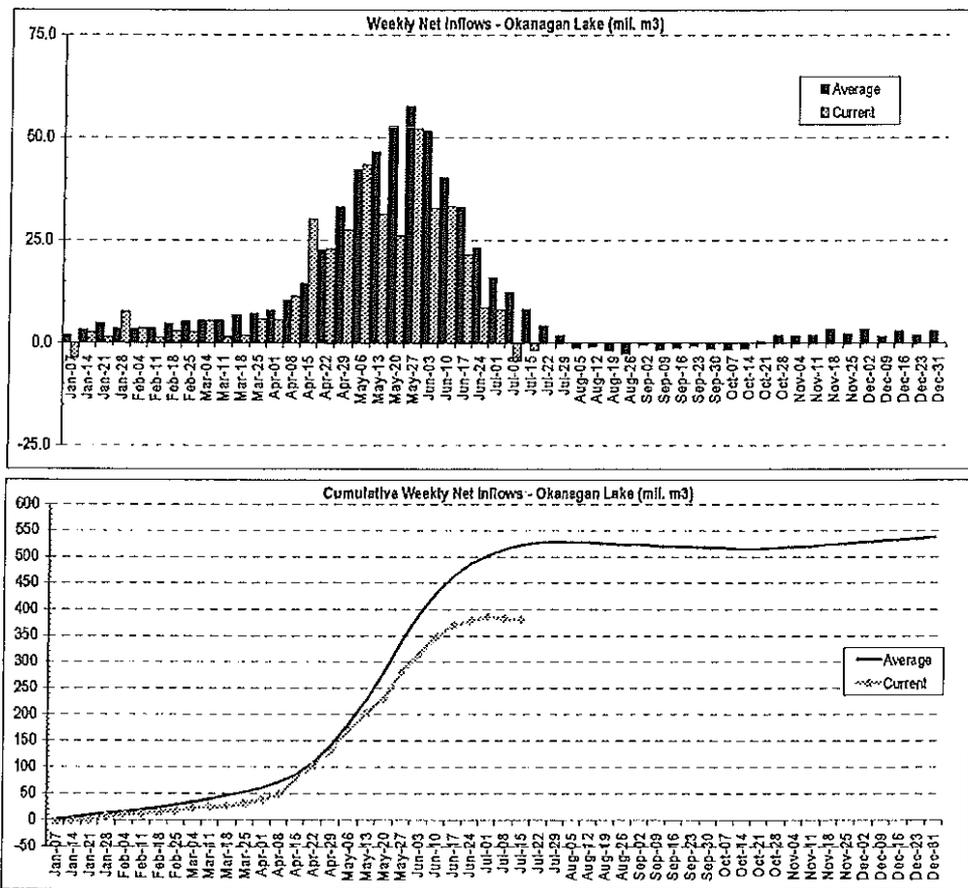
1. Close the Excel output file or choose Model Predictions from your Windows taskbar;
2. Select the *Current Scenario* tab;
3. Click the “Edit” button;
4. Modify “Outflow Constraints;” and
5. Re-run OKFWM.

Step 9: Review output reports to better classify water year

A fundamental indicator for determining whether a water year will likely emphasise low, average or high inflow management issues is the cumulative weekly net inflows. This information is available from the *Model Predictions* tab, by choosing:

Net inflows (weekly) - includes cumulative inflow plot + statistical comparison with past years

which gives:

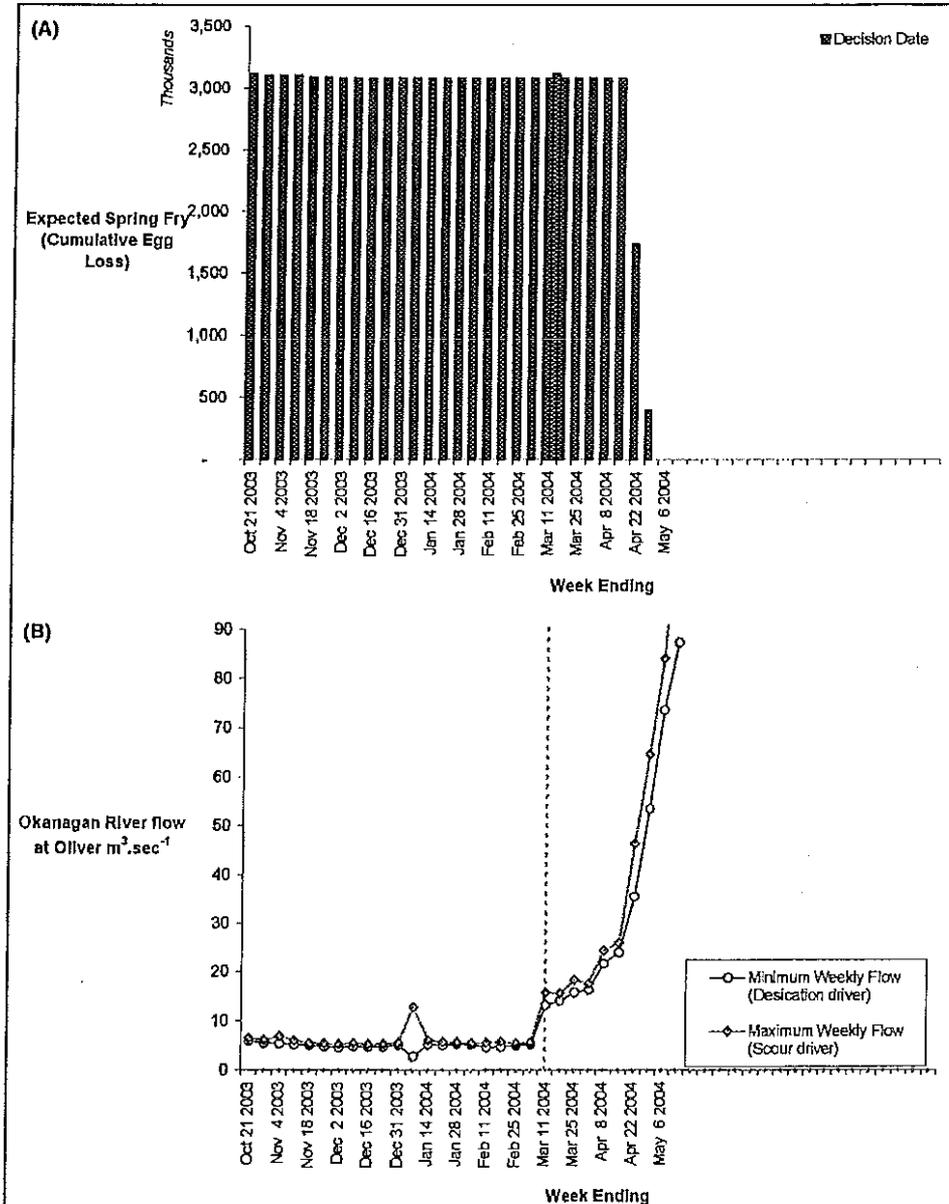


From real-time data, the trends in this plot can be used to determine whether to increase or lower weekly water releases at Okanagan Lake dam.

For sockeye egg/alevin survival issues, the following report is informative:

Sockeye egg abundance over time (desiccation and scour impacts)

This report contains information on cumulative egg losses associated with minimum and maximum weekly flows (see image below). This report can be used to determine the extent and acceptability of sockeye egg/alevin mortality owing to future flows (i.e., flows after the decision date).



Step 10: Fine tune release policy and make trade-offs when there is no “win-win” situation

Continue adjusting the Outflow Constraints and examining OKFWM’s primary hazard report to obtain a workable balance of seasonal releases. Your aim is to have every objective’s hazard bar show green. Since this is frequently not feasible, you should follow the water management guidelines and strategies provided in Chapters 2, 3, and 4.

Step 11: Document rationale for decisions and share results with others

The COBTWG FWMT Operations Group members are responsible for documenting these decisions. Throughout the season, all members should document the rationale for specific release decisions / changes. In particular, document the rationale associated with any major adjustments to releases as well as the thinking behind how certain risks are being mitigated. This provides an audit trail, and important information for mid-season and post-season reviews.

Starting in water year 2006/2007, the recommended best practice process for documenting decision rationale, or any other relevant findings, observations, comments etc. is to post messages and supplementary files on the *Narratives* tab. Narratives are recorded and displayed by water year. Select the water year for which you wish to view narratives from the “Water Year” drop-down box at the top left corner of the OKFWMT main window.

The following screen image shows a chain of narratives, based on the water year 2005-2006⁸, involving a variety of threads by several different users.

⁸ The narratives in this example were composed explicitly for the purpose of illustrating narrative best practices in this user guide. Therefore, the dates in the “Created” and “Last Modified” columns are not realistic. In an authentic narrative chain, these dates would reflect the actual date each message was composed and subsequently modified (if applicable).

Home | Inflow | Output | Help | Log Off

Okatawa Fish/Water Management Tool

Water Year: 2005-2006 [brian.symonds]

Scenario Manager | Output Scenario | Model Predictions | **Narratives** | Diagnostics

Show All Authors

ID	Subject	Owner	Created	Last Modified	# in Thread	
46	Re: Real time data problems again?	clint.alexander	30-Sep-06 13:05:01	30-Sep-06 13:08:28	2	
45	Real time data problems again?	don.mckee	30-Sep-06 13:04:06	30-Sep-06 13:04:06	2	
44	Sockeye submodel change	kim.hyatt	30-Sep-06 13:02:41	30-Sep-06 13:02:41	1	
43	Potential temp/O2 squeeze problem - pulse releases needed	kim.hyatt	30-Sep-06 13:01:23	30-Sep-06 13:01:23	1	
42	OKFWM has proved its worth	brian.symonds	30-Sep-06 12:55:33	30-Sep-06 12:55:33	1	
41	Jun 21 06 Outlook	kim.hyatt	30-Sep-06 12:53:53	30-Sep-06 12:53:53	1	
40	Re: FWMT net inflow chart	kim.hyatt	30-Sep-06 12:51:15	30-Sep-06 12:51:47	2	
39	FWMT net inflow chart	don.mckee	30-Sep-06 12:43:55	30-Sep-06 12:43:55	2	
38	Re: Reset RFC estimate to original 450 estimate	clint.alexander	30-Sep-06 12:42:30	30-Sep-06 12:43:08	2	
37	Reset RFC estimate to original 450 estimate	don.mckee	30-Sep-06 12:42:15	30-Sep-06 12:42:15	2	
36	Re: Tributary inflow submodel	kim.hyatt	30-Sep-06 12:40:38	30-Sep-06 12:41:02	5	
35	Re: Tributary inflow submodel	don.mckee	30-Sep-06 12:40:13	30-Sep-06 12:40:26	5	
34	Re: Tributary inflow submodel	kim.hyatt	30-Sep-06 12:37:56	30-Sep-06 12:39:24	6	
33	Re: Alert: OK Lake trajectory II	brian.symonds	30-Sep-06 12:36:44	30-Sep-06 12:37:08	3	
32	Re: Alert: OK Lake trajectory	brian.symonds	30-Sep-06 12:34:07	30-Sep-06 12:35:24	3	
31	Alert: OK Lake trajectory	clint.alexander	30-Sep-06 12:33:50	30-Sep-06 12:33:50	3	
30	Re: Tributary inflow submodel	clint.alexander	30-Sep-06 12:29:43	30-Sep-06 12:31:19	5	
29	Tributary inflow submodel	don.mckee	30-Sep-06 12:29:25	30-Sep-06 12:29:25	5	

Narratives are listed in descending order of creation, with the most recent post at the top of the table. The "Owner" column indicates the author of each message, and the column labelled "# in Thread" indicates the number of messages in a particular conversation. Messages can also be deleted from the chain of narratives using the "Delete" button at the end of each entry in the table. Note, however, that messages can only be deleted by their owners. For all other messages in the table, the "Delete" button is disabled.

New messages can be created either as part of an existing thread, or as the first message in a new thread. To begin a new thread, click on the "New Thread" button.

The screenshot shows the 'Okanagan Fish/Water Management Tool' interface. At the top right, there are links for 'Home', 'Inflow', 'Account', 'Help', and 'Sign Off'. The main title is 'Okanagan Fish/Water Management Tool'. Below the title, there is a 'Water Year' dropdown menu set to '2005-2006' and a user name '(brian.symonds)'. A navigation bar contains several menu items: 'Station Management', 'Current Scenario', 'Model Prediction', 'Narrative', and 'Diagnositics'. The 'Narrative' menu is currently selected. Below the navigation bar, there is a form for creating a new narrative. The form includes a 'Narrative ID' field with the value '[New] (Editing)' and a 'Subject' field. To the right of the 'Subject' field is a checkbox labeled 'Share with Other Users'. Below the 'Subject' field is a large 'Details' text area. At the bottom of the form, there is an 'Attachments' section with the text '[No attachments]'. Below this is a 'New Filename' field and a 'Browse' button. At the very bottom of the form, there are 'Save' and 'Cancel' buttons.

Enter a descriptive subject line and type your message into the “Details” text box. You can also attach a file to your message if you wish. (For example, if you prefer to type a Word document, you could simply attach this file, and indicate to users in the “Details” box: “See attachment”). To attach a file, click on the “Browse” button to locate the file on your computer (or local network) you wish to attach. Click “Open” and then “Upload”. Click “Save” to send your message into the narrative chain. Note: you should allow a few moments for the upload process to complete, before navigating away from the page or attempting to add another attachment.

At any time after initial creation, you can edit any of your own messages. To do this, left-click on the message to open it. Click “Edit” (see image below). This action will open your message in edit mode. Make your changes and then “Save” to send the modified message back into the narrative chain. The “Last Modified” date in the narrative table will update to indicate that you have edited the message.

Home | Inquiries | Account | Help | Sign Off

Okanagan Fish/Water Management Tool

Water Year: **2005-2006** [brian.symonds]

Scenario Manager | Current Scenario | Model Predictions | Narratives | Diagnostics

Order | View Thread | View All

Narrative ID: 53 Owner: brian.symonds
Subject: Re: Alerts: Ok Lake trajectory II Last Modified: 09-Sep-06 12:57:05

Reply | **Edit**

Details: **Everyone:** Share with Other Users: **Yes**

Following up on my email on the weekend, we are making further increases in releases down this system this morning. This will include bumping releases from Okanagan to just under 60 m³/s and pushing Oliver flows up to around 70 m³/s.

This is not expected to impact either sockeye or kokanee, but it might impact the ONA fish trap in the river in Penticton.

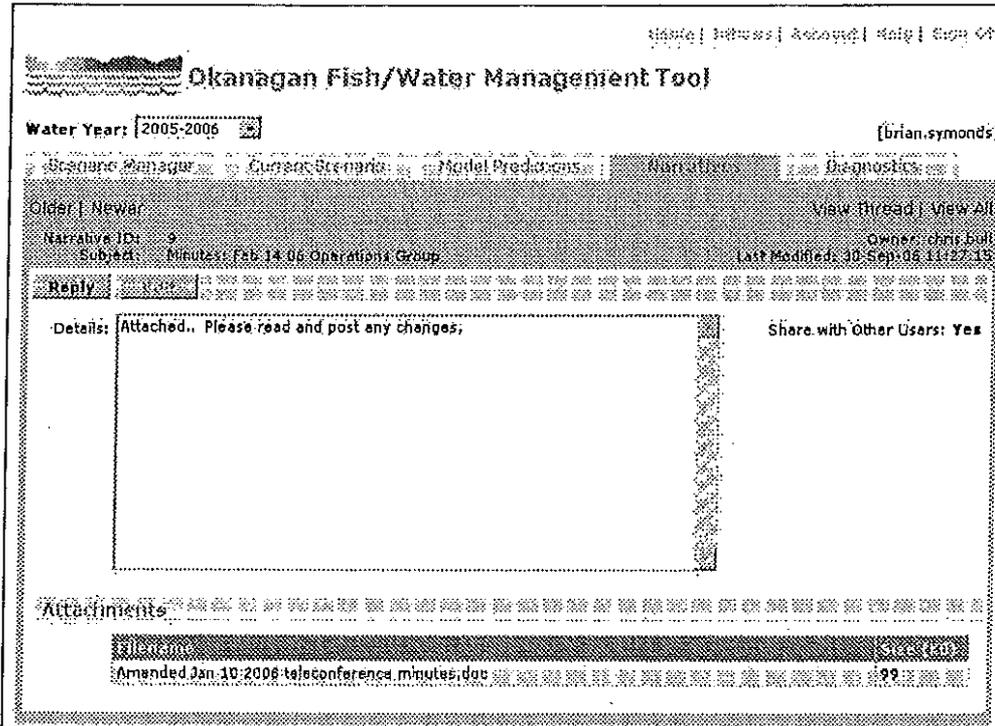
Areas we will be watching closely are:

1. The level of Vaseux Lake: In order to move water through Vaseux Lake we will be freeboarding the gates on the dam. Despite freeboarding the gates Vaseux Lake will continue to rise as we let more out of Skaha Lake.

Attachments

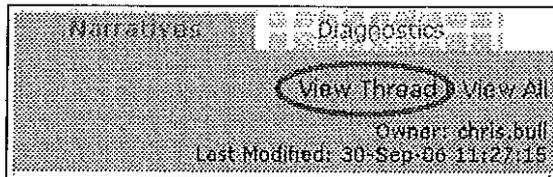
[No attachments]

View any message in the narrative chain by left-clicking on it.



Click on the “Reply” button if you wish to contribute to the message thread. Follow the procedure for creating a message described above.

The message illustrated in the screen image above is part of a message thread. You can access all messages in the thread by clicking on the “View Thread” link in the upper right corner of the tab.



Best practices for posting narratives include:

- having the lead fisheries biologist on the team post critical start-up information by November/December, e.g., peak spawning dates, proportion of females, etc., so that everyone can access it and use it to update their scenarios;
- attaching run results to posts so other users can see them without the need to re-run the model (e.g., esp. useful during group teleconference calls);
- posting all key information for an upcoming teleconference meeting so it is readily accessible to everyone on the call; participants can all look at the same source material without the need to search through numerous emails or attempt to run-up the model “last minute”;
- use the *Narrative* tab instead of email for routine communication about FWMT management; but *use emails when you need an immediate response from someone* (the *Narrative* feature does not 'alert' anyone -- users must log-in of their own accord to read posts).
- respond to the appropriate thread, not always posting things as a new thread; create a new thread only for new topics; and
- attach supporting files, like meeting minutes, run results, instead of re-typing things in the description box or describing information in abstract terms.

An example set of narratives, based on actual correspondence during the 2005-2006 water year, has been posted on the *Narratives* tab for reference. Select the 2005-2006 water year from the drop-down box on the tab and check the “Show all Authors” box to see all of the posts. These posts reflect the “best practices” for using narratives that are listed above.

CHAPTER 7

Understanding OKFWM Hazard Assessment Reports

When OKFWM performs a model run, it generates several different reports. The “multi-objective hazard assessment” is the primary output. The system also automatically provides several critical diagnostic output reports on actual vs. historical weekly net inflows, emergence timing reports for kokanee and sockeye salmon, and real-time lake elevations, river flows and water temperatures. These reports are useful to refer to during in-season water management. This chapter discusses only the hazard assessment reports in detail. Some information on the other reports is included in Step 9 of Chapter 6.

OKFWM hazard assessment report

OKFWM uses “traffic-light” performance indicators to help users interpret the output reports.  means the objective is in the good or desired range,  means the objective is in an undesired range and there are potential losses, and  means the objective is in a highly undesired range and there are significant losses. This traffic-light system means users do not have to associate and balance numeric outcomes using different units and scales with prudent water release decisions. This output presentation allows apprentice users to participate in collective decisions, and it has also proven valuable to senior fishery and water management engineers when “cutting to the chase”.

In addition to the performance indicators, OKFWM also stores numeric outcomes. These numeric outcomes are not required for making decisions on a daily basis during in-season management, but they are available in the Excel output files for the main hazard report if users want to look at them (click on the tabs labelled Avg Data, Min Data or Max Data).

The goal in managing Okanagan Lake, as with all locations in the Okanagan basin, is to maximise “green” for the various objectives. In certain water and temperature years, however, this is not possible and trade-offs must be made based on priorities and/or values. Table 3.3 provides *some* guidelines for socio-economic objectives, but these must be weighed relative to fisheries objectives. Other factors must also be considered when trying to obtain a balance. Such factors include new laws (e.g., Species at Risk Act), the strength of a particular run of kokanee or sockeye (e.g., very small run vs. large run), and details on what is being flooded (pasture land on two small land holdings vs. large tracts of lakefront Kelowna property). An acceptable balance can only be achieved in-season if water and fisheries managers work together to put these issues into their proper context by holding regular discussions.

When considering OKFWM's hazard reports, it is also important to note the period of time when each objective is relevant. Flooding is relevant at all times of year, irrigation water supply is relevant only during the growing season, and lake recreation is relevant during the spring and summer. For illustration, flooding can occur at a particular time in a year, and then, in theory, it can happen again. In contrast, once a kokanee or sockeye egg is killed, it cannot be "killed again". Thus, the importance of avoiding a red or yellow hazard for fisheries "the second time" is not the same as for flooding. Once a yellow or red de-watering or scour mortality event is incurred for fish eggs, further yellow/red bars are of little consequence—unless the lake elevation or river flow is even lower (or higher) than the elevation that caused the first event.

Understanding the graphs

OKFWM's hazard assessment (traffic light) report is introduced below with the objectives and an image of the graph shown for each of Okanagan Lake, Okanagan River and Osoyoos Lake.

Each graph summarises the management objectives using an example water elevation time series between October 1 and September 30 (a full water year). The hazard thresholds (i.e., green, yellow, red bars) are anchored to specific quantitative performance indicators generated by OKFWM's biophysical models (see Alexander and Hyatt 2005 for details). At any time, these hazards are graphed to a mixture of real-time (actual) and forecast lake elevation values. The horizontal length of each bar reflects the time-frame over which the particular objective applies.

Below the series of coloured bars, each graph presents a line that is initially black and then becomes light blue. The black line shows actual (real-time) lake elevation or river flow and the blue line is the forecast elevation or flow beyond the decision date.

The orange line on river flow graphs indicates the inflow from unregulated tributaries. It is critical to anticipate rates of net tributary inflow between March and June when setting releases at Okanagan Lake dam. This is a variable well informed by real-time data (i.e., comparing same-day flows between Okanagan Falls and Penticton and between Oliver and Penticton). Changes in rates of tributary inflow in spring are worth careful consideration as run-off from snow-melt can change rapidly.

The meaning of symbols on some graphs is noted on each one where they occur.

Note: Only the primary objectives considered by the Fish/Water Management Tools (FWMT) Steering Committee are considered and plotted for each location. While there may be other relevant issues to be taken into account, they are beyond the scope of this document.

Okanagan Lake Objectives

Six management objectives are of concern for Okanagan Lake (Figure 7.1):

1. lakeshore flooding;
2. non-agricultural water intakes (for domestic water supply);
3. agricultural intakes;

4. navigation of boats (e.g., in/out of marinas);
5. navigation at docks/boat launches; and
6. kokanee egg survival (related to lake drawdown, egg de-watering).

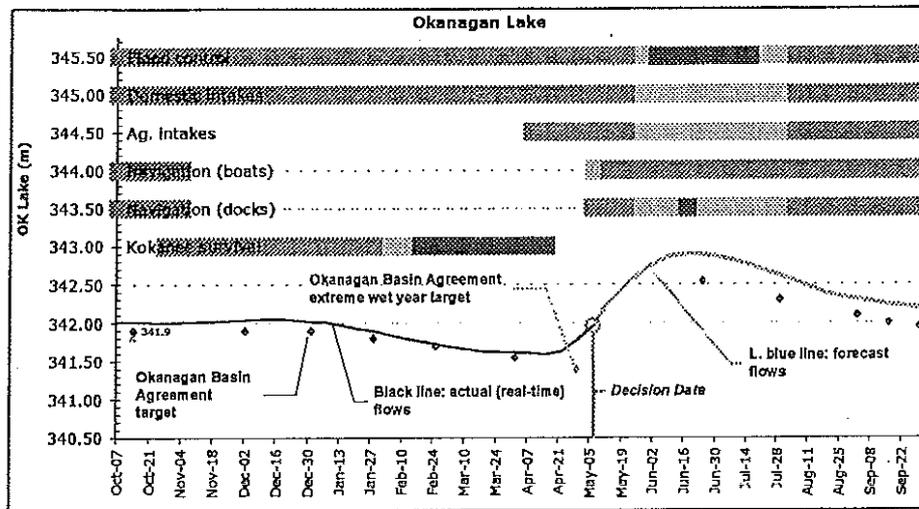


Figure 7.1. Okanagan Lake water and fisheries objectives. Green (▨) = good/desired; Yellow (▨) = undesired/potential losses; Red (▨) = highly undesired/significant losses. The horizontal length of each bar reflects the time-frame over which the objective applies.

Okanagan River Objectives

Management of Okanagan River involves flood risk, agricultural water supplies and sockeye salmon survival. These objectives vary by site. The water releases at Okanagan River near Penticton are controlled by Okanagan Lake dam (Figure 7.2). Downstream river flows are scaled to these releases and are affected by net tributary inflows and downstream water withdrawals (Figure 7.3 and Figure 7.4). Details on specific socioeconomic relations were introduced earlier (see Chapter 3).

Okanagan River at Penticton

Two management objectives are of concern for Okanagan River at Penticton (Figure 7.2):

1. river flooding; and
2. river recreation (for a float tubing business, anchored to trip return frequency).

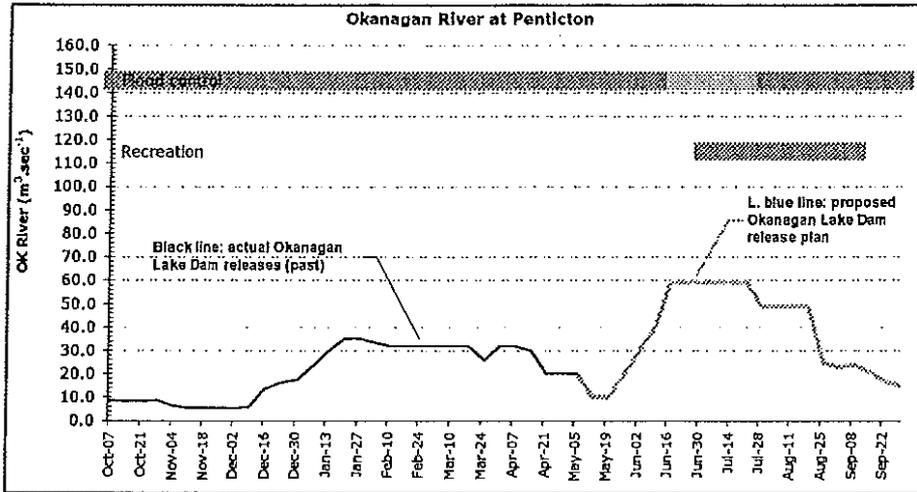


Figure 7.2. Okanagan River management objectives near Pentlcton. Green () = good/desired; Yellow () = undesired/potential losses; Red () = highly undesired/significant losses. The horizontal length of each bar reflects the time-frame over which the objective applies.

Okanagan River at Okanagan Falls

One management objective is of concern for Okanagan River at Okanagan Falls: river flooding (Figure 7.3). Downstream of Pentlcton, uncontrolled tributaries add flow to the managed release from Okanagan Lake dam. At certain times of year, this flow may be negative, which reflects net water withdrawal from pumps and evaporative losses.

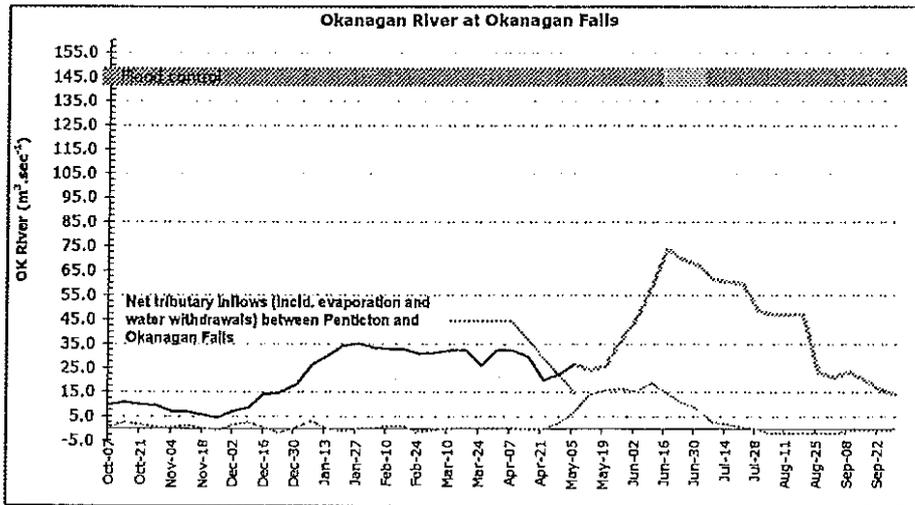


Figure 7.3. Okanagan River management objectives near Okanagan Falls. Green () = good/desired; Yellow () = undesired/potential losses; Red () = highly undesired/significant losses. The horizontal length of each bar reflects the time-frame over which the objective applies.

Okanagan River at Oliver

Five management objectives are of concern for Okanagan River at Oliver (Figure 7.4):

1. river flooding;
2. domestic water intakes;
3. agricultural water intakes;
4. sockeye egg survival; and
5. sockeye alevin survival.

Downstream of Penticton, uncontrolled tributaries add flow to the managed release from Okanagan Lake dam. At certain times of year, this flow may be negative, which reflects net water withdrawal from pumps and evaporative losses.

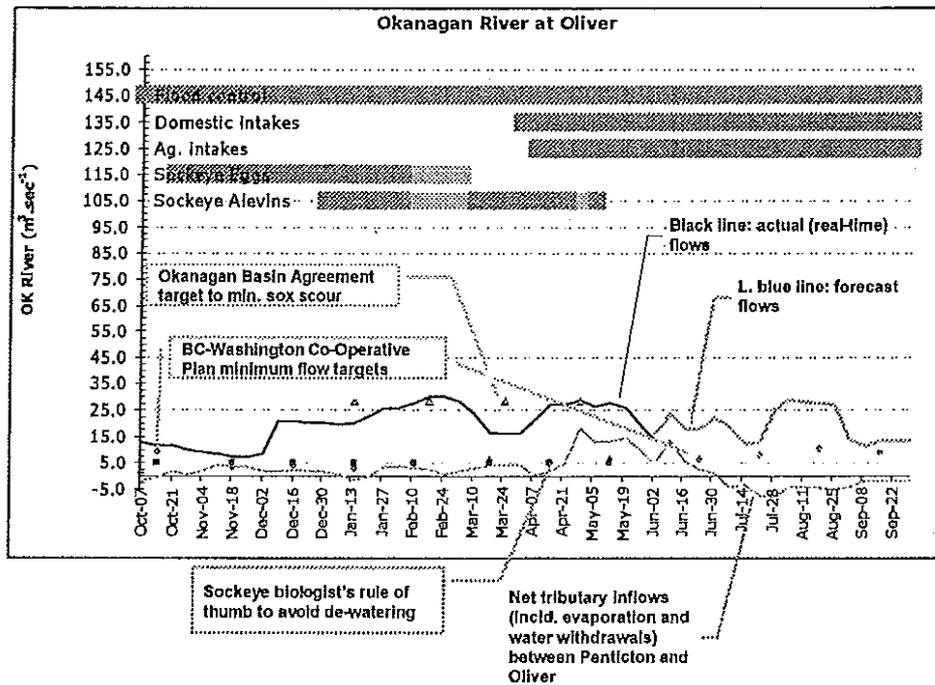


Figure 7.4. Okanagan River management objectives near Oliver. Green (█) = good/desired; Yellow (█) = undesired/potential losses; Red (█) = highly undesired/significant losses. The horizontal length of each bar reflects the time-frame over which the objective applies.

Osoyoos Lake Objectives

Management of Osoyoos Lake involves mitigating poor temperature and oxygen conditions for rearing sockeye fry. These conditions, also referred to as a temperature-oxygen squeeze, can develop in low flow/warm water years (Figure 7.5). Pulse summer releases of about 128 million m³ (July through August) or 157 million m³ (July through September) are hypothesised to alleviate the temperature-oxygen squeeze (Figure 7.6). The fundamental biophysical relation for in-lake rearing conditions in Osoyoos Lake was introduced earlier (see Chapter 3 and details in Alexander and Hyatt 2005).

Note: specific guidelines and flow required to mitigate the temperature-oxygen squeeze are likely to change with results of future pulse flow experiments.

One primary management objective is of concern: viable rearing habitat for sockeye fry (Figure 7.5).

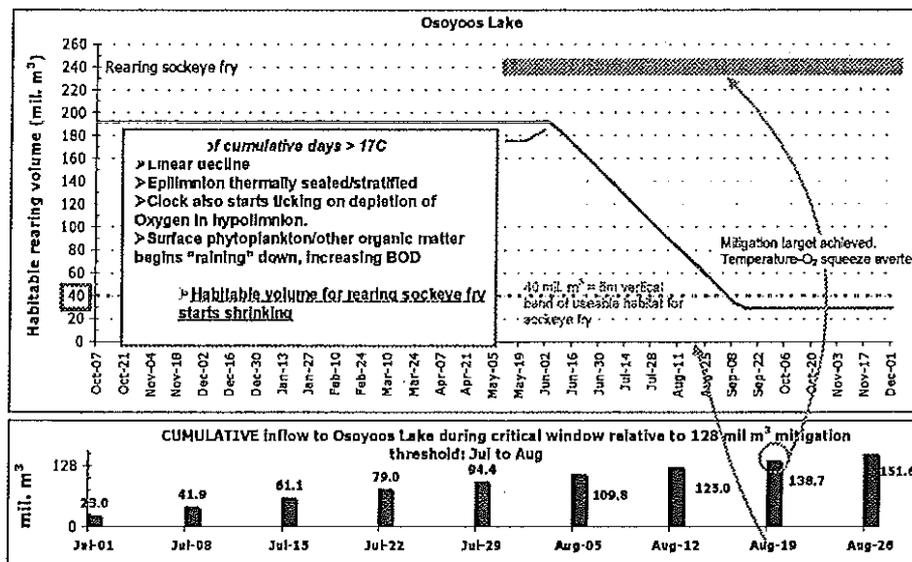


Figure 7.5. Osoyoos Lake water and fisheries objectives. Green (▨) = good/desired; Yellow (▨) = undesired/potential losses; Red (▨) = highly undesired/significant losses. The horizontal length of each bar reflects the time-frame over which the objective applies.

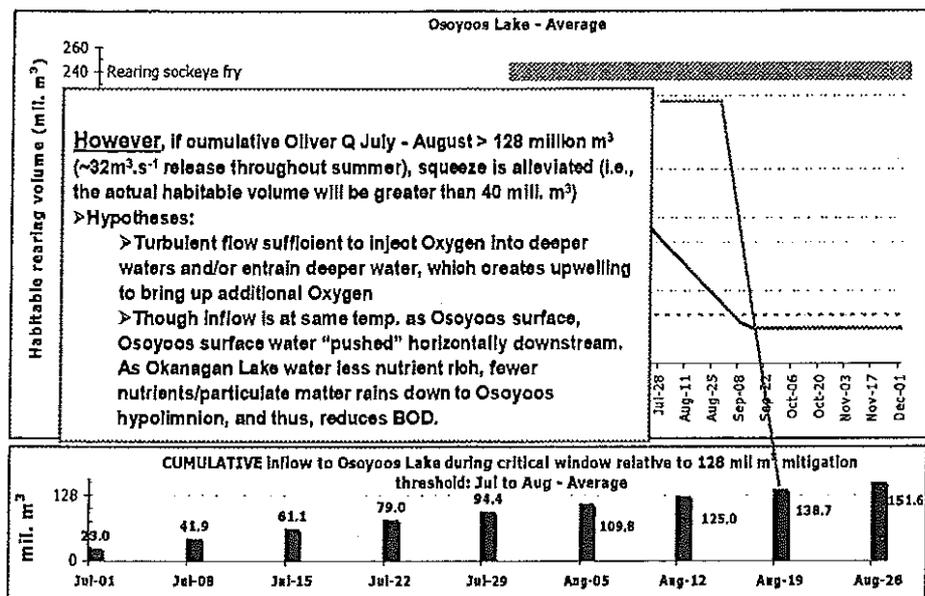


Figure 7.6. Pulse summer releases (July–August period) are hypothesised to alleviate temperature-oxygen squeeze for rearing sockeye fry once release flows exceed approximately 128 million m³. Alternatively, 145 to 167 million m³ July–September may alleviate squeeze mortality concerns. Q = river discharge entering Osoyoos Lake (i.e., approximated by Okanagan River discharge at Oliver). BOD = biochemical oxygen demand.

Hazard definitions

Performance Measure		Green	Yellow	Red	Time Period	Relevant Flow / Elev. Metric
<i>Sockeye</i>	Survival rate - Incubation (minimum during week)	15%	10 to 18%		Oct - Mar	Maximum / minimum ¹
	Survival rate - Rearing (minimum during week, extrapolated to entire rearing period)	65%	45 to 65%		Mar-Sept	None ²
<i>Kokanee</i>	Incubation (cm of lake drawdown between egg deposition and emergence)	15 cm	13 to 25 cm		Oct-Mar	Change in average elevation
Socioeconomic						
Agricultural water intakes (Ok River)	Flow (m ³ /s)	6.5	6 to 8.5		Apr-Sep	Minimum
	Licensed water that cannot be withdrawn (m ³ /s)	0.14	0.14 to 0.39			
Non-agricultural water intakes (Ok River)	Flow (m ³ /s)	6.5	6 to 8.5		All	Minimum
	Licensed water that cannot be withdrawn (m ³ /s)	0.08	0.08 to 0.21			
Agricultural water intakes (Ok Lake)	Lake elevation (m)	342.61	342.61 to 343.09		Apr-Sep	Minimum
	Licensed water that cannot be withdrawn (m ³ /s)	0.08	0.08 to 0.39			
Non-agricultural water intakes (Ok Lake)	Lake elevation (m)	342.61	342.61 to 343.09		All	Minimum
	Licensed water that cannot be withdrawn (m ³ /s)	0.08	0.08 to 2.2			
Lake Recreation (boats)	Lake elevation (m)	341.6	341.7 to 341.9		May-Oct	Minimum
	# sailboats navigation problems	85	89 to 268			
Lake Recreation (docks)	Lake elevation (m)	342.6	342.6 to 342.9		May-Oct	Maximum
	# docks inoperable	45	89 to 268			
River Recreation	Flow (m ³ /s)	20	10 to 20		Jun-Sep	Average
	\$/day economic impact	\$437	\$432 to \$1,814			
Lake Flooding	Flow (m ³ /s)	342.5	342.55 to 342.75		All	Maximum
	\$millions in property damage	\$1,564	\$1.3 to 17.6M			
River Flooding (Penticton)	Flow (m ³ /s)	59	59 to 60		All	Maximum
	# buildings subject to flooding	0	9 to 91			
River Flooding (Okanagan Falls)	Flow (m ³ /s)	65	65 to 78		All	Maximum
	# buildings subject to flooding	1	1 to 11			
River Flooding (Oliver)	Flow (m ³ /s)	63	60 to 96		All	Maximum
	# buildings subject to flooding	64	64 to 354			

1. Maximum flows are used to determine mortality due to scour; minimum flows are used to determine mortality due to dessication.
2. Rearing mortality is based on temperatures and density-dependent interactions.

References & Further Reading

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