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Technical Memorandum

DATE: December 17, 2012 **YOUR FILE:**

TO: Craig Wightman, R.P.Bio., BC Conservation Foundation

CC: Adam Silverstein, Fisheries and Oceans Canada, Nanaimo
Cowichan Watershed Board, Duncan
Water Stewardship Division, Ministry of Forests, Lands and Natural Resource Operations, Nanaimo

FROM: Craig Sutherland, P.Eng., Water Resources Engineer

RE: **COWICHAN LAKE WEIR**
Provisional Rule Band Operating Rules
Our File 0673.013

Background

The trend in seasonal inflows to Cowichan Lake appears to be decreasing over the last several decades. A review of historical inflow records indicates that average spring/summer inflows (April to September) have reduced by about 17% since 1953 (KWL, 2011). Moreover, average summer (June to September) inflows have declined by 35% during the period 1955 to 2008 (Chapman 2011). As a result, operation of the Catalyst Paper Corporation's (Catalyst Paper) weir at the outlet of Cowichan Lake has required that summer flows released to the Cowichan River be frequently reduced below the water licence condition of 7 m^3/s in order to maintain lake storage in support of the Crofton pulp mill operation, and to meet fisheries conservation requirements.

Under Catalyst's current operational Rule Curve, discharge in the upper Cowichan River is to be maintained at a minimum of 25 m^3/s until April 30th, 15 m^3/s from May 1st until June 14th, and then held at the Preferred Minimum Flow Release of 7 m^3/s until fall rains recharge the lake. These are optimum flow targets and critical time periods affecting native salmon, steelhead and trout life-histories and biology in the Cowichan River. They were established in response to in-stream observations of habitat use/dependencies by native species, and the sensitivities of those habitats to flow changes mediated by seasonal operation of the Catalyst Paper weir (Burns, Harding and Tutty 1988; Wightman and Ptolemy 1989; Burns 2003; Wright and Pellett 2006). Flow-related impacts on side-channel connectivity and changes in wetted mainstem channel perimeter can result in widespread juvenile stranding, redd (spawning 'nest') desiccation and disruption to adult spawning behavior. There can also be reductions in macro-invertebrate production in riffle habitat (loss of fish food organisms) and changes to salmonid rearing habitat quality. Consequently, the flow targets above are considered risk-averse and in the best long-term interest of Cowichan fish species conservation.

Current weir operation practices require that gates be operated to spill water from storage when lake levels are greater than 0.10 m above the Full Supply Level (FSL)[1]. However, this has not resulted in improvements to

[1] Definitions of capitalized technical names are included in the Glossary in Appendix A.

maintaining 7 m^3/s in the river through the entire summer period, and has frequently resulted in lake levels not starting at FSL on July 9th, typically the start of the seasonal storage "draw down" period.

The Proposed Rule Band Approach

In May/June 2012, the Cowichan Watershed Board, Cowichan Tribes, the CVRD and Fisheries and Oceans Canada requested that the provincial Water Stewardship Division (WSD) adopt a "Rule Band" approach to current weir operating practices. This would allow lake levels to be managed within a 0.2 m band above the licenced FSL and above the existing Rule Curve until September 30th, at the current prescribed rate of summer storage release.

A review of recent lake level data indicates that during summer months (July to September) lake levels are falling at an average rate of about 1.0 cm/day to maintain a the Preferred Minimum Flow Release of 7 m^3/s. This is in comparison to an average rate of about 0.8 cm/day required by the Rule Curve for the period from July 9th to November 4th. If lake levels were to start at FSL on July 9th and fall at a rate of 0.96 cm/day, the lake level would fall to ZSL in 98 days or by Oct 15th. Allowing lake levels to start up to 0.2 m above FSL on July 9th would extend the period by which the Preferred Minimum Flow Release of 7 m^3/s release can be released from the lake by about 20 days from October 15th to November 4th.

The proposed upper limit of the Rule Band falls from 0.2 m above FSL on July 9th to meet the existing rule curve by September 30th. This means that lake levels would not be operated above the existing Rule Curve after September 30th to limit potential impacts that higher lake levels at the end of the control period might have on the first high lake levels in the fall, after the return of the seasonal rains.

In addition, when the lake level is 0.2 m above the weir or the FSL and the overshot gates are fully raised (closed) and the boat lock is closed, the river discharge is about 25 m^3/s. Therefore, the early season (April 1st to May 1st) release of 25 m^3/s could be maintained without the need for constant adjustments to the overshot gates. The gates would only need to be lowered (opened) when inflows to the lake increased above 25 m^3/s and lake levels begin to rise beyond 0.2 m above the FSL.

This Rule Band approach essentially represents the manner in which the weir was operated up until 2007-2008, under Catalyst's water licence, and as directed by the Ministry of Environment's WSD.

Provisional Rule Band Operating Rules

The following Provisional Rule Band Operating Rules are proposed to support an increase in the likelihood of meeting the weir's FSL on July 9th, and maintaining the Preferred Minimum Flow Release of 7 m^3/s downstream of Cowichan Lake (measured at Water Survey of Canada Gauge – 08HA002) until at least November 4th, in accordance with the existing operating Rule Curve.

The proposed Provisional Rule Band Operating Rules are as follows:

1. Overshot gates shall not be raised and boat lock gates shall not be closed to control storage in Cowichan Lake prior to April 1st.
2. After April 1st the boat lock may be closed and gates operated, as required.
3. From April 1st to April 30th, flows shall be released to the river at a minimum of 25 m^3/s. Releases to the river shall be increased when lake levels are above 0.2 m above FSL (El.162.57 m) until such time as the lake levels fall back below 0.2 m above FSL.
4. From May 1st to June 14th, flows shall be released to the river at a minimum of 15 m^3/s. Releases to the river shall be increased when lake levels are above 0.2 m above FSL (El.162.57 m) until such time as the lake levels fall back below 0.2 m above FSL.

5. From June 15th to July 8th, flows shall be released at the Preferred Minimum Flow Release of 7 m^3/s. Releases to the river shall be increased when lake levels are above 0.2 m above FSL (El.162.57 m) until such time as the lake levels fall back below 0.2 m above FSL.
6. From July 9th to November 4th, flows shall be released from the lake at a rate of 7 m^3/s and must be increased above 7 m^3/s when lake levels rise above the Maximum Control Lake Level, as outlined in attached Table 1 and shown in Figure 1. The increased flows should be maintained until such time as lake levels fall below the Maximum Control Lake Level.
7. At no time from April 1st to November 4th shall Cowichan River flows be reduced below the Minimmum Preferred Flow Release of 7 m^3/s without approval of the Ministry of Forests, Lands and Natural Resource Operations in Nanaimo. A request to reduce flows should be considered when lake levels fall 0.2 m below FSL or the existing rule curve.
8. Increases and decreases in the rate of river flow shall be controlled by provisional ramping rates outlined in Table 2.

These proposed Provisional Rule Band Operating Rules will allow the Cowichan Lake weir to be operated in general accordance with the *Cowichan Weir Start-Up, Operational and Seasonal Protocols* prepared by Michelle Vessey (formerly of Catalyst Paper Corporation, Crofton Division) for the Cowichan Water Management Ad-Hoc Committee in October 2008. This will increase the likelihood of achieving FSL on July 9th and maintaining the Preferred Minimum Flow Release of 7 m^3/s through the normal summer/fall lake draw down period. Figure 1 provides a graphical representation of the Provisional Rule Band Operating Rules.

Impacts of Provisional Operating Rules

It should be noted that maintaining water levels above the existing Rule Curve is dependent on inflows to the lake. During dry years it is unlikely that sufficient inflow will be available to maintain lake levels above FSL or above the existing Rule Curve. However, for average or above average years, having the ability to capture increased inflows during the control period will improve the reliability of the system and increase the likelihood of maintaining the Preferred Minimum Flow Release.

An operational computer model of the Cowichan Lake weir was developed by KWL to test reliability of the Provisional Rule Band Operating Rules. The model routes flow through the lake to the river incorporating the proposed Rule Band, outflow schedules and ramping rates. The model is governed by a simple water balance relationship:

Change in Storage over time = Lake Inflow – Outflow to the River

The model uses back-calculated lake inflow from historical daily lake level and river flow data from 1962 to 2012.

TABLE 1 – Provisional Rule Band

Date	Low Flow Trigger Lake Level[1] (m-GSC)	Existing Lake Level Rule Curve (m-GSC)	Maximum Control Lake Level[2] (m-GSC)
April 1st	162.17	162.37	162.57
July 9th	162.17	162.37	162.57
September 30th	161.70	161.90	161.90
November 4th (Zero Storage Level)	161.40	161.40	161.40

Note:
1 – When lake levels fall below the Low Flow Trigger Lake Level, a request to reduce flows below the Preferred Minimum Flow Release for the applicable period should be considered. The recommended reduced minimum flows are shown in Table 2. Reduction in river flows below the Preferred Minimum Flow Release of 7 m^3/s must be approved by the Ministry of Forests, Lands and Natural Resource Operations (Nanaimo).
2 – When lake levels rise above the Maximum Control Lake Level, river flows should be increased in accordance with the ramping rate (see Table 2) until such time as lake levels return below the Maximum Control Lake Level.

TABLE 2 – Provisional Minimum Release Schedule and Ramping Rates

Date Range[1]	Minimum Release Schedule (m^3/s)	Recommended Reduced Minimum Release[2] (m^3/s)	Minimum Ramping Rate[3] (m^3/s/day)
April 1st to April 30th	25	20	3
May 1st to June 14th	15	12	2
June 15th to July 8th	7	6	0.5
July 9th to November 4th	7	5.5	0.5

Note:
1 – Date ranges include ramping period from 25 m^3/s to 15 m^3/s at 3 m^3/s over three days and ramping period from 15 m^3/s to 7 m^3/s at 2 m^3/s over four days.
2 – Recommended reduction in river flow releases when lake levels fall below the Low Flow Trigger Lake Level (Table 1). Reduction in river flows below the Preferred Minimum Flow Release of 7 m^3/s must be approved by the Ministry of Forests, Lands and Natural Resource Operations (Nanaimo).
3 – The Ramping Rate shall be the greater of either the Minimum Ramping Rate or 15% of the average river flow (measured at the Cowichan River at Cowichan Lake Gauge) for the previous two days. Note that ramping rates should be increased during periods of high inflow when lake levels are rising quickly. It is recommended that river flows be increased at a rate faster than provisional ramping rates when lake levels are rising faster than 3 cm/day.

Summary of Findings

The model is indicating that:

1. Based on a review of historical data the control period flow releases have been maintained at or above 7 m^3/s in 20 of 51 years (39%) and lake levels have been maintained at or above ZSL in 41 of 51 years (80%);
2. Providing an allowance of 0.1 m above the FSL and requesting a reduction in flow releases if lake levels fall 0.2 m below the FSL or the Rule Curve would result in lake levels being maintained at or above ZSL in 50 of 51 years (98%), and results in river flows being maintained at or above the Preferred Minimum Flow Release of 7 m^3/s in about 25 of 51years (49%);
3. Increasing the allowance for lake levels to rise 0.2 m above the FSL and using the proposed Maximum Control Lake Level results in river flows being at or above the Preferred Minimum Flow Release of 7 m^3/s in about 33 years of 51years (65%).

Providing more flexibility in operation of the weir during the control period by adopting the proposed Rule Band approach does provide some improvement in the reliability of maintaining the Preferred Minimum Flow Release. Under the Rule Band the flows could be maintained about 65% of the time compared to about 49% of the time under the current Rule Curve approach. In order to provide any further improvement in the reliability of the Cowichan Lake weir at meeting flow targets, additional storage which can be fully controlled will be necessary. A 0.3 m increase in seasonal storage by raising the weir was recommended in the Cowichan Basin Water Management Plan (2007).

Previous Cowichan Lake storage operation modelling completed by KWL in 2010 and updated in 2012, indicates the Provisional Rule Band Operating Rules could improve the ability to:

1. achieve the FSL on July 9th;
2. maintain the Preferred Minimum Flow Release of 7 m^3/s during the summer period;
3. increase the likelihood of providing two Fish Pulse releases in September and October; and
4. maintain lake levels above the zero storage level up to November 4th.

Storage analysis also indicates that maintaining lake levels at 0.2 m above the FSL from April 1st to July 9th has limited impacts on high lake levels and seasonal flooding (KWL Assoc. Ltd., 2010). A review of historical data for this period indicates that lake levels have never been recorded above the average annual maximum lake level (164 m-GSC) after April 1st. As such, the proposed operational protocol recommends weir start-up on or after April 1st.

Finally, previous analysis does indicate that increased lake levels near the end of the control season (notionally October 15th) could result in increased peak lake levels in the early fall. Therefore, the proposed operating rules have incorporated a draw down period at the end of the control season which would result in lake levels being at or below the existing Rule Curve by September 30th. This would minimize potential for lake levels to be above the Rule Curve when fall rains return and minimize the likelihood of the proposed protocol increasing fall peak water levels on the lake.

A summary of the analysis is shown in Table 3, which compares the impact of the current Rule Curve with the Rule Band approach. Figure 2 shows how lake levels and river flows would have changed with implementation of the Rule Band during summer of 2012.

TABLE 3 – Rule Curve vs. Rule Band Assessment Results (1962 to 2012).

Scenario	Lake Level at or above FSL on July 9th	Lake Level at or above ZSL throughout Control Season	Flow at or above Preferred Minimum Flow Release ($7\ m^3/s$)	Flow at or above Preferred Minimum Flow Release during early control period[4]	Fish Pulse[5]	
					Pulse on Sept 20th	Pulse on Sept 20th and Oct 10th
Historical Record[1]	12 years out of 51 (24%)	41 years out of 51 (80%)	20 years out of 51 (39%)	29 Years out of 51 (57%)		
Model using Rule Curve with 0.1 m allowance over FSL[2]	24 years out of 51 (47%)	50 years out of 51 (98%)	25 years out of 51 (49%)	42 years out of 51 (82%)	27 years out of 51 (53%)	6 years out of 51 (12%)
Model using Recommended Rule Band protocol[3]	34 years out of 51 (67%)	51 years out of 51 (100%)	33 years out of 51 (65%)	45 years out of 51 (88%)	42 years out of 51 (82%)	6 years out of 51 (12%)

Table shows the number of years that criteria shown in the header row are achieved over the entire operating period of the upgraded weir from 1962 to 2012, inclusive.

Notes:

1 – Historical record based on review of Cowichan Lake (WSC 08HA009) and Cowichan River at Lake Cowichan (08HA002) records. This record reflects all of the weir operational decisions which have been made throughout the operating period. It should be noted that 2011 and 2012 data are provisional and may be subject to change. Recent river flow measurements completed in August 2012 indicate that the Cowichan River at Lake Cowichan WSC gauge may be under predicting low flows by approximately 6.3%. As the discharge measurement data have not yet been quality checked or reviewed by WSC, the 2011 and 2012 data used in the analysis have not been adjusted to account for error at the time of writing.

2- Model using existing Rule Curve but with an allowance to control lake levels up to 0.1 m above the FSL. This scenario also allows flow releases to be reduced below the Preferred Minimum Flow Release of 7 m^3/s if lake levels drop 0.2 m below the existing Rule Curve. Model also provides allowance for flows to be dropped below early-season flows to 20 m^3/s from April 1st to April 30th and 10 m^3/s from May 1st to June 15th should lake levels fall below FSL by 0.2 m.

3 – Model using recommended Rule Band with allowance for lake levels to be controlled up to 0.2 m above FSL and the existing FSL and Rule Curve for the period from April 1st to September 15th. This scenario also allows flow releases to be reduced below the Preferred Minimum Flow Release of 7 m^3/s if lake levels drop 0.2 m below the existing Rule Curve. Model also provides allowance for flows to be dropped below early-season flows to 20 m^3/s from April 1st to April 30th and 10 m^3/s from May 1st to June 14th should lake levels fall below FSL by 0.2 m.

4 – Indicates years where Minimum Release Schedule for early control period is maintained at or above 25 m^3/s from April 1st to April 30th and at 15 m^3/s from May 1st to June 15th.

5 – Fish Pulse indicates the model shows lake levels to be high enough on Sept. 20th, or on both Sept 20th and Oct 10th, to release a pulse migration flow of 18 m^3/s.

Climate Change

As previously discussed, the historical hydrometric records indicate a downward trend in inflow to the lake. Regionally, summer flows across eastern Vancouver Island are expected to decrease in the future as a result of forecast longer drier periods. In order to assess historical changes in inflow, the Rule Band assessment results were re-analyzed to assess how changes in inflow over time would impact the reliability of maintaining lake levels at or above FSL on July 9th, and maintaining the Preferred Minimum Flow Release. Results have been re-analyzed based on Climate Normal periods from 1961 to 1990, 1971 to 2000 and 1981 to 2010. Results are shown in Table 4.

These indicate that had the weir been operated in accordance with the proposed Rule Band approach, the reliability would have decreased over-time. The model indicates that for the the proposed Rule Band approach:

1. on July 9th lake levels would have been at or above FSL about 63% of the years for the period 1962 to 1990 dropping to about 53% of the years for the period from 1981 to 2010;
2. Preferred Minimum Flow Release could be maintained at or above 7 m^3/s for 73% of the years for the 1962 to 1990 period compared to 57% of the years for the 1981 to 2010 period;
3. the early season Preferred Minimum Flow Releases prior to July 9th could have been maintained 93% of the years for the 1962 to 1990 period compared to 83% of the years for the 1981 to 2010 period; and
4. the reliability of Fish Pulse release on September 20th would not have changed significantly over the entire period varying between 67% to 70% for the three 30 year periods..

Climate forecasts for the Cowichan Valley have been prepared by the Pacific Climate Impacts Consortium (PCIC, 2012). The analysis indicates that by the 2050s:

1. average summer (June-July-Aug) daily temperatures are forecast to increase between 15^0C to 17^oC; and
2. average summer precipitation is forecast to be reduced by 10% to 30%[2].

A hydrological climate change analysis of Cowichan Lake carried out by KWL in 2011 using the PCIC climate forecasts indicates that the forecast changes in temperature and precipitation outlined above could result in summer inflows (Apr to Sept) further decreasing by between 9% to 16% by the 2050s.

A preliminary assessment of Climate Change impacts on the reliability of the proposed Rule Band approach was also carried out. The assessment involved re-analyzing the existing Rule Curve and proposed Rule Band approaches using the Cowichan Lake Operation Model with the daily lake inflows reduced by 9% and 16% for the spring and summer period from April 1st to Sept 30th. The range of forecast changes in lake inflow are based on hydrological model output using 25th and 75th percentiles of the range of forecast changes in precipitation and temperature (KWL, 2011). Results of the forecast changes in reliability to the 2050s are also shown in Table 4.

Moving into the future, it is anticipated that reliability of the proposed Rule Band approach would continue to decline as lake inflows continue to drop. The model estimates that by the 2050s:

1. the ability to maintain lake levels at or above FSL on July 9th would drop to between 43% to 50% of the years; and

[2] Future climate projections described in this study are based on absolute changes in average temperature and percent change in average precipitation from 1961-1990 Normal Period. This study uses standard naming convention developed by the IPCC for future periods with 2020s representing the 2011 to 2040 Normal Period and 2050s representing the 2041 to 2060 Normal Period.

2. the ability to maintain the Preferred Minimum Release of 7 m^3/s would also drop to between 43% to 50% of the years.

TABLE 4 – Impacts of Changing Climate on Proposed Rule Band Approach

Time Period[1]	Lake Level at or above FSL on July 9th	Lake Level at or above ZSL throughout Control Season	Flow at or above Preferred Minimum Release (7 m3/s)	Flow at or above Preferred Minimum Release during early control period[5]	Fish Pulse[2]	
					Pulse on Sept 20th	Pulse on Sept 20th and Oct 10th
1961 to 1990 Climate Normal Period	19 years out of 30 (63%)	30 years out of 30 (100%)	22 years out of 30 (73%)	28 years out of 30 (93%)	21 years out of 30 (70%)	3 years out of 30 (10%)
1971 to 2000 Climate Normal Period	17 years out of 30 (57%)	30 years out of 30 (100%)	20 years out of 30 (67%)	25 years out of 30 (83%)	20 years out of 30 (67%)	3 years out of 30 (10%)
1981 to 2010 Climate Normal Period	16 years out of 30 (53%)	30 years out of 30 (100%)	17 years out of 30 (57%)	25 years out of 30 (83%)	21 years out of 30 (70%)	3 years out of 30 (10%)
Future 2050s Period (Low Range)	15 years out of 30 (50%)	27 years out of 30 (90%)	15 years out of 30 (50%)	24 years out of 30 (80%)	20 years out of 30 (67%)	3 years out of 30 (10%)
Future 2050s Period (High Range)	13 years out of 30 (43%)	26 years out of 30 (87%)	13 years out of 30 (43%)	24 years out of 30 (80%)	17 years out of 30 (57%)	3 years out of 30 (10%)

Table indicates the number of years that criteria shown in the header row are achieved over the Climate Normal Periods.

Note:

1 – Time periods based on standard 30-year climate normal periods. The future 2050s period represents the 2041 to 2060 period. Low Range considers 9% reduction in total April to September lake inflow and High Range considers 16% reduction in total April to September lake inflow. Percent reduction based on Cowichan Lake Climate Change Impact Assessment Study (KWL, 2011)

2 – Fish Pulse indicates the model shows lake levels to be high enough on Sept. 20th, or on both Sept 20th and Oct 10th, to release a pulse migration flow of 18 m^3/s.

Recommendations

It is recommended that:

1. An application to modify the current operating rules for the Catalyst Paper Water Licence be submitted to the Ministry of Forests, Lands and Natural Resource Operations for implementation of the Provisional Rule Band Operating Rules outlined in this technical memorandum;
2. A detailed review of potential impacts as a result of increased early summer lake levels be completed, including lakeshore erosion, impacts to riparian habitat and impacts to lake shore private properties;
3. Cowichan Watershed Board and/or the Cowichan Water Management Ad-Hoc Committee should review, update and finalize the draft *Cowichan Weir Start Up, Operation and Seasonal Protocols* (Vessey, 2008) which would provide improved operational guidelines for the Catalyst weir. The finalized protocols should provide further guidance on:
    a. Recommended weir start-up considerations at the beginning of the seasonal control period;
    b. Recommended maximum ramping rates for increasing and decreasing flows during the control period;
    c. Recommended early season flows (25cms and 15cms) and associated Low Flow Trigger Lake Levels for reducing flows to try to achieve the FSL by July 9th;
    d. Recommended lower bound of the proposed "Rule Band" to help guide decisions about when to reduce flows below 7m^3/s; and
    e. Recommended end of season weir-shut down procedures.
4. Once adopted, the provisional operation protocols should be reviewed and updated at regular intervals (~ every 5 years) to reflect potential changes in inflow as a result of climate change.

Closing

The analysis outlined above indicates that implementation of the Provisional Rule Band Operating Rules would provide enhanced flexibility to better manage storage on Cowichan Lake in the spring and early summer up to 0.2 m above the FSL. More flexibility in management of Cowichan Lake storage in the spring and early summer will increase the capability to maintain Preferred Minimum Flow Release to the Cowichan River and provide fish migration pulses in the early fall. Modelling using the historical inflow record from 1962 to 2012 indicates that increasing the Maximum Control Lake Level from 0.1 m to 0.2 m above FSL and allowing water levels to rise up to the proposed Maximum Control Lake Level when inflows allow, would increase the likelihood of maintaining the Preferred Minimum Flow Release of 7 m^3/s from 25 of 51 years (49%) to 33 of 51 years (65%).

Forecasting into the future, it is anticipated the ability to maintain the Preferred Minimum Flow Release will continue to decline. Using a forecast reduction of summer inflows (April to Sept) of 9% to 16% by the 2050s, the ability to maintain the Preferred Minimum Flow Release of 7 m^3/s drops to be between 43% to 50% of the years analysed.

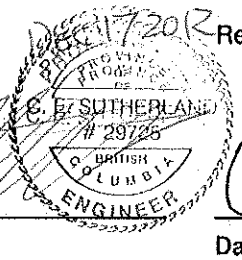
It should be noted the proposed Rule Band approach is considered to be an interim solution to improving the reliability of maintaining the Preferred Minimum Flow Release of 7 m^3/s to the Cowichan River. It must be emphasized that increasing the controllable storage at Cowichan Lake remains the only viable solution to providing adequate minimum flows over the long term, as recommended in the Cowichan Basin Water Management Plan (2007).

Submission

We hope this provides sufficient information to support an update to the operational protocols for the Cowichan Lake weir. Should you require any further assistance or have questions, please contact the undersigned at (250) 595-4223.

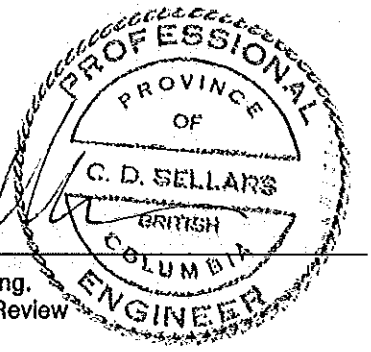
KERR WOOD LEIDAL ASSOCIATES LTD.

Prepared by:



Craig Sutherland, P.Eng.
Water Resources Engineer

Reviewed by:



David Sellars, P.Eng.
Senior Technical Review

CS/

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Revision History

Revision #	Date	Status	Revision	Author
0	May 29, 2012		DRAFT – For Review	CS
1	December 17, 2012		FINAL	CS

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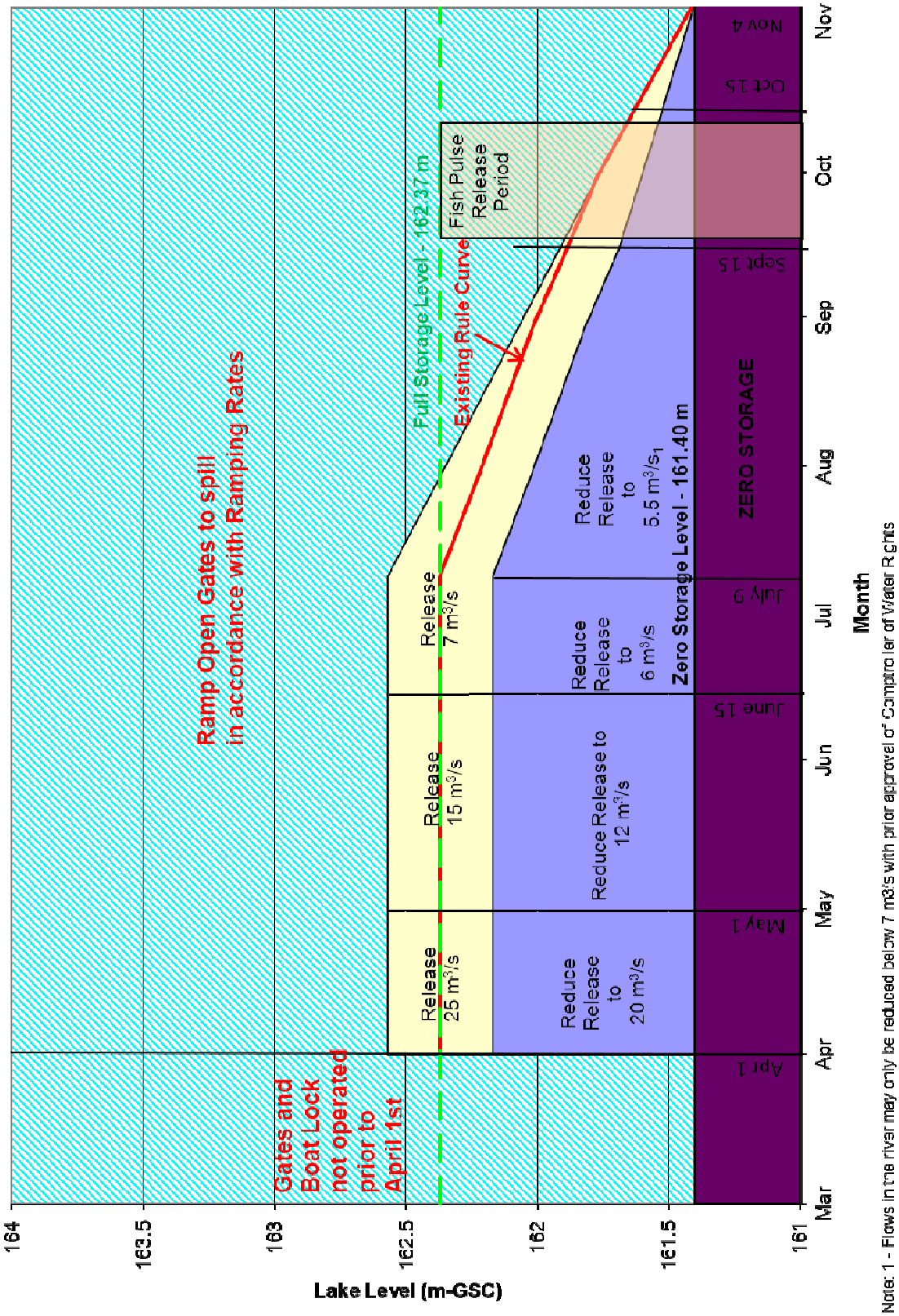


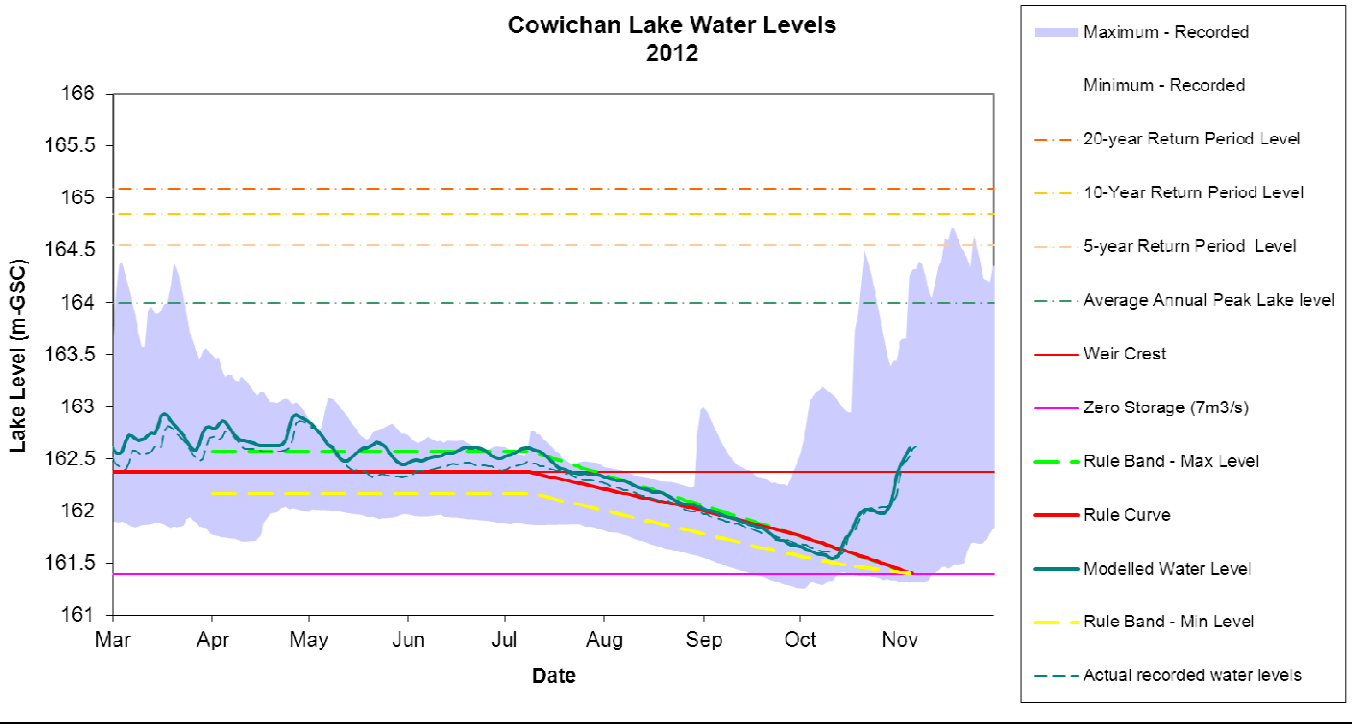
Note: 1 - Flows in the river may only be reduced below 7 m3/s with prior approval of Comptroller of Water Rights

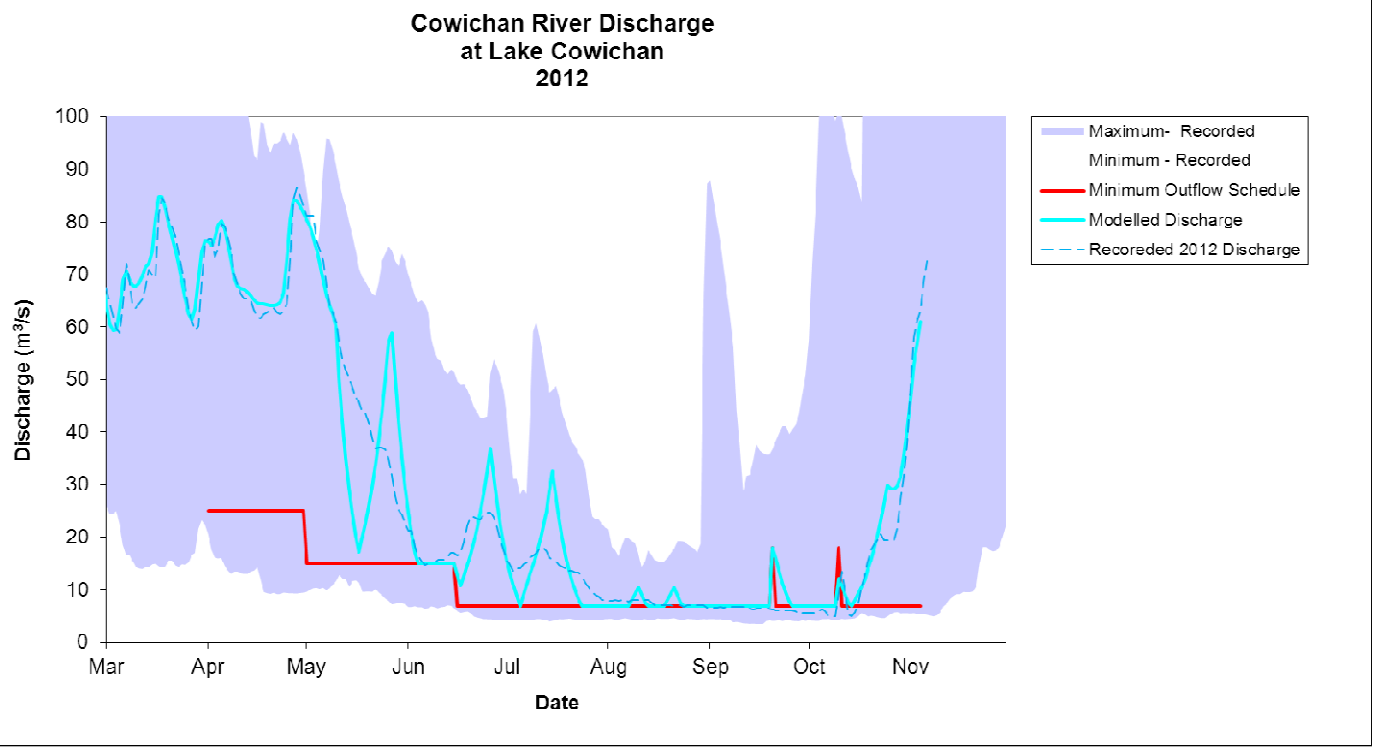
KERR WOOD LEIDAL associates limited CONSULTING ENGINEERS

BC Conservation Foundation – Cowichan Lake Weir Operation Assessment

Project No.	Date
0673.013	Nov. 2012

Cowichan Lake 2012 Operation Protocol
Recommended Rule Band and Flow Release Schedule
Figure 1





KERR WOOD LEIDAL associates limited CONSULTING ENGINEERS

BC Conservation Foundation – Cowichan Lake Weir Operation Assessment

Project No.	Date
0673.013	Dec. 2012

Cowichan Lake 2012 Operation Protocol
Recorded vs Modelled Lake Levels and River Flows
Figure 2

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APPENDIX A - GLOSSARY

TABLE A-1 – Definitions

Term	Definition
Control period (earliest April 1st to as late as early November)	Period when gates are raised and the boat lock is closed such that river flows and lake levels are regulated at the weir structure. The period typically lasts from early spring, when the lake level begins to fall below the weir crest, to the end of summer season when fall rains return and the lake level starts to rise.
Cowichan Lake Weir	Timber-crib and rubble structure constructed at the outlet of Cowichan Lake in 1957 and upgraded in 1961. The structure consists of a boat lock on the left bank (looking downstream), the timber weir and a set of four overshot gates on the right bank. The overshot gates are used to control both lake level and river discharge during the control period.
Fish Pulse	Increased flow near the end of the control period to assist with adult salmon migration. The pulses typically occur around the last week of September and the first week of October, if storage conditions permit. A pulse consists of ramping discharge from 7 m^3/s to 18 m^3/s over 6 hours, maintaining flow at 18 m^3/s for 30 hours and then reducing flow back to 7 m^3/s over a 12 hour period. It should be noted that lake levels must be at or above El. 161.72 m in order to release a flow of 18 m^3/s into the river from the lake.
Full Storage Level (FSL) (162.37 m-GSC)	Elevation of the top of the weir crest. Maximum lake level where river flow can be fully controlled by the weir and gates.
Low Flow Trigger Lake Level	The Low Flow Trigger Lake Level is the lower limit of the Rule Band and provides guidance on when a request to reduce flow releases to the river below the Preferred Minimum Flow Release (7 m3/s) should be considered. It should be noted that the Ministry of Forest, Lands and Natural Resource Operations must approve any reduction in river flow below the Preferred Minimum Flow Release.
Maximum Control Lake Level	The Maximum Control Lake Level defines the upper limit of the Rule Band and is the lake level at which flows must be increased. River flows must continue to be increased at the Provisional Ramping Rates until lake levels return below the Maximum Control Lake Level.

TABLE A-1 (cont.) - Definitions

Term	Definition
Minimum Flow Release Schedule	The schedule that defines the preferred minimum discharge rates to the Cowichan River through the control period: - 25 m^3/s prior to May 1 if conditions allow; - 15 m^3/s prior to June 15; and - 7 m^3/s from June 15 to the end of weir control period when inflow increases and lake levels start to rise (typically before Nov 4).
Preferred Minimum Flow Release	The preferred minimum release of 7 m3/s from June 15th to the end of the Control Period is the accepted minimum flow required to support habitat needs in the river, water users downstream and to meet the requirements of the water licence. Reduction in flow below the Preferred Minimum Flow Release must be approved by Ministry of Forests, Lands and Natural Resource Operations (Nanaimo).
Ramping Rate	The rate at which the river flow can be adjusted. This defines how quickly the controlled river flow can be changed. The protocol defines the rate as: - 3 m^3/s per day up to May 1st - 2 m^3/s per day after May 1st and before July 8th - 0.5 m^3/s per day after July 9th Or 15% of the average of the river flow the previous day, whichever is greater.
Rule Band	The Rule Band defines a set operating range for lake levels in which the Preferred Minimum Flow Release can be maintained. The Rule Band lies between the Maximum Control Lake Level and the Low Flow Trigger Lake Level.
Rule Curve	The Rule Curve defines the optimal lake level during the draw down season from July 9th until early November. It is the primary tool used to balance the need to conserve storage in the lake while ensuring lake levels are drawn down as low as possible at the end of the season to limit the impact to the first peak lake levels in the fall.
Zero Storage Level (ZSL) (161.40 m)	Lowest lake level where Preferred Minimum Flow Release of 7 m^3/s is released from the lake with the gates fully open (lowered) and the boat locks closed. When lake levels fall below ZSL river flows can no longer be controlled and drop below minimum flow until inflows increase and lake level rises above ZSL.