Cowichan Watershed Health and Chinook Initiative Critical Limiting Factors and Action Planning Workshop

Limiting Factor Profiles- Very High and High Risk Factors

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VERY HIGH AND HIGH RISK FACTORS

ADULT STAGING AND MIGRATION

LF1. Predation of adults in the estuary and lower river by pinnipeds during low flows <15 cms)

Biological Communities Goal: Protect, enhance, manage and restore native aquatic and terrestrial species and biological communities to improve and maintain biodiversity in Cowichan watersheds.

Interim Status:

Red Status

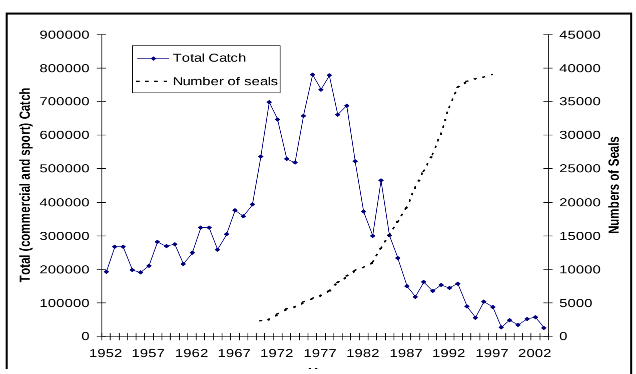
Predation impacts appear to be a very high limiting factor for both adult and juvenile Cowichan Chinook.

Risk/Priority: Current Risk is Very High, Future Risk is Very High

Working List of Actions:

1. Establish adequate flows during the staging and in-migration period to facilitate upstream migration and minimize holding time in the lower river and estuary.
2. Manage the location and quantity of log booms to minimize the predation of seals and seal lions on chinook holding in the estuary
3. Provide sufficient instream cover features in the estuary and lower river for migrating adults that are specifically designed to provide refuge for chinook from seals
4. Undertake a study to estimate the distribution and abundance of pinnipeds during the chinook inmigration and holding period and determine the mortality rate of chinook by seals and sea lions
5. Determine how predation of chinook by seals varies with flow levels through a flow-radio tagging study.
6. Determine the quality of holding habitat in Cowichan bay and identify if there are concerns with holding habitat quality
7. Establish a protocol for a target flow (ie suggested at 20 cms CES workshop) during the prime chinook holding time that would be implemented when the chinook stock is in decline and the returns are less than 3000
8. Utilize a more regular release of pulse flows to move holding chinook from the estuary and lower river, particularly when the returns are below target total return levels.

Rationale/Critical Habitat Requirements: The majority of fall run chinook arrive and hold in Cowichan Bay by September, waiting for the fall freshet necessary to migrate upriver (W. Luedke, 2013 pers. comm.) The seasonal movement of harbor seals (*Phoca vitulina*), Stellar sea lions (*Eumetopias jubatus*) and California sea lions (*Zalophus californianus*) into the Cowichan Estuary coincides with the arrival of adult salmonids during the late summer and fall. Pinnipeds have potential to play a major role on the overall predation of adult chinook, particularly during years with low water levels. Adults become more vulnerable in shallow habitat with



Trends in total salmon catch and seal abundance in the Strait of Georgia (Nagtegaal 2009 unpublished report).

predation more significant in the lower river and estuarine areas with limited instream cover.

The number of seals residing in the Cowichan River and estuary appears to be increasing relative to a decade ago. The current estimated population of seals in the Cowichan estuary is approximately 300 individuals with seals typically congregating around the log boom areas. As well, up to 100 seals have been observed at the floating bridge but these seals may be more of a concern for chum salmon (CEW 2013). By October, sea lions also migrate into the estuary to reside and feed, thereby increasing the incidence of chinook predation by pinnipeds (CEW 2013). In comparison, a study in 1990 estimated that seal abundance in the estuary ranged from a low of 30 in April to a peak of approximately 100 in December with an estimated 23% (Sept) to 48% (Nov) of the harbor seals diet consisting of chum and chinook salmon (Bigg et al.1990, Olesiuk et al. 1990). In 2004 there were an estimated total return of 3341 chinook, of which 2146 spawned naturally in the river, 575 collected for broodstock, 320 adults harvested in the Cowichan Band food fishery and approximately 300 lost to predation by seals (Nagtegaal et al. 2006). In 2005, it was estimated that harbour seals target primarily chinook and chum salmon and consume approximately 9 tonnes of salmon annually in Cowichan Bay (Thompkins et al. 2005). Therefore, a decade ago, seal predation on chinook adults was estimated to range from 100 to 500 adults (Riddell et al. 2000).

Current predation rates are likely higher with a larger number of seals residing in the lower river and estuary. As well, the seals appear to have become more efficient hunters, utilizing the log booms and as well, being assisted in some years with an extended period of low flows and longer holding times for chinook in the estuary and lower river.

The log booms appear to be providing a place of refuge for the seals, allowing them to escape from predators as well as using them as haulout sites and birthing areas. The log booms also provide an ideal feeding area for the seals as chinook also utilize the booms for cover and refuge, but they are easy prey for the seals resting directly overhead and particularly during low tide cycles (CEW 2013). The seals appear to be targeting the female chinook, feeding primarily on the abdominal areas and leaving the rest of the carcass.

The distribution of seals within the Cowichan River is more extensive that originally thought. In 2009, for the first time fisheries personnel from the Cowichan Tribes observed that seals were migrating further upriver and observed them in the mainstem upstream of the enumeration fence site. Over the last few years there are also reports of seals migrating upriver as far as Skutz Falls and seals have also been observed in the coho pools from early October until January (CEW 2013). The extent of predation by pinnipeds appears to be dependent on chinook residence time in the lower river and estuary (Nagtegaal and Carter 2000). Therefore, seasonal periods of low water that delay upstream migration of chinook would likely increase the incidence of predation.

The past removal of log jams in the lower river may have exacerbated the issue of seal predation on chinook by removing ideal cover and complexity for chinook and has now put them at greater risk of predation. However, the incidence of seal predation may be more the result of augmentation of seal habitat in the form of log booms relative to the loss of refuge habitat in the lower river (CEW 2013).

In summary, the combination of low flows and delayed upriver migration, lack of refuge and increasing abundance of seals and sea lions has increased the vulnerability and incidence of chinook predation in the lower river and estuary.

Critical Habitat Requirement: Safe holding habitat in estuary and lower river prior to upriver migration

Factors Affecting Habitat Requirements: Low flows, abundance of predators, fishing pressure, high quality migration habitat with deep holding pools and good in-stream cover

Status in the Cowichan: increasing predation by seals in estuary and lower river, lack of adequate cover in estuary and lower mainstem Cowichan and Koksilah due to extensive shallow glide habitat lacking in-stream cover

Map Id and/or Location on the river: estuary and lower river

Potential Watershed Pressure:

- Land-use impacts
- Estuary alterations

Potential Watershed State Indicators:

- Salmonid population structure
- Species interactions (predation)

Potential Chinook Specific Indicators:

- # of adults or % mortality due to predation by pinnipeds in the Cowichan estuary
- abundance of pinnipeds in the lower river and estuary from late July/early August through November
- distribution of pinnipeds in the Cowichan River
- abundance and trends of the Georgia Strait seal and sea lion population

Potential Benchmarks:

- Determine an acceptable target level of predation that can realistically be sustained by the Cowichan fall run chinook population
- Develop a target level for the harbor seal population that can be sustained in the Cowichan River estuary without having detrimental effects on chinook production
- Establish a target flow (ie suggested at 20 cms CES workshop) during the primary holding period that would be implemented when the chinook stock is in decline and the returns are less than 3000

Status/Existing Habitat Protection and/or Restoration Measure in place: None

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LF2: Limited or delayed spawner access through lower river and Skutz Falls reach to prime habitat upstream of Skutz Falls

Hydrology Goal– Move toward normative* flow conditions to protect and improve watershed and stream health, channel functions, and public health and safety.

Red Status

Low flows in the early summer through fall limit Chinook access and increase predation impacts

Risk Rating: Current Risk is High, Future Risk rating is Very High

Working List of Actions:

The following list of proposed recovery strategies in intended to be a starting point for discussion by a technical working committee with additional strategies to be added and ranked based on the data available, estimated cost and funding availability.

FLOW1: Adopt and Implement the Water Basin Plan recommendations (2008). CVRD Board accepted Demand Management options but supply side options and amendment of rule curve variation and rule curve refinements not currently supported by CVRD board. (HG-9)

FLOW2: Develop a plan to release adequate maintenance flows to improve fish migration, increase summer flows to the mainstem and to improve connectivity of off channel and tributary habitat that considers:

- Investigate water storage options that includes increasing the height of the flow control weir [HG-9]
- Investigate options for storage at Fairservice (Cooks') lake where the 2.1 ha marsh could potentially yield a flow release of 2.3 L/s for approximately 150 days with 2 m of storage. Further hydrological analysis requirement is needed to determine if a flow of 2.3 L/s would be adequate flow to maintain habitat.
- Investigate potential headwater storage options in the Robertson River (T. Burns, CEW 2013)
- Richards, Holt and Averill Creeks: Conduct assessment of water storage potential to improve summer baseflows and rearing habitat. Prepare water storage designs and flow management plans for suitable sites. Crofton reservoir now providing flow attenuation

FLOW3: Develop a Monitoring and education program for Cowichan Lake residents to illustrate seasonal variations in the water surface elevation in the lake and downstream in the river proper.
Illustrate where the control point is in an effort to gain support and cooperation with the water storage project.

- Undertake a littoral habitat assessment and bathymetric assessment of the lakeshore area to identify the location and habitat values of the potential drawdown zone.

FLOW4: **Continue pulse flows and assessments** to determine effectiveness to stimulate chinook migration from warmer less protected water of the lower river to cooler, more protected habitat in the middle reaches of the river, thereby facilitating upstream migration of CH past the counting fence and through the lower and middle reaches of the Cowichan mainstem

- Document years when chinook spawn in the middle and lower reaches of the river due to low flows and when chum are likely to spawn over chinook redds

FLOW5 : **Continue collective decision making process for operation of the weir**, including or in-season decisions, allowable lake levels, pulse flow timing and frequency, season for weir control etc. If feasible, continue to control the weir into late October or through fall spawner migration to allow further time to operate the counting fence and at the same time being mindful of issues concerning lake levels and lake erosion

FLOW6: Develop public information materials on BMP for Water Conservation through more efficient use of water. Target landowners with water withdrawal licenses (SW-3 CowR, SW-5 Koksilah R)

FLOW 7: Adjustments to the rule curve.

Rationale/Critical Habitat Requirements: During the late 1950's, the natural hydrological characteristics of the Cowichan mainstem were altered by construction of a 1 m high low head weir at the outlet of Cowichan Lake to store spring run off. The dam was constructed to ensure an adequate summer water flow to supply water intakes (approximately 40 km downstream at river km 10) for the Crofton Mill (Catalyst) and the City of Duncan municipal water supply. At present, seasonally stored water is released from approximately mid-April to mid October through the weir at the outlet of Cowichan Lake. Flow releases are managed according to a Rule curve that is designed to provide a minimum maintenance flow of 7.08 cms (250 cfs) established to provide adequate rearing habitat conditions for salmonids. By September 15, flows are to be increased to 9.91 cms (350 cfs) to assist the migration of chinook salmon (Burt and Wightman 1997). For more details, see Burt and Roberts (2002).

The weir has not affected the mean annual discharge but has altered seasonal flows by decreasing spring flows and increasing summer low flows, particularly in September (Burt and Robert 2002). The storage of water by the weir results in a net gain of flow upstream of the pulp mill intake with no impacts to natural river hydrology downstream of the intake at km 10 (T. Rutherford, pers. comm.). The Catalyst diversion is more substantive at 2.8 cms relative to the City of Duncan at 0.16 cms (McKean 1989 in Burt and Roberts 2002). The pulp mill also provides water to the Municipality of North Cowichan for domestic use in the Town of Crofton (LGL 2005). However, low flow related issues persist in the lower river and include barriers to chinook migration, increased water temperatures, reduced water depth and increased susceptibility to predators.

Upstream access by chinook spawners can be limited by a combination of low flows and natural features that include shallow aggraded sections in the lower river, Skutz Falls located 15 km downstream of the lake and Marie Canyon (a 3-meter drop over a 30 m run) located 5 km downstream of Skutz Falls. Optimal flow levels for passage through Skutz Falls is not well documented. Annual spawning distribution dependent on stream flows with the majority of chinook will migrate to spawn upstream of Skutz Falls providing water levels are suitable for passage through the falls and lower river (T. Rutherford and D. Elliott, pers. comm.). DFO escapement data identifies that up to 66% of the chinook run will spawn in the lower river in years with low flows during the migration period (Burt and Robert 2002). Spawning habitat through the lower river is considered to have less favorable substrates due to a higher proportion of cobbles and boulders (DFO 2008) as well as the accumulation of fine sediments (particle size <6.35 mm) through low gradient sections. In general, there is a lower egg to fry survival rate in the lower river.

Adequate stream flows are also critical to minimize holding time and migration delays in the lower river and estuary as residence in the warmer waters of the lower river and estuary can increase stress and migration mortality. Migration delays in the lower river leaves chinook more susceptible to predation by pinnipeds and fisherman through extensive shallow riffle/glide sections in the Cowichan and Koksilah mainstem

The ability to sustain adequate maintenance flows is dependent on available water storage in Cowichan Lake and precipitation during the regulation period. Stream flows rarely exceed the minimum standard and in some years, provisional flows are not met due to the lack of storage. According to minimum flows recorded by the WSC between 1981 and 2001, provisional flows were not met for 16 out of 21 years (76% of the time). Seasonal inflows to Cowichan Lake appears to be decreasing over the past few decades and has resulted in insufficient storage to sustain the conditional release of 7 cms to support Crofton's water license and to meeting fisheries conservation requirements (KWL 2012). A study undertaken in 1991 indicates that an increase of 0.57 m in the weir height would provide sufficient water storage to augment summer and fall flows for salmonids (KPA 1991 in LGL 2005).

As well, a flow monitoring study completed in October 2012 revealed that a flows ranging from 6.5 to 10.7 cms in the Cowichan mainstem at Greendale resulted in a flow of only 2.6 to 2.8 cms at the South Fork (BCCF 2013). Flow losses were the result of water withdrawals in combination with natural losses including evaporation.

Since 1987, fall pulse flow water releases have been an effective annual strategy to stimulate chinook migration from warmer, less protected waters of the lower river to cooler, more protected habitat in the middle reaches of the river, when sufficient water storage is available. (Hop Wo et al. 2005). In Oct 2010: At the monthly CSRT meeting, a committee established to review pulse methodology in relation to fish, First Nations fishery, lake residents and counting fence.

Water management is steadily becoming an issue of increasing importance due to the anticipated effects of drier summers due to climate change coupled with the increasing demand for water to satisfy forecasted population growth. In the Cowichan valley, the population is predicted to increase by 27% over the next 25 years (Westland 2005). At the current time, human water withdrawals greatly exceed inflows during the period of summer low flow and therefore increasing the risk that there is insufficient water storage to sustain fisheries values, ecological values, recreational opportunities and flows required for dilution of effluents in the lower river (Nelitz 2007). Projected water demands for the fall of 2031, (assuming low precipitation flow scenario) will be 4 times greater than the amount of water flowing into the system (Westland 2005). A substantial amount (54%) of the annual water consumption occurs between May and September and if adequate spring inflows cannot be stored in the lake, the mainstem Cowichan River could regularly dewater during the late summer/fall during years with hot, dry summers (Nelitz 2007).

As well, a study in 2012 revealed that 6.5 cms of flow in the upper mainstem results in only 2.6 cms of flow in the lower river due to water withdrawals/consumption in combination with natural factors including evaporation. Causal Factors include the lack of water storage to sustain summer maintenance flows, water diversion and extraction for domestic and industrial use as well as drought over the low flow period.

Critical Habitat Requirement: Adequate maintenance flows to facilitate upstream passage of spawners

Factors Affecting Habitat Requirements: industrial and domestic water use/extraction, low flows, operation of the weir, amount of total water storage available, precipitation during migration period

Status in the Cowichan: Min maintenance flow of 7 cms established for rearing during summer low flows, increases to 9.9 cms after Sept 15 for CH migration. Recent study indicates that 6.5 - 10 cms in the upper river equates to only ~ 2.6 cms in the lower river (BCCF 2013). Between 1971-2000 preferred minimum release met 20 out 30 years (67%) and between 1981-2010 PMR met 17 out of 30 years (57%) (KWL 2012). Upstream chinook access difficult during low flows, limited access or delayed migration can result in chinook spawning d/s of Skutz falls where sites are lower quality with higher proportion of large cobble and fines. Low flows exacerbate predation rates, poor water quality, high water temperatures and loss of migration and rearing habitat quality and quantity. Only viable solution to providing adequate minimum flows over the long term is to increase the controllable storage in Cowichan Lake (KWL 2012).

Map Id and/or Location on the river: throughout mainstem but critical for extensive shallow reaches in lower river and through Skutz Falls Marie canyon

Potential Watershed Pressure:

- Land-use impacts
- Water withdrawals
- Vegetation management

Potential Watershed State Indicators:

- Hydrograph alteration and flows
    - Number of successive days without rainfall between April and November
    - Water extraction during Aug – Oct (m^3/month as % of MAD)

Potential Chinook Specific Indicators:

- magnitude and duration of flows during spawning period
- stream discharge during the CH migration and spawning period
- Rainfall records over low flow period

Potential Benchmarks:

- Min maintenance flow of > 7 cms during the chinook migration period.
- Discharge less than 20% Natural mean annual discharge during July/Sept.
- Compare watershed ratios for extraction and rank based on proportion (low, med, high) (Stalberg et al. 2009).

Status:

- 1988 and 1990: **Pulse Flows** DFO initiated experimental short pulse flow period (5-10 days) during low flow conditions in early fall to facilitate u/s migration (Nagtegaal and Riddell 1998). Since 1988, fall pulse flow water releases have been an effective annual strategy to stimulate chinook migration from warmer, less protected waters of the lower river to cooler, more protected habitat in the middle reaches of the river, when sufficient water storage is available. (Hop Wo et al. 2005). Oct 2010: At the monthly CSRT meeting, a committee established to review pulse methodology in relation to fish, First Nations fishery, lake residents and counting fence.
- August 2003, an ad hoc multi-interest committee known as the **Cowichan River Committee** cooperatively managed water flows by making in-season flow management decisions during times of the annual drought period. Committee included Cowichan Tribes, Catalyst Paper, DFO and MOE. This group collectively makes.
- 2004: **Cowichan Stewardship Round Table** (CSRT) formed as a community based partnership that includes representatives from the Cowichan Tribes, federal and provincial agencies, local government, non-government organizations, industry and the public.
- 2007 Cowichan Basin **Water Management Plan** funded and developed by the Cowichan Valley Regional District, BC MOE, DFO, Catalyst Paper Corporation, Cowichan Tribes and the Pacific Salmon Commission with significant input and support from public and non-profit organizations. (Westland 2007).
- 2008: Water Basin Plan recommended and report received and amended by CVRD Board Sept with Demand Management options accepted. Supply side options not currently supported by CVRD Directors. In Feb 2010, there was no support provided to amendment of rule curve variations or refinements and proposal taken to community for public consultation in 2010.
- 2009: Hydrometric real time monitor to record lake and river level funded and installed by Catalyst in July
- February 2010: **Cowichan Water Board (CWB)** formed to address water release issues with intent to have protection of ecosystems a top priority when making decisions about water allocation. Representation by CVRD, Federal and Provincial government, Cowichan Tribes, 4 members at large. They have no regulatory authority at this time but have a technical advisory committee to the Board. Hosted workshops on the Rule band approach to operation of the weir and fisheries values of Cowichan River.
- In 2010: Hydrological inflow model for Cowichan Lake being developed by Alan Chapman under funding managed by Living Rivers Society, can be used to determine storage capacity. Rainfall is

dominant factor affecting lake inflows for Cowichan basin with Cowichan L being one of wettest areas on Vancouver Is with average 2.4 m/yr of rainfall. Snow has minimal effect on runoff and there has been a 36% reduction in summer runoff since 1984

- 2016: Structured Decision Making for Flows for Fish, expert based process, developing model to determine risk of not meeting proposed flows with various storage options.
- Nov 2016: workshop on global climate changes, forestry and target setting for water issues in the Cowichan

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LF3: Loss of safe migration route through the lower mainstem Cowichan River due to channelization, loss of habitat complexity and in-stream cover features

Risk Rating: Current Risk is High, Future Risk rating is Very High

Rationale/Critical Habitat Requirements: The channelized mainstem reach immediately downstream of the Highway 1 bridge is characterized by homogenous and deep, extensive glide/riffle zone that illustrates the loss of a natural pool/riffle ratios and natural frequency of LWD and riparian habitat that were likely present prior to the diking and channelization. The loss of vertical and lateral complexity reduces the frequency of protected alcoves, undercut banks, accumulation of stable large woody debris as well as stable substrates. As well, there has been an alteration of natural instream cover (i.e. LWD, boulders, rooted aquatic plants) and the loss of instream features results in the reduction of invertebrate production, depth and frequency of lateral pools as well as the loss of refuge habitat for salmonids. These habitat features can be the most significant factor affecting fish production in channelized streams (Tarplee 1971 in Lill et al.1975).

The effects of delayed access through the lower Cowichan and Koksilah Rivers by chinook spawners is exacerbated by the lack of habitat complexity and good holding habitat for chinook. Natural channel and channel bank characteristics in the mainstem and off channel habitat have been altered by construction of flood protection dikes as well as urban, linear and agricultural development.

The lower mainstem habitat offers only marginal quality holding habitat due to aggraded shallow reaches, lack of instream cover and complexity as well as a low frequency of functional LWD and deep holding pools through the lower floodplain reaches of the Koksilah and Cowichan Rivers. The lack of cover and extended shallow sections leave the spawners exposed and vulnerable to predation and interception. Higher habitat complexity throughout the mainstem Cowichan and Koksilah Rivers would also increase rearing habitat quality.

Downstream view of the lower Koksilah River illustrating extensive shallow habitat that can be observed throughout the lower floodplain reach that is lacking sufficient deep pool cover and complexity for migrating spawners (fall 2009).

Critical Habitat Requirement: High quality migration route with adequate refuge habitat

Factors Affecting Habitat Requirements: Flood protection and flood maintenance works, accelerated coarse bedload transport

Status in the Cowichan: Numerous flood management dikes on both banks of the lower Cowichan and Koksilah River, lack of habitat complexity and instream cover, lack of good holding pools (>1 m deep) and prevalence of extended shallow sections that lack cover components

Map Id and/or Location on the river: lower river downstream of Trans Canada hwy bridge

Potential Pressure Indicators: N/A

Potential Pressure Indicators:

- % urban development by sub-basin and watershed
- % impervious area, % watershed logged, % agricultural development by sub basin and by watershed (Ecofish 2007).
- Linear length of flood control dikes
- Total km of flood protection dikes or altered shorelines due to urban, industrial or resource development activities along the mainstem

Potential State Indicators and Status:

- % and type of instream features (overhead veg functn'l LWD, boulders, % pool habitat)
- Channel stability (pool: riffle, bankfull channel width: depth ratios (Ecofish 2007)
- Substrate quality (Ecofish 2007)
- Macro invertebrate indices (Ecofish 2007).
- % instream cover, frequency of functional LWD,
- # of deep holding pools/km

Potential Benchmarks:

- **% pool habitat**: Good: >55%, Fair 40-55% and Poor: <40%. **Pool frequency:** G < 2 channel width per pool, Fair: 2-4 CWPP, Poor: > 4 CWPP. **LWD pieces per channel width**: G > 2, F: 1-2 and P: < 1.
- **Bldr cover in riffles**: G: >20% F: 10-30% and P: <10%. (Johnstone and Slaney 1996). See Tripp and Bird 2004
- Natural frequency and quality of instream features (undercut banks, functional LWD, deep pool habitat etc)

Existing Habitat Protection and/or Restoration Measure in place:

- See bank protection works section above
- Additional channel restoration works completed in Bonsall slough, Robertson blind, Somenos C, Busy Place C, Bible Camp
- 2 bank protection projects in the lower CowR: JUB (3 rk weirs, 3 LWD structures), Mariners pool (rock groynes), lower Koksilah R: 2 bank protection sites.

Working List of Recovery Strategies/Measures:

HAB3: Discourage further urban, industrial or resource development within the floodway or within intact riparian forests, maximize flood capacity, allow natural inundation of the floodplain during high flows.

HAB4: Adopt the approach of integrated flood planning where all flood management instream works should include a minimum compensation component of 2:1 habitat complexing in the lower floodplain reach.

HAB6: Assess feasibility of removing specific dikes and constructing setback dykes to allow natural inundation through the floodway

HAB9: Assess and remove large and/or channel spanning debris jams that pose a flood hazard and/or are contributing to bank erosion and instability. i.e. Koksilah River at km 3+290

HAB10: Implement a monitoring program with annual reporting for proposed and past LWD removal sites

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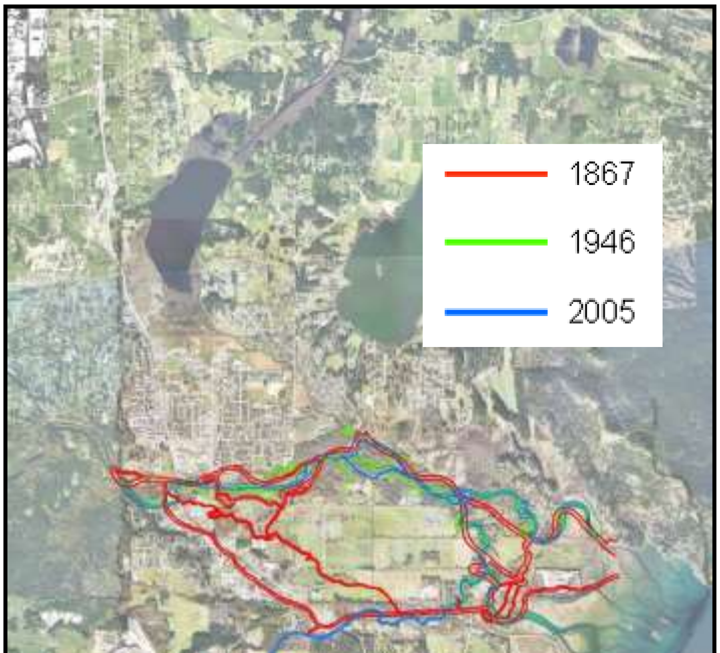
LF 4: Aggradation creates a migration barrier in the lower Cowichan mainstem during the summer and early fall low flow period

Risk/Priority: Current Risk is High Future is Very High

Rationale/Critical Habitat Requirements: Upstream access by chinook spawners through the lower Cowichan River is affected by the aggradation of coarse sediment in the lower reaches of the Cowichan mainstem at specific locations including immediately upstream of the Trans Canada Highway bridge, the JUB outfall site and in the North Fork immediately downstream of the South Fork confluence.

The mainstem Cowichan River flows from a steep canyon reach and spills onto an unconfined alluvial plain in the lower river that resembles a low gradient fan. Surveys from1867 document that the river branched into several channels and spilled across the floodplain with no large amounts of sediment transport. Once european settlement commenced, the channel pattern of the mainstem was altered in 1946 and again in 1962 with the river channelized and shifted from its natural alignment (D. McLean, nhc CEW 2013). In 1958, there was a large log jam in the mainstem Cowichan near the Somenos confluence causing the river to avulse and was re-directed.



Aerial image of the lower Cowichan floodplain reach illustrating the braided meandering channel pattern of the mainstem in 1867 (red) relative to the channelized pattern observed by 2005 (blue) (nhc 2012).

Over the 20th century, the sediment source and gravel supply increased due to land disturbance and the fact that the mainstem runs through 40 km of glacial outwash sediment. By 1990's, additional mainstem meanders were cutoff and between 1993 to 2004 a total of 1 km of the mainstem was lost due to avulsions and in turn created the release of 300,000 cubic meters of sediment downstream (D. McLean, nhc, CEW 2013).

The sediment transport capacity decreases as you move downstream with mainstem deposition occurring in selective reaches of the lower river. Increased flows occur through transport zones that includes constrictions at railway and highway bridges as well as channelized reaches that result from flood protection diking. Subsequently, deposition zones are located immediately downstream of the constrictions at sites including the JUB outfall, confluence of the Somenos C and in the North Fork downstream of the South Fork confluence.

In the Cowichan River, annual bedload transport rates are quite variable, ranging from up to 50,000 cubic meters in one year and then almost none the next (D. McLean, nhc, DEW 2013). On average, an estimated 7000 m^3 of bedload materials accumulates annually in the lower Cowichan River (nhc 2009).

The accelerated bedload delivery of coarse sediments to the lower Cowichan River reduces channel width and increases channel width. The lack of channel depth when combined with low summer flows can limit upstream migration through the lower river, particularly through the North Fork. For example, in most years the north arm provides access for the majority of chinook migrants but during the fall of 2009, the North Fork was dewatered as a result of aggradation and low water conditions. Therefore, upstream migrants were forced to turn round and navigate up the South Fork that created the potential for increased stress, migration delays in the estuary and exposure to predation by seals as well as the terminal fishery (T. Rutherford and D. Elliott pers. comm.). Another passage incident occurred in 2006 when low flows limited migration opportunities and the Cowichan Tribes captured and transported chinook from the lower river to the upper river due (D. Elliott). Delays to migration causes stress and increased vulnerability to predation and can result in an increase in spawner mortality.

View of the Cowichan River North Fork on July 20, 2012 at a flow of 13.5 cms at the Duncan WSC gauge illustrating how aggradation is limiting fish passage through the North Fork. (BCCF 2013).

The accumulation of sediment in the lower Cowichan mainstem also reduces channel depth and can increase migration mortality due to high exposure through the lower mainstem Cowichan and Koksilah River. Aggradation also exacerbates problems associated with bank erosion/instability, channel shifting, increased flood levels and restricted fish access/flows to off channel habitat (nhc 2009).

Critical Habitat Requirement: Stable channel morphology, maintenance of channel capacity and natural level of sediment transport

Factors Affecting Habitat Requirements: coarse and fine bedload aggradation, higher high flows

Status in the Cowichan: High sediment transport rates to lower Cowichan River, variable on annual basis but estimated average of 7000 m3/yr. Aggradation in combination with low flows limits upstream fish passage during summer/early fall low flow period.

Map Id and/or Location on the river: North Fork, Quamichan village, JUB outfall reach, immediately u/s of railway bridge

Potential Pressure Indicators:

- Linear length or % of stream banks along the mainstem that are actively eroding, likely as a result of adjacent resource or urban development
- Timing and duration of dewatering in the North Fork.
- # km or % of stream banks that are diked or altered for bank protection

Potential State Indicators and Status:

- Channel bed disturbance:
- Accumulation of bedload in the lower river
- Location and duration of passage issues due to deposition of coarse sediments
- # deep holding pools/km or # pools per bfw

Potential Benchmarks:

- Sediment transport rates in channel.
- Natural sediment delivery and transport rates
- Goal to minimize dewatering of the North Fork during the chinook migration period.
- Target: ____ # deep holding pools/km or # pools per bankfull channel width

Existing Habitat Protection and/or Restoration Measure in place:

- 2-3 gravel/debris removal projects in the lower Cowichan R., at railway crossing, JUB outfall and North/South fork (nhc 2009).
- 2 gravel/debris removal projects in the lower Koksilah R (nhc 2009)
- Proposed 3 year sediment removal plan for lower river at 2 sites in nhc 2009.

Working List of Recovery Strategies/ Measures:

- Develop a Sediment management Plan and maintain the channel profile, particularly in the lower river.
    - Develop and implement an annual pilot gravel removal program. Proposed sites include the point bar immediately upstream of the railway bridge, the JBUB sites, Quamichan confluence and Tooshley Island at the confluence of the North and South Fork.
    - Sites with a large amount of accumulation may need to be done every 2-3 years whereas others can be maintained less often
    - This program should consider relocating the gravel from the lower river to the upper river chinook spawning reaches.
    - Gravel removal works should consider a minimum of 2:1 habitat compensation component to improve instream cover and complexity in the mainstem of off channel habitat within the Cowichan Basin
    - Adopt the Adaptive Sediment and Debris Management as outlined by nhc 2012 that provides an adaptive approach to gravel removal, altering the program and adjust the volume of gravel removed according to how much accumulates.
    - Gravel removal works should be monitored on an annual basis for a minimum of 5 years to evaluate the effectiveness of the projects and make appropriate adjustments

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INCUBATION

LF18: Predation of chinook eggs and alevins by fish (sculpins, trout), birds etc.

Risk/Priority: Current Risk is Very High, Future Risk is Very High

Rationale: Predatory fish including sculpins and brown trout are known to feed on both eggs and alevins in the Cowichan River, particularly when the supply of invertebrates is limited. At this time, it is unknown if predation is a significant factor to incubation survival and the overall production of fall run chinook.

The State of Environment also identified a concern regarding the predation of chinook eggs and alevins by natural predators. At this time, there is little documented information regarding the effects of predation on chinook eggs and alevins by other fish species in the Cowichan river. Therefore, further assessment could be undertaken to determine whether this factor is limiting to chinook production in the Cowichan River.

Critical Habitat Requirement:

Factors Affecting Habitat Requirements:

Status in the Cowichan:

Map Id and/or Location on the river:

Potential Pressure Indicators: N/A

Potential State Indicators and Status:

- Abundance of predators by species (sculpins, birds etc)

Potential Benchmarks:

Existing Habitat Protection and/or Restoration Measure in place:

Working List of Recovery Measures:

LF23: Limited access or no access to existing and historical off channel habitat (Trailer park channel, Priests slough/marsh)

Risk/Priority: Current Biological Risk is Very High, Future Risk is Very High

Rationale: Urban, rural, agricultural, linear, industrial development in combination with flood management activities have altered natural stream flow patterns over the Cowichan and Koksilah floodplain area. Historically, the mainstem river branched and spilled across the floodplain but the current alignment of both the mainstem Cowichan and Koksilah Rivers resembles a predominantly a channelized stream pattern. As a result, historical off channel areas are isolated from stream flows and unavailable as fish habitat.

Historical information suggests that there are several sites in the lower river that were once utilized by fish and contributed important habitat to overall fish production. For example, at one time Priests Marsh provided valuable habitat for chinook and coho but the marsh is not significantly inundated by flows any longer. As well, the Trailer park channel area off the right bank of the Cowichan mainstem immediately downstream of the Trans Canada highway was once utilized by significant numbers of chum salmon for spawning habitat and also provided good rearing habitat for coho prior to infilling and construction of the trailer park. As well, anecdotal evidence from Cowichan Tribes elders and members working at the hatchery suggest that chinook and steelhead have historically used floodplain tributaries around the Five Fingers area as spawning habitat up until the late 1970's prior to diking and disconnection of these channels (CEW 2013). Anecdotal information also suggests that chinook were observed in upper John Charlies channel as late as the early 2000's but beaver dams limited their access during the mid – 2000's (CEW 2013). (*Note: more information may be available from John Charlie, Gary Charlie or Cowichan Tribes hatchery employees*). Anecdotal evidence suggests that historical areas are able to make a significant contribution to the existing habitat quantity (CEW 2013).

A survey is needed to determine the approximate area of rearing habitat that's been lost relative to the amount of historical fish habitat within the floodplain reach downstream of the Trans Canada Highway. The results of the study would document the total amount of habitat lost and as well, provide a target for the amount and type of rearing habitat.

In general, the experts agreed at the March 2013 workshop that the restoration of alienated rearing habitat once utilized by chinook is an important component in the overall strategy to rebuild the chinook stock in Cowichan River. The potential benefits of rearing habitat restoration are high.

Critical Habitat Requirement: Unrestricted passage for fry through mainstem and OC habitat

Factors Affecting Habitat Requirements: Riverside and floodplain development, linear development, urban development

Status in the Cowichan: Availability of historical off channel habitat has been altered through isolation and/or infilling

Map Id and/or Location on the river: Trailer park channel, Priests marsh, Glenora

Potential Pressure Indicators: N/A

Potential Pressure Indicators:

- Area of isolated or underutilized historical off channel habitat

Potential State Indicators and Status:

- Abundance and distribution of salmonids

Potential Benchmarks:

- Restore to historical quantity and quality of off channel habitat to restore fish habitat and flood capacity

Existing Habitat Protection and/or Restoration Measure in place:

- As above, at least 5 major sidechannel improvements where fish access and flow have been restored.

Working List of Recovery Strategies/Measures:

- Assess the total area of rearing habitat lost in the floodplain reach of the Cowichan and Koksilah River relative to historical conditions.

- **HAB18:** Identify and assess fish access to seasonal or historical off channel along the mainstem Cowichan River that may have been previously altered and isolated by urban and resource development activities (see text for more details).
- Rehabilitate habitat and restore flow to historically utilized off channel and side channel habitat utilized by chinook
    - Priests Marsh channel: the marsh does not significantly inundate as historical records suggest and there is potential for a 1.5 to 2 m channel from the Quamichan village downstream and through lower Priests Marsh. (R. Wong, 2013, Current Environmental)
    - Somenos channel: in the past channel excavation has increased groundwater inputs to the channel and improved rearing habitat conditions through the summer. Maybe more beneficial to coho who rear throughout the summer in the lower river but could assist with maintaining adequate temperatures for returning chinook spawners

- Investigate the feasibility and value of outplanting hatchery fry into these sites to assist with naturalizing and re-establishing utilization of these areas by chinook

LF25: Loss of high quality rearing habitat and natural instream complexity (> 1 m deep holding pools, functional LWD, stable riffle pool habitat, undercut banks)

Risk Ratings: Current Biological Risk is Very High, Future Risk rating is Very High

Rationale: The growth and survival of chinook fry is also dependent on good quality rearing habitat characteristics that include: adequate frequency and quality of deep (>1m) pool habitat, instream cover including boulder cover, functional LWD and undercut banks as well as presence of good overhead cover and intact, functional riparian vegetation. The lower Cowichan River historically provided high quality rearing conditions and instream complexity that have been reduced over time. As well, off channel areas have been isolated from fish access and flows. Overall, the lower mainstem habitat is less effective as a nursery are for rearing chinook fry (CEW 2013).

The channelized mainstem reach immediately downstream of the Highway 1 bridge is characterized by homogenous and deep, extensive glide/riffle zone that illustrates the loss of a natural pool/riffle ratios, loss of channel bank features, natural frequency of LWD and Native riparian habitat that was present prior to construction of flood protection dikes. The loss of vertical and lateral complexity reduces the frequency of protected alcoves, undercut banks, accumulation of stable large woody debris as well as stable substrates. Instead, there are sections in the lower river where there are large accumulations of small woody debris that have altered natural shoreline features. As well, there has been an alteration of natural instream cover (i.e. LWD, boulders, rooted aquatic plants) and the loss of instream features results in the reduction of invertebrate production, depth and frequency of lateral pools as well as the loss of refuge habitat for juvenile salmonids. These habitat features can be the most significant factor affecting fish production in channelized streams (Tarplee 1971 in Lill et al.1975).

Downstream view of the mainstem Cowichan river at the intake to Major Jimmy's sidechannel illustrating the large accumulation of woody debris along the right bank and the resulting lack of natural channel bank characteristics (2009).

Loss of instream complexity as well as the loss of natural channel bank features that typically provide a source for LWD recruitment has resulted from extensive diking for flood protection and channelization of the mainstem Cowichan River. The Cowichan River mainstem has been artificially straightened and relocated through construction of flood control dikes with over 80% of the right bank from the Allenby Bridge down to the Pimbury bridge currently confined by riprap (nhc 2009). Channelization for flood control creates an enlarged and straight channel with the capacity to sustain most of the floodwaters, but the adjacent floodplain is typically drained with the loss of seasonal inundation necessary to sustain the ecology of floodplain vegetation (Lill et al.1975). Impacts of channelization on fisheries values include an overall reduction in species diversity and abundance relative to a non-channelized system.

The effects of delayed access through the lower Cowichan and Koksilah Rivers by chinook spawners is exacerbated by the lack of habitat complexity and good holding habitat for chinook. Natural channel and channel bank characteristics in the mainstem and off channel habitat have been altered by construction of flood protection dikes as well as urban, linear and agricultural development.

The lower mainstem habitat offers only marginal quality holding habitat due to aggraded shallow reaches, lack of instream cover and complexity as well as a low frequency of functional LWD and deep holding pools through the lower floodplain reaches of the Koksilah and Cowichan Rivers. The lack of cover and extended shallow sections leave the spawners exposed and vulnerable to predation and interception. Higher habitat complexity throughout the mainstem Cowichan and Koksilah Rivers would also increase rearing habitat quality.

Downstream view of the lower Koksilah River illustrating extensive shallow habitat lacking sufficient deep pool cover and complexity for migrating spawners (fall 2009).

Critical Habitat Requirement: High quality rearing habitat characteristics with good instream complexity

Factors Affecting Habitat Requirements: Flood protection and maintenance works, Urban, linear and agricultural development, road construction and infilling low elevations sites in the lower river

Status in the Cowichan: Channelized sections in lower river due to flood protection works including diking, bank protection works, as well as road construction, riverside developments have altered natural instream complexity and channel characteristics (channel capacity, lateral and vertical complexity)

Map Id and/or Location on the river: ds of TC highway In Cowichan and Koksilah

Potential Pressure Indicators: N/A

Potential Pressure Indicators:

- % urban development by sub-basin and watershed
- % impervious area, % watershed logged, % agricultural development by sub basin and by watershed (Ecofish 2007).
- Linear length of flood control dikes
- Total km of flood protection dikes or altered shorelines due to urban, industrial or resource development activities along the mainstem

Potential State Indicators and Status:

- % and type of instream features (overhead veg functn'l LWD, boulders, % pool habitat)
- Channel stability (pool: riffle, bankfull channel width: depth ratios (Ecofish 2007)
- Substrate quality (Ecofish 2007)
- Macroinvertebrate indices (Ecofish 2007).
- % instream cover, frequency of functional LWD,
- # of deep holding pools/km

Potential Benchmarks:

- **% pool habitat**: Good: >55%, Fair 40-55% and Poor: <40%. **Pool frequency:** G < 2 channel width per pool, Fair: 2-4 CWPP, Poor: > 4 CWPP. **LWD pieces per channel width**: G > 2, F: 1-2 and P: < 1. **Bldr cover in riffles**: G: >20% F: 10-30% and P: <10%. (Johnstone and Slaney 1996). See Tripp and Bird 2004
- Natural frequency and quality of instream features (undercut banks, functional LWD, deep pool habitat etc)

Existing Habitat Protection and/or Restoration Measure in place:

- See bank protection works section above
- Additional channel restoration works completed in Bonsall slough, Robertson blind, Somenos C, Busy Place C, Bible Camp
- 2 bank protection projects in the lower CowR: JUB (3 rk weirs, 3 LWD structures), Mariners pool (rock groynes), lower Koksilah R: 2 bank protection sites.

Working List of Recovery Strategies/Measures:

HAB2: Restore natural channel features in the lower Cowichan River mainstem, including the removal of the accumulated SWD has altered natural shoreline and instream habitat features along the RB immediately downstream of Major Jimmy's SC

HAB3: Discourage further urban, industrial or resource development within the floodway or within intact riparian forests, maximize flood capacity, allow natural inundation of the floodplain during high flows.

HAB4: Adopt the approach of integrated flood planning where all flood management instream works should include a minimum compensation component of 2:1 habitat complexing in the lower floodplain reach.

HAB6: Assess feasibility of removing specific dikes and constructing setback dykes to allow natural inundation through the floodway

HAB9: Assess and remove large and/or channel spanning debris jams that pose a flood hazard and/or are contributing to bank erosion and instability. i.e.Koksilah River at km 3+290

HAB10: Implement a monitoring program with annual reporting for proposed and past gravel removal and LWD removal/recompleting sites

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LF31: Lack of good quality estuarine and nearshore habitat.

Risk/Priority: Current Biological Risk is Very High, Future Risk is Very High

Rationale: The first few months of life is the most critical life stage for salmonids with *growth* being the critical element for survival. Insufficient feeding conditions in rearing habitat limits potential for early growth and brood year strength appears to be determined in the first 4 months of ocean life (CT 2010). A recent study has also observed that the rate of estuarine growth is positively correlated to the rate of freshwater growth and that growth is directly correlated with survival (D. Ruggerone in CT 2010). Therefore, when ocean productivity is low, it becomes more critical to protect and restore freshwater and estuarine habitat to facilitate growth and survival during the marine phase.

High value habitat features for fish production within the estuary include nutrient rich brackish waters, stable vegetated foreshore habitat, vegetated intertidal habitat i.e. eelgrass beds as well as shallow, low gradient mud and gravel flats. Good quality rearing habitat provides a high level of habitat complexity that includes matrix of tidal channels with a sufficient amount of instream complexity to provide cover from predators as well as suitable substrates for algal growth and colonization by invertebrate larvae. Eelgrass beds and freshwater marshes are preferred habitat in estuaries for salmonid juveniles as they use the vegetation for cover and also feed on invertebrates that colonize the aquatic plants (Waldichuk 1993).

The estuary provides critical element in the production of chinook within the Cowichan River. The intertidal face between salt water and fresh water provides important habitat for smolts and is key for acclimation and developing resistance to vibrio. Chinook fry are thought to migrate back and forth through this interface to acclimate and migration may be linked to tidal cycles. The majority of wild chinook fry are about 4 grams when they migrate to the estuary and their ability to transition to the marine environment may be related to size.

There is a lack of knowledge regarding this transitional phase regarding the length of time chinook fry spend in the nearshore area, what habitat types they prefer, the availability of food, distribution within the lower river, estuary and nearshore area and rates of predation (CEW 2013). There is also a lack of information regarding the size of early smolts and growth rates over the summer and fall for both wild and hatchery chinook. DFO is proposing a pilot pit tagging project for the spring of 2014 to investigate juvenile chinook utilization in the lower river and as well, will provide information on adult returns (CEW 2013).

The abundance of fresh brackish marsh and salt marsh habitat for fish production has been significantly altered and lost due to agricultural development in the estuary and foreshore area of the Cowichan River (CEW 2013).
The peak of industrial activity occurred during the 1970's and by the mid 1970's, 72% of the estuary has been affected by diking, reclamation of foreshores marshlands for agricultural purposes, storage and sorting of logs on the estuary flats, dredging and landfill (Lill et al. 1975). Other impacts to the estuary include urbanization of the south shore of Cowichan Bay, pollution from municipal sewage discharges and agricultural runoff

(Nagtegaal and Riddell 1998). As well, there is a major concern regarding the significant loss of the complex web of tidal channels that appear to be infilling over that last few years due to sedimentation (CEW 2013). There is minimal instream complexity remaining in the nearshore estuary area (CEW 2013).

Chinook fry reside in the estuary between mid April to August, with survival of fry and smolts affected by food availability as well as habitat quantity and quality. Therefore, any incremental improvements to chinook productivity within the freshwater and estuarine life history stages can assist in the overall recovery of fall chinook stocks. Restoration efforts to agricultural lands in the nearshore estuary and foreshore area have been ongoing and have significantly improved foraging habitat for migratory and local bird species. However, these sites could also be provided high quality transitional fish habitat, but for the most part they are not "fish friendly" (CEW2013).

Critical Habitat Requirement: Good quality estuarine habitat with adequate complexity with cover

Factors Affecting Habitat Requirements: Amount of development and/or disturbance to natural riparian, foreshore, intertidal and nearshore habitat

Status in the Cowichan: Loss of complex web of tidal channels, natural abundance and composition of benthic communities eelgrass habitat, isolated channel features and associated ecological communities

Map Id and/or Location on the river: lower river and estuary

Potential Pressure Indicators:

- % or area of foreshore altered (Ecofish 2007)
- % surface area disturbed in-shore

Potential State Indicators and Status:

- Area, distribution, type and change in area of tidal and submerged wetlands (Dent et al. 2005).
- Shoreline features and condition by ratings (G, F and P)

Potential Benchmarks:

- % of area of allowable altered subtidal, intertidal and foreshore habitat

Existing Status/Habitat Protection and/or Restoration Measure in place:

Knowledge Gaps:

- Length of time chinook fry spend in the nearshore area, distribution in the lower river and estuary, size and habitat types
- the availability of food, distribution within the lower river, estuary and nearshore area
- type of predators and rates of predation (CEW 2013).

Working List of Recovery Strategies/Measures:

1. Consider restoration of channel profiles and habitat complexity in the tidal channels as they have been infilled by fine sediments over the past few years
2. Assess opportunities to improve transitional fish habitat in the existing protected areas established for wildlife and migratory birds in the estuary and foreshore areas of the Cowichan River

3. Support or contribute to ongoing DFO studies that are address the lack of knowledge factors as listed above
4. Pursue and support fish habitat restoration on existing parcels of land set aside for wildlife and migratory bird habitat (CEW 2013).
5. Investigate the opportunities for fish habitat restoration and arboreal restoration in the nearshore estuary area through restoration works and/or the purchase of land (CEW 2013)
6. Review the existing management process for the estuary and support the designation of another co-chair with MoE through appointment under the order in council. More active management of the estuary would facilitate more active protection and restoration works (CEW 2013).