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Cleveland Dam Trap and Truck Program

GVWD Staff Assessment

November 2021

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1.0 INTRODUCTION

The Fisheries and Oceans Canada (DFO) Capilano River Hatchery below Cleveland Dam (CLD) transports adult Coho Salmon and Coastal Rainbow Trout / Steelhead from the hatchery's fish trap, and Steelhead fry from onsite fish culture into the high quality habitat of the upper Capilano Watershed. Greater Vancouver Water District (GVWD) operates reservoir trap nets (TNs) and rotary screw traps (RSTs) within the Capilano Water Supply Area (WSA) to capture out-migrating Steelhead smolts (SHS) and Coho smolts (COS). Captured fish are transported downstream around CLD to the estuary below, thereby mitigating fish mortality associated with travelling over the spillway. Since 2008 this 'Trap and Truck' program has been collaboratively conducted by GVWD, DFO, the Province of BC, Squamish Nation, and the District of West Vancouver.

Upon completion of GVWD's *Joint Water Use Plan for the Capilano and Seymour Watersheds* (JWUP) the Province of BC issued the 2018 Section 93 *Order to Implement the Joint Water Use Plan for the Capilano and Seymour Watersheds.*[1] This Order includes a variety of requirements related to dam operations and fisheries monitoring. Under 'Schedule C', condition '1.a.ii', GVWD must '*Assess effectiveness of the fish trap and truck program at Cleveland Dam*' (the 'study'). This assessment will occur in 2021 and will meet the requirements described in GVWD's 'Terms of Reference – 2021 Study'.[2]

A variety of GVWD staff have led and participated in the Trap and Truck Program and are familiar with the specific operations and requirements. This document addresses the GVWD staff component of the study which will then be reviewed in detail by the consultant, assessed in their expert third-party reporting and submitted to the province as a component of the study. GVWD staff have consolidated all past-consultant recommendations associated with the program[3] and provide a status assessment and professional opinion on each recommendation in regard to viability and other considerations.

[1] http://orbit.gvrd.bc.ca/orbit/llisapi.dll/app/nodes/24435686
[2] https://orbit.gvrd.bc.ca/orbit/llisapi.dll/link/42032676
[3] http://orbit.gvrd.bc.ca/orbit/llisapi.dll/properties/29187785

3.0 PAST PROJECT RECOMMENDATIONS ASSESSMENT

3.1. Trapping – Reservoir

- Continue operation of all trap nets from April 1st to June 15th (Instream Annual Reports, 2008 – 2018).
    - Ten reservoir trap nets are currently operated on an annual basis and have been since 2012, with the exception of years such as 2021 (six trap nets) when reservoir elevation does not allow for deployment at all fishing sites. This number of traps is reasonable to set up, maintain, and service with existing resources. The best fishing locations in the reservoir have been utilized, with some variation in productivity among sites. Start and end dates are 'soft'; April 1st is a reasonable start target but may be delayed in some years without significant consequence due to low catch in early April. Delays typically relate to operational restrictions such as lower than normal water levels due to maintenance at CLD. Fishing will typically end in early June following consecutive days of low catch.

- Evaluate the placement of new trap nets in the area of TN1 in conjunction with the possible use of a floating barrier net to direct out-migrating smolts into these nets (Instream Annual Report, 2011).
    - A number of trap configurations were trialed in this area. There are significant challenges in holding position during higher reservoir inflows, morning outflow and afternoon inflow winds. Algae build up and debris also threatened trap integrity and position. Trials were not successful in maintaining trap shape for capture effectiveness.

- Upgrade the Capilano Lake traps to increase effectiveness and catch consistency (Lill, A., 2015).
    - Traps have been modified and relocated to maximize efficiency based on field experience.

- Install an effective debris boom as proposed for Upper Capilano Lake by the GVWD to reduce debris issues at Cleveland Dam. It will also facilitate smolt collection south of the boom (Lill, A., 2015).
    - The current debris boom that is deployed near Mid-Lake is scheduled for replacement in 2022. GVWD operations staff also collect and store shoreline debris in bagging booms for later removal by excavator at the West Abutment of CLD and Mid-Lake boat launch. Staff have also had success installing a short debris catch, consisting of two boom logs anchored perpendicular to shore, immediately North of TN6 which is the trap net that typically has the most issues with debris accumulation, as well as a typically high capture efficiency.

- Do not proceed with a barrier net and pumped floating collector in Upper Capilano Lake unless it is the only affordable option and is protected by a debris barrier boom system across the lake (Lill, A., 2015).
    - The Mid-Lake debris boom is scheduled for replacement. A barrier net and floating surface collector will be included in a pending options assessment relating to downstream fish passage assessment / hydropower development feasibility.

- Proposed full-spanning reservoir net-pen smolt trap close to upper end narrows (Pat Slaney recommendations in Lill, A., 2015).
    - The report details many challenges with this proposal including debris accumulation, net damage, predation risk, and trap avoidance with smolt residualization and ultimately recommends that existing trap nets may be more effective. The authors agree with this assessment.

- Use of Merwin traps (Lill, A., 2015).
    - Merwin traps were researched and the more complex trap design was not favoured. Staff from Tacoma Power that had previously used Merwin traps recommended to not use them due to poor capture efficiency (10% in a good year).

- Increase SHS transport numbers by alternative methods of fish capture (Instream 2008 – 2018 Synthesis Report, 2018).
    - In 2015 the use of a purse seine fishing vessel was trialed as a means to increase SHS capture and further assess SHS behaviour in the reservoir. The vessel fished for a total of six days, deploying 101 sets. A total of 139 SHS and two COS were captured using this method, representing 25% of the total SHS capture for the season. SHS were mostly captured in pelagic zones near the mid-lake area of the reservoir. Environmental conditions were by far the most extreme on record given zero snowpack for the first time on record and a severe spring drought resulting in the earliest thermal stratification on record; these conditions contributed to extremely low reservoir spill and may have influenced capture rates that would otherwise not be expected. This pilot project was not continued beyond 2015 due to costs, efforts and concerns around perceived public perception of a large fishing vessel on the reservoir. It is considered that the critically low SHS abundance and high relative costs of a contract seine boat and new gear is problematic for similar methodology. Experience gained may allow a more focused and less labour - intensive program, as well as other areas of improvement.

- Increase length of wing nets to test catch efficacy (LGL Limited, 2019).
    - Various wing net lengths have been used in the past. Wing net length is often limited by the proximity to shore and the ability to deploy and service anchor lines with the boats. Fish capture has not been notably better with extended wing sections and typically leads to far more challenges in maintaining trap shape, which is one of the most important factors in effective capture, and debris accumulation. Staff experience on the reservoir suggests traps with smaller wings and shortened leads perform better than those with longer wing nets.

- The bottom panel may benefit from a frame along its outline connected to a rubberized bottom panel that is shaped slightly conical towards its centre where a bucket could be attached. This way most or all fish would be sliding along the rubberized bottom into the water filled bucket when the bottom panel is lifted, and air exposure and dip net handling could be avoided or minimized. Practicality of this system could be tested in a pilot study (LGL Limited 2019).
    - This recommendation was not considered feasible given required effective methodologies to get the fish corralled and within dip net reach. Current methodologies

are highly effective at getting all of the fish out of the trap, and time out of water is minimal. Other earlier employed methods of getting fish out of the net were highly problematic.

3.2. Trapping – Upper Capilano River (upstream of reservoir)

- Evaluate the potential for establishing a third RST site in the Capilano River upstream of the Eastcap Creek confluence as a method to increase Steelhead smolt catch (Instream Annual Report, 2011).
    - A trap was operated at the Mid-Valley site from 2012 to 2018. The site was challenging in both high and low water conditions, with reduced fishing opportunities and a smaller Steelhead smolt capture compared to the Dean Creek site. Fishing days and capture efficiency did not justify efforts. Trap performance was reviewed in *Capilano Trap and Truck: RST Performance Review* (Dixon, 2020)

- The modification and upgrading of existing RSTs to improve safety standards and allow for partial trap fishing in the case of low/high water flows (Instream Annual Report, 2012).
    - Trap condition and associated hardware were substantially rebuilt and upgraded in approximately 2013 by GVWD. The RSTs were initially sourced from DFO and the province, and RST condition is currently satisfactory with inspections and repairs (if necessary) completed annually.

- Make some short-term improvements, but phase out Rotary Screw Traps (RSTs) as collection devices in the Upper Capilano River as soon as a more effective system is operational (Lill, A., 2014).
    - This was reviewed in 2015 and it was determined that RSTs would be maintained until a more effective system is found for Steelhead collection (see below reference to screening facility). In 2019 the Mid-Valley and Lakehead RST locations were discontinued due to low-overall trap performance when balanced with effort and resources. The Dean Creek RST continues to operate annually.

    - Development and construction of an adjustable diversion weir and smolt screening and collection facility in the Upper Capilano to replace the RSTs (Lill, A., 2014). A three year planning study was completed. The most suitable site was chosen, however considerable limitations due to river configuration and moderate to extreme flows were identified. The project was valued at just over $10,000,000 (2014 dollars) and estimated to be 50% effective at most. A pilot project was valued at over $450,000. Primary concerns were a likely inability to collect fish at flows greater than 40 m^3/s, which in normal years was estimated to fish 46% of the outmigration period. Years with more precipitation and higher snowpack would lead to even less use. Furthermore, current SHS abundance would not justify this capital expenditure with uncertain results.

- Continue to operate an RST in the Upper Capilano River (Dixon, G., 2020).
    - A review by GVWD staff suggested that the Dean Creek site is the most productive site to continue running an RST with the primary intent of maximizing SHS capture. The same

review suggested operating the trap on weekends to further increase Steelhead smolt capture potential. This recommendation was implemented for the 2021 season, with the RST operated on weekends during peak out-migration to increase SHS capture. This aligns with past weekend operations by Instream Consultants at the Dean Creek RST.

3.3. Tagging and Monitoring

- Operation of RSTs at upper river sites from March 15th to June 1st, to provide river yield estimates and COS abundance estimates (Instream Annual Reports, 2008 – 2017)
    - Yield estimates were conducted from 2008 to 2018. They were discontinued in 2019 to minimize fish handling, sources of injury, and to focus efforts on transporting all caught fish to the lower river. A strong relationship has been developed between spillway discharge and capture efficiency which can be used to indicate, although not validate, estimated out-migration abundance (COS only).

- Increased efforts to establish a defensible SHS yield from the upper watershed (Instream Annual Reports, 2009 & 2010).
    - SHS abundance is very low and abundance estimates are not viable, particularly in consideration of minimizing fish handling and focusing efforts on immediately transporting all fish caught to the lower river. Hybridization and residualization further confounds efforts in SHS abundance estimates which were tried on a number of occasions with no success. It was the opinion of Don McCubbing that perhaps 10% capture efficiency of SHS was a reasonable estimate of trapping success.

- Continued program of time stratified COS and SHS ageing from all trapping sites to assist in assessments of production yield from out-plantings and adults and compare with habitat yield models (Instream Annual Reports, 2008 – 2015).
    - Attempts at correlations between adult stocking and smolt production did not show a significant relationship. Comprehensive age-length relationships have been developed in the past (i.e. adult stocking density not shown to have a significant relationship with smolt production). It has been largely assumed that the number of Coho spawners stocked fully seeds available habitat and other factors such as over-winter survival are likely of greater importance than stocking density in regard to COS production.

- Remote and manual scanning of adult Coho and Steelhead brood for PIT tags on return to Capilano Salmon Hatchery and in terminal First Nations fishery for survival estimates and yield contribution evaluation (Instream Annual Reports, 2008 – 2017).
    - PIT tagging was discontinued in 2018 for COS and 2016 for SHS. Abundance estimates were discontinued at the same respective times in the interest of minimizing handling and focusing efforts transporting all fish caught to the lower river.

- Begin analysis of Coho hatchery return data collected from PIT tagging and other adult returns to contribute to smolt release strategy (Instream Annual Report, 2010)
    - Past research indicated non-significant relationship between smolt release location and marine survival (adult returns).

- Continued PIT tagging of Coho smolts for abundance estimates and Steelhead trout for marine survival (Instream Annual Report, 2011 & 2012).
    - Marine survival is poor, but the proportion of unmarked (i.e. adipose intact) returns to the Capilano River Hatchery has markedly improved since 2009. This dataset provides perhaps one of the best and least invasive indicators of program success available to us, although challenging to scientifically validate.

- Commence Steelhead smolt radio telemetry program in late March (pre-migrating smolts should be captured above mid-valley). (Instream Annual Report, 2014).
    - An extensive Steelhead smolt telemetry study was conducted from 2014 to 2018. The results were considered not particularly useful in improving operations to any degree. With an interest in minimizing handling and focusing on transporting all captured Steelhead smolts, SHS radio telemetry efforts should be considered complete.

- Consider a future three-dimensional acoustic tagging and tracking study to facilitate design of improved lake traps and/or dam collection facilities (Lill, A., 2015).
    - In 2015 it was determined that this study would be undertaken following the radio-telemetry program if further information was required.
    - An acoustic telemetry study was conducted (Stables, 2009) and deemed acoustic tracking an unsuitable method for the Capilano Reservoir.

- Evaluate the seeding levels (i.e. adult stocking) of the upper Capilano River by ground-truthing the capacity models (Instream 2008-2018 Synthesis Report. 2018).
    - The stocking density has been generated by very basic DFO modelling of available upper river habitat and a juvenile carrying capacity study was conducted by Instream (2012). This recommendation is considered outside the scope of this smolt trap and truck effectiveness assessment.

- Continue with mark recapture study to generate population estimate (Instream 2008 – 2018 Synthesis Report, 2018).
    - Yield estimates were conducted from 2008 to 2018. They were discontinued in 2019 to limit fish handling, sources of injury, and to focus efforts on transporting all caught fish to the lower river. Effort was large, multi-strata abundance estimates complex and expensive, and abundance estimate confidence limits were large. Note a back-calculation can be conducted based on average dam discharge during the smolt out-migration period to determine and estimate capture efficiency based on the decade of intensive monitoring.

- If the mark recapture program was to continue, it would be beneficial to re-evaluate the use of a PIT antenna or manual PIT scanners to detect tagged fish at the Capilano Hatchery. This will provide valuable insight and information on the survival rates of no mark/wild fish and survival rates of fish passing over the Cleveland Dam. Technology advancements have allowed PIT antennas to operate on various power sources, including AC power. The amount of maintenance could be minimal if the right equipment is selected (Instream 2008-2018 Synthesis Report, 2018).

- Suggest that in the interests of minimizing fish handling and resource requirements, utilizing the ratio of mark vs. no-mark adult returns continues to provide a reasonable proxy. Benefits of additional PIT data in improving juvenile trap and truck effectiveness are questionable.

3.4. Spillway Mortality Mitigation

- Passage of smolts via the drum gate/spillway with removal of protruding rock at the base of the spillway to provide suitable plunge depth (Ward and Associates, 2004).
    - Rock-breaking was completed in 2009; follow-up assessment was not conducted. Benefits of follow-up and further works if deemed required are questionable given the sheer drop at CLD

- Minimize reservoir spill at dam during the operations window to increase trap net capture during prime SHS migration period (Instream Annual Report, 2014).
    - New (2021) low level outlets (LLO) may offer an opportunity to utilize LLOs for some level of downstream discharge (up to a specified moderate flow threshold) with dam safety considerations taking precedence. DFO and provincial input / support required regarding downstream thermal habitat conditions. Discussed further below in section 4.0.

- Restore basin pool at base of spillway to original average depth (Pat Slaney recommendations in Lill, A., 2015).
    - A significant engineering and fisheries biology exercise would need to be conducted to determine scope of channel modification and any likely benefits of doing so. If spillway discharge can be minimized and / or a hydropower / fish passage facility is constructed, this will not likely be required.

3.5. Permanent Bypass / Collection Facility with Hydropower Installation

- Construction and operation of a west side siphon/pump system and diversion channel to collect and transport smolts migrating down the west shoreline, as well as a small open channel down the valley side, allowing conveyance of smolts in a small flow of water, which would be returned to the river at a suitable location at the bottom of the canyon from east shore (Ward and Associates, 2004).
    - Large infrastructure options will be considered in an options assessment depending on status / future of hydropower development and downstream fish passage feasibility.

- Smolt passage via Westside Helical Screw Pump and diversion channel (Ward and Associates, 2004).
    - Pending hydropower / fish passage options assessment.

- Consider advancing options for smolt collection at Cleveland Dam, both pre and post a hydropower project (Lill, A., 2015).
    - Pending hydropower / fish passage options assessment.

- Undertake a review of current storage and spillway management protocols with the objective of reducing high spill magnitudes and frequencies. This would potentially provide better utilization of the proposed hydropower project for generation and attraction flows for a possible smolt collection at the Cleveland Dam (in-house plus outside facilitation if required) (Lill, A., 2015).
    - There is potential to manage high spill magnitudes following LLO upgrades, discussed further in section 4.0 below.
    - Pending hydropower / fish passage options assessment.

- Undertake surveys and a feasibility study of potential measures to reduce mortality of smolts passing over the spillway into the plunge pool (Lill, A., 2015).
    - Pending hydropower / fish passage options assessment.

3.6. Genetics

- Take DNA from adult Steelhead stocked in the Upper Capilano River (Lill, A., 2015).
    - Capilano River Hatchery staff collect tissue samples from all Steelhead adults they capture in their fish trap, including those that are transported into the upper Capilano River. The tissue samples are not processed by hatchery staff, but held for Provincial fisheries authorities (no known process has occurred). Trout genetic analyses have been undertaken on juveniles / parr upstream of Cleveland Dam. Interestingly, documentation exists showing importation of Steelhead brood from Washington State in the 1960s.

- Sampling of DNA on adult trout to determine hybridization rate, also sample juvenile trout for DNA to provide additional information on the hybridization rate of transported fish (Instream Annual Report, 2017).
    - Two studies have been conducted, illustrating challenges in accurate field ID and significant hybridization in the smolt population and reservoir adults (also noting adult rainbow trout in reservoir indication residualization).

- Consider calibrating field identification (of Steelhead smolts) using DNA analysis every 5 years, or, if there is a changeover in field staff since the last calibration was conducted (Jackman, 2019).
    - This was last completed in 2018. Positive field identification was estimated at 90%.

3.7. Fish Handling

- Air exposure and handling of smolts with a dip net should be minimized since it can pose stress to fish and lead to scale loss. We therefore recommend using dip nets with rubberized netting material and continued use of fish ID windows (LGL Limited, 2019).
    - Nets with rubber mesh were purchased and trialed during the 2021 season, with no concerns noted.

- Transport containers (e.g. from the RST to the truck transport tank) should be covered with a dark lid and the tank itself should be of a non-transparent dark colour (LGL Limited, 2019).

- Dark lids have been made for the containers. The 20 gallon pails currently used are dark and non-transparent. Dark non-transparent five gallon pails were purchased and utilized in 2021, replacing the white five gallon pails that were previously used.

- Temperature monitoring should continue and ice should be kept onsite for particularly hot days (LGL Limited, 2019).
    - Active temperature monitoring continues. Pending consideration for use of river water and / or ice when extreme conditions necessitate (e.g. 2015). Fish handling considerations including temperature monitoring are included in GVWD's fish-handling guidance document.[4]

- To further reduce handling, it could be determined whether size ratios are directly linked to species identification and thus handling and air exposure could be avoided all together. If this length to species correlation can be established within acceptable confidence, the addition of a fish size grader could be considered to eliminate fish handling (LGL Limited, 2019).
    - Sorting by size would likely prove ineffective at reducing handling given that each size class would still have non-target fish (e.g. Cutthroat juveniles and Dolly Varden) intermixed with the target fish. Manually sorting through each size class would still be required to separate non-target and target individuals and to enumerate the target catch by species. Length distributions of larger COS and smaller SHS also overlap in distribution.

- Rubberized mesh could also be used as the bottom panel of the box to avoid abrasion when the bottom is lifted to the surface to dip fish out of the fish box into the boat holding tanks (LGL Limited, 2019).
    - When pulling up trap nets staff are instructed to not completely pull the net to the surface and avoid dewatering the fish, thereby minimizing contact with the net mesh.

3.8. Community Engagement

- Conduct 2015 workshop(s) with agency, First Nations, angler and stewardship representatives to a) review the findings and recommendations from our reports and the outcome of the 2015 radio-telemetry study and b) to discuss possible measures to improve passage of adult Steelhead to the DFO Capilano facility for Steelhead production and transport to the watershed above Cleveland Dam (Lill, A., 2015).
    - These items have been regularly discussed at the Seymour Capilano Roundtable.

[4] http://orbit.gvrd.bc.ca/orbit/llisapi.dll/app/nodes/21766367

4.0 MINIMIZING SPILLWAY DISCHARGE DURING SMOLT OUTMIGRATION

Based on a decade of study and analyses, estimated capture efficiency of the smolt out-migration has been shown to be directly correlated with CLD spillway discharge (Figure 1). Higher discharge results in a stronger attraction flow and subsequently less opportunity to capture fish prior to their out-migration over the CLD spillway. The 2021 replacement of the LLO valves marks a considerable opportunity to significantly reduce fish mortality at the CLD spillway by diverting a portion of freshet flows through the LLOs instead of over the spillway. With increased use of the LLOs, out-migrating SHS and COS are anticipated to remain confined to the reservoir, as they do not sound to depths of ~70m (the approximate depth at full pool elevation of the LLO inlets). This will provide increased opportunity to successfully capture and transport the smolts downstream around the dam. The historic spring / early summer drought of 2015, which had the lowest average spillway discharge on record, had the highest smolt capture efficiency of 48%. It is hoped that maximizing use of the LLOs during the smolt out-migration may increase capture efficiency in excess of 50%. Success of this initiative on an inter-annual basis will be dependent on freshet flows as influenced by snowpack and weather conditions.

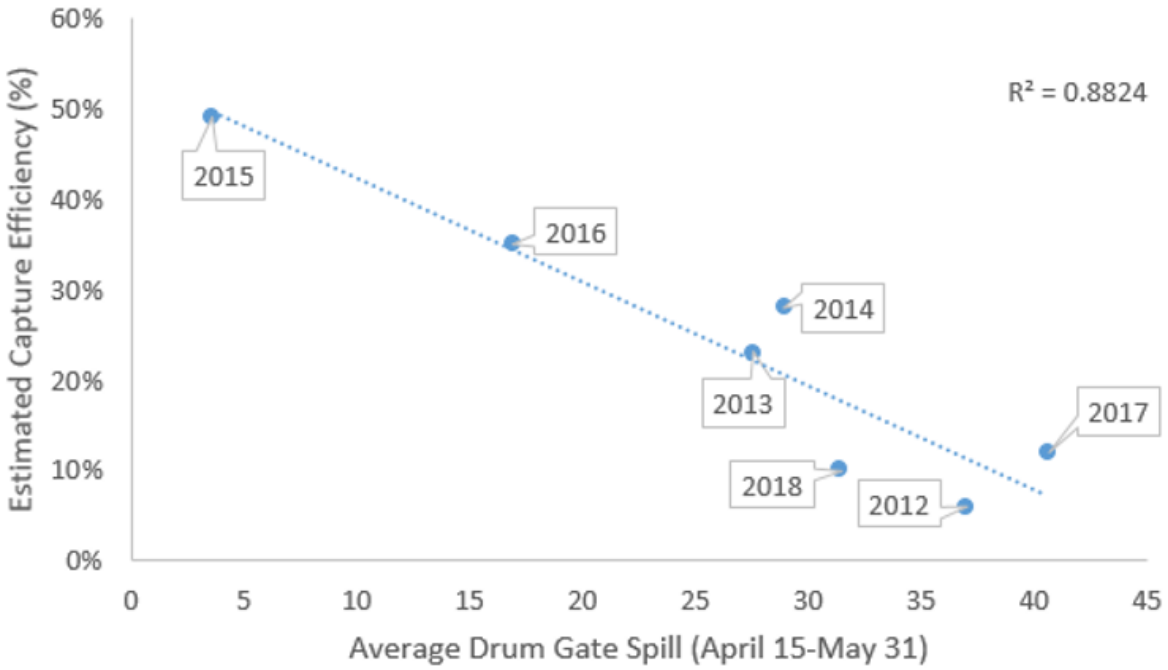

Figure 1 - Estimated smolt capture efficiency versus average Drum Gate spill (m^3/s) for April 15 - May 31.

Although there are potential thermal habitat impacts to the lower Capilano River (currently being studied and assessed – see figure 2), the superiority and relative abundance of wild fish and pristine habitat upstream of CLD and the reduction of spillway mortality is a critical consideration. First Nations, Provincial (re: Steelhead) and Fisheries and Oceans Canada support for utilizing the LLOs as the primary discharge means during the spring out-migration period is a requirement of this transition in dam operations. The transition to increased utilization of the LLOs will also require a complete engineering assessment to determine any infrastructure limitations or other considerations.

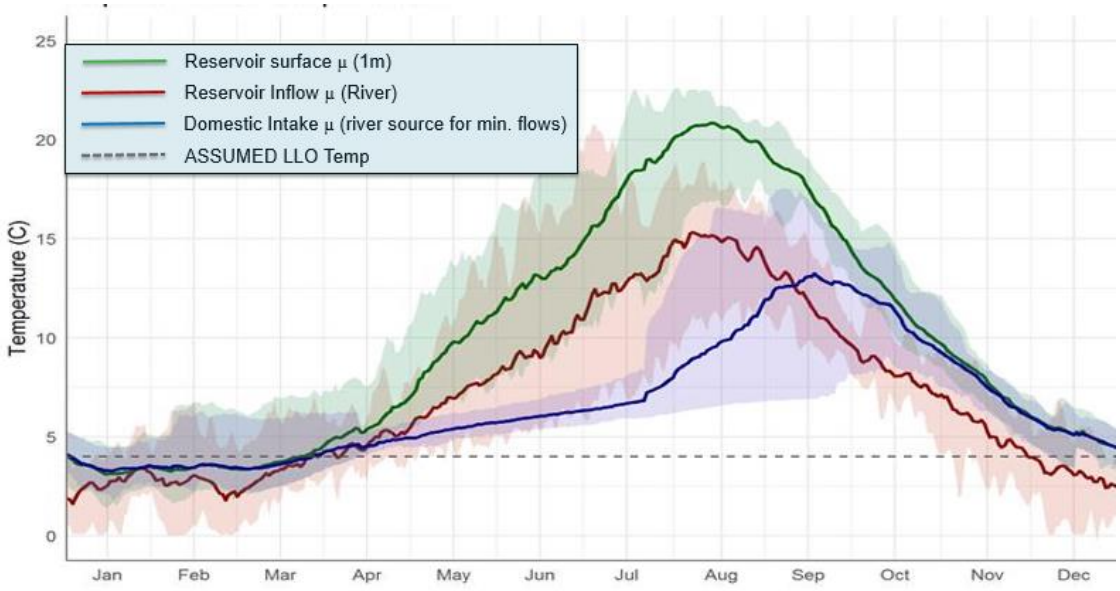

Figure 2 - temperature profile for select Capilano Reservoir elevations based on 2011 - 2020 thermister dataset.

It is anticipated that the LLOs will be able to provide for the majority of Capilano Reservoir discharge, with the exception of stormflows in excess of approximately 100 m^3/s. Albeit, a lower threshold would be required for dam safety reasons and satisfactory time to activate dam spillway infrastructure; say 50 m^3/s for sake of discussion. Figure 3 provides a 10-year flow record as it relates to the total LLO capacity.

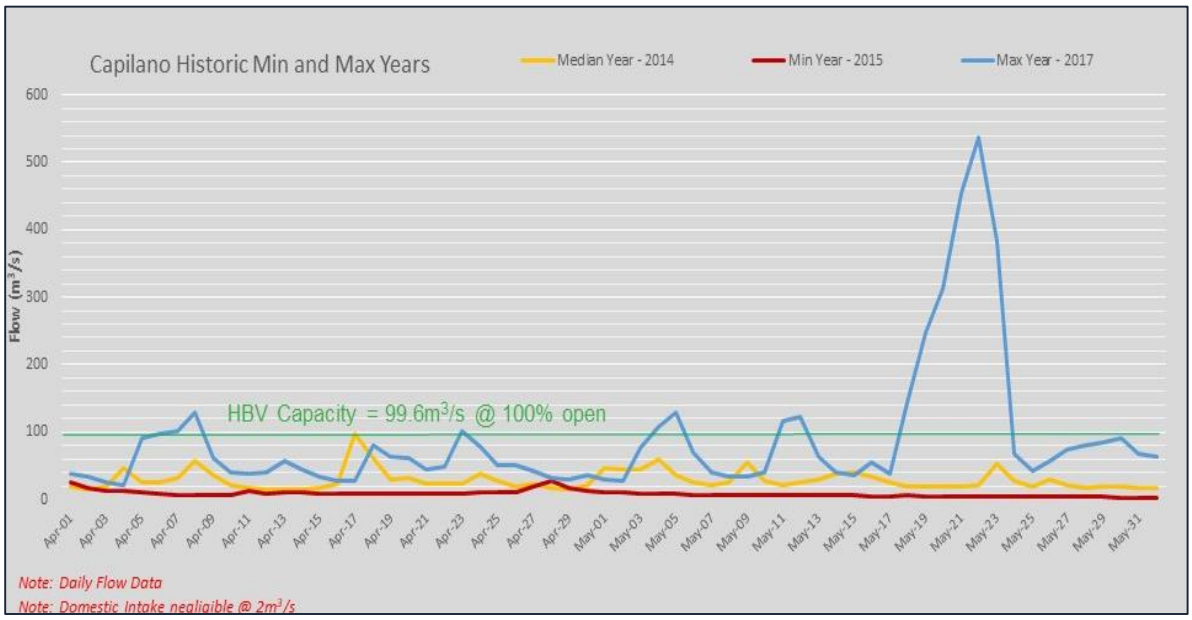

Figure 3 - Maximum, median, and minimum daily flows for period of 2010 - 2019.

5.0 ADDITIONAL RECOMMENDATIONS CONSIDERED BY GVWD STAFF

5.1. Fish counter on Cleveland Dam Spillway

Installing a fish counter on the CLD spillway will provide an opportunity to track migration of SHS and COS, and other species as they leave the Capilano Reservoir. A fish counter is operated by DFO at Cariboo Dam within Burnaby Lake Regional Park. The unit is arranged to count adult salmon returning to Burnaby Lake. Although this Dam is a fraction of the size of the CLD Drum Gate spillway, the counter may be worthy of further discussion. In 2017 GVWD staff attended the Vaki Riverwatcher workshop[5] in Burnaby, BC and discussed potential application of the Vaki Smoltwatcher placed in-line with potential smolt outmigration infrastructure.[6]

[5] https://www.aquaculturenorthamerica.com/riverwatcher-workshop-1202/
[6] https://www.youtube.com/watch?v=2gwDWI9kLrE

5.2. Permanent Fish Release Site with Fixed Infrastructure

Finding an appropriate fish release site in the Capilano River / Estuary or ocean downstream of Cleveland Dam has been an ongoing challenge. A number of factors are required to make for an ideal release site and include: ease of truck / trailer access to a river site, public safety, habitat conditions, predator aggregation and salinity. An ideal site has not been found despite utilization of virtually all readily accessible locations on the lower Capilano River and elsewhere (e.g. DFO's West Vancouver Labs). GVWD staff are currently completing releases at the north shaft location of GVWD's First Narrows watermain tunnel crossing. Fish would ideally be gradually acclimatized to receiving waters prior to release, so a shore-based tank(s) at this location is being considered, where Reservoir and estuarine water could be mixed.

5.3. Effects of transport on fish survival

There has been consistent interest in understanding whether a 'holding-period' is required or of benefit after capture or transport, and prior to release. Researchers in Oregon found that transportation of Coho juveniles by truck caused a stress response that resulted in lower survival rates to adulthood. The researchers recommended a holding period after transport to alleviate this impact (Schreck, Solazzi, Johnson, and Nickerson 1989). To date a brief holding-period of approximately 10 hours is provided on higher catch days (>1000) for fish which are captured in the morning and released the same evening, however a longer trial of up to one or a few days may be of benefit to allow fish-stress to decrease prior to release.

5.4. Fish condition after 24 - 48 hours at release site

No impacts have been observed during transport of smolts from fresh-water to the marine environment, however the concept of acclimatization to increased salinity has been reviewed. An ocean net pen may be of use to determine smolt survival 24-48 hours (or longer) after release due to the combined impacts of transport-stress and a sharp rise in salinity. This would be particularly relevant at the West Vancouver Labs site. There is less concern about release into the estuarine environment of the lower Capilano River.

5.5. Comparison of day/night releases

Both GVWD and DFO commonly release out-migrating smolts in the evening to decrease likelihood of predator aggregation and increase fish survival. Releases are ideally conducted at high-tide. A significant predator population exists at the estuary including seals, herons, seagulls, and mergansers (a UBC study found hundreds of Capilano Coho PIT tags in the Stanley Park heron rookery). These predators have been noted to have significant impacts on newly-released smolts particularly during the day. Research could be conducted to further establish whether evening-releases are of benefit to out-migrating smolts, possibly through a longer-term PIT study based on adult returns.

5.6. Inquire with Freshwater Fisheries BC (FFBC) staff regarding use of Trap Nets at Dragon Lake

GVWD staff conduct continuous improvements to trap net operations and liaise with other agencies conducting similar works. The specifics of trap net design, location, and function could be further discussed with Dragon Lake broodstock collection staff.[7,8]

6.0 ADDITIONAL RESOURCES

GVWD staff have consolidated historical, operational, and research-related articles into a single document entitled *'Capilano Fisheries History and Research Summary'*. The intent of this document is to paint the picture of the fisheries resource in Capilano since CLD construction.[9]

Further documents for review include:

FishBio. 2017. *Bumpy Ride: Challenges of Trapping and Hauling Salmon.* Retrieved from: https://fishbio.com/field-notes/the-fish-report/bumpy-ride-challenges-trapping-hauling-salmon

Keefer, M., Caudill, C., Peery, C., Lee, S. 2008. *Transporting juvenile salmonids around Dams impairs*

[7] https://orbit.gvrd.bc.ca/orbit/llisapi.dll/link/43222540
[8] https://www.youtube.com/watch?v=cJTwivCYdfw
[9] https://orbit.gvrd.bc.ca/orbit/llisapi.dll/link/48834140

adult migration. Retrieved from: https://esajournals.onlinelibrary.wiley.com/doi/full/10.1890/07-0710.1

Lusardi, L., & Moyle, R. 2017. *Two-Way Trap and Haul as a Conservation Strategy for Anadromous Salmonids*. Retrieved from https://watershed.ucdavis.edu/files/biblio/LusardiandMoyle2017.pdf

Mosser, C., Thompson, L. Strange, J. 2012. *Survival of captured and relocated adult spring-run Chinook salmon (Oncorhynchus tshawytscha) in a Sacramento River tributary after cessation of migration.* Retrieved fr**om** https://link.springer.com/article/10.1007/s10641-012-0046-x

Northwest Power and Conservation Council. 2016. *Staff Paper: Review of Fish-Passage Technologies at High Head Dams.* Retrieved from https://www.nwcouncil.org/sites/default/files/2016-14.pdf

Schreck, C.B., Solazzi, M.F., Johnson, S.l. and Nickelson, T.E., 1989. Transportation stress affects performance of Coho salmon, *Oncorhynchus kisutch. Aquaculture,* 82: 15-20. Retrieved from https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=transportation+stress+affects+performance+of+Coho+salmon&btnG=

WHOOSHH. 20201. *Fish Cradle*. Retrieved from https://www.whooshh.com/Our-Innovations/Products/Systems/Fish-Passage/fish-cradle