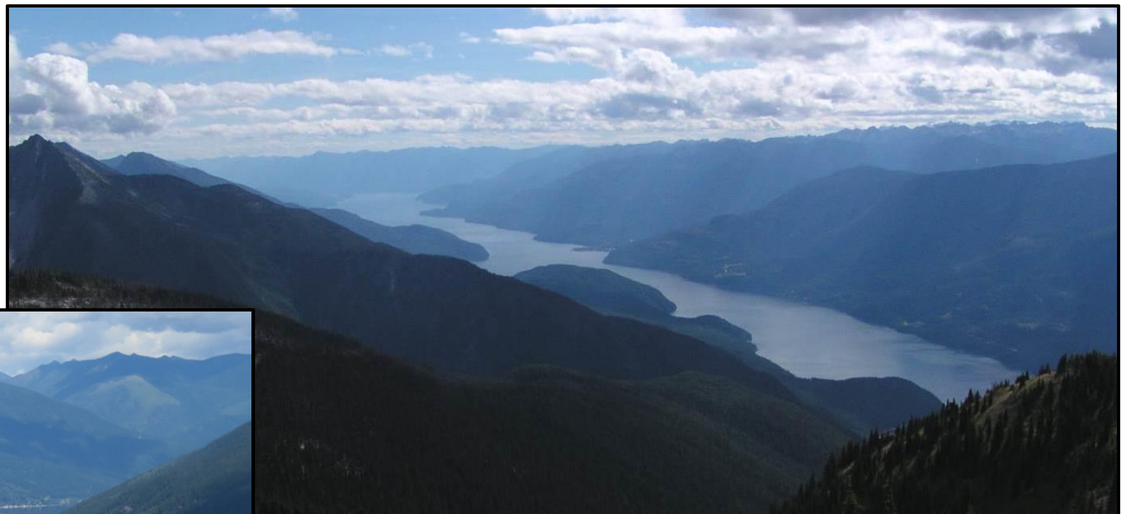
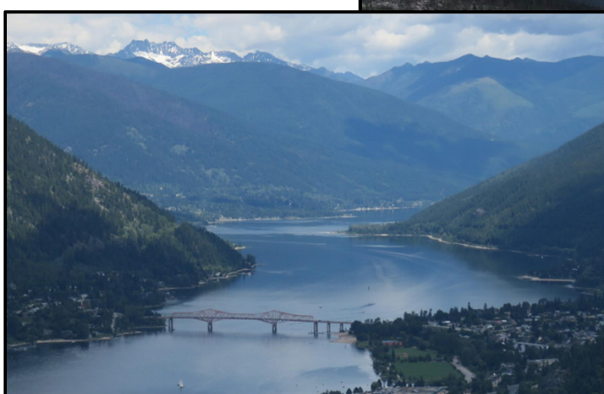
# Alterations to the Hydrology of Kootenay Lake

## A Short Chronology

G. Utzig, P.Ag.    3/9/21

**North Arm**





**West Arm**


**Creston/ Yaqan Nukiy Floodplain Pre-dam Pre-diking**

**Grohman Narrows**

**Libby**

**Duncan**

**Corra Linn**

## 1. Introduction

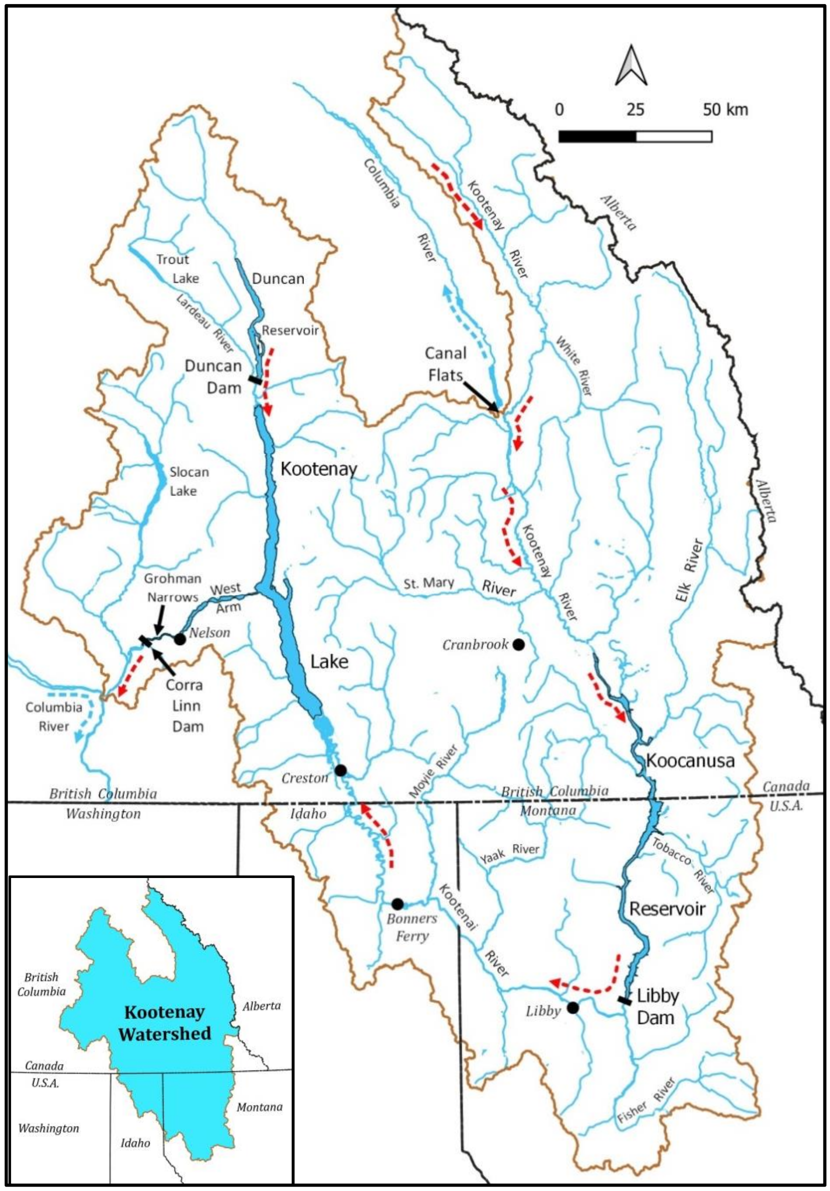



**Figure 1.** Kootenay River Watershed.

Kootenay Lake is a central feature within the Kootenay River watershed (see Fig. 1). The lake and the watershed are largely shaped by the complex geologic and glacial history of the region. Although Kootenay Lake is in the West Kootenay, the Kootenay River, the largest source of water feeding Kootenay Lake, originates in the East Kootenay, an area with a different geology, climate and vegetation. Although the lake itself and the majority of the Kootenay watershed occurs in Canada, the Kootenay River flows into the US, and then returns to Canada just before entering Kootenay Lake. This makes management of the watershed a complex international issue, with both countries simultaneously upstream and downstream. After 10,000 years of functioning as a natural intact system, the last century has seen substantial alterations to Kootenay Lake and its watershed.

Currently Kootenay Lake is held at an elevation of approximately 531 to 532 m from early August to early January. During January through March lake levels steadily decrease to reach a minimum elevation at the end of March of just over 530 m. As spring freshet begins after April 1, the lake rises steadily to about 533 m on average, but sometimes to as high as 534.5 m when there is a high snowpack and/or a wet spring. The rate of increase is variable, depending on seasonal weather patterns. After the peak, the level then decreases until early August. This seasonal pattern is a significant departure from what occurred under natural conditions. The spring and early summer peak elevations have been reduced, and the lake is now held about a metre higher than what occurred naturally during the fall and winter. Previously, on average the lake reached a peak of about 535 m and then decreased steadily to about 531 m by the end of September, dropping further to about 530.5 by January, and remaining there until the end of March. The following sections describe the anthropogenic interventions that have brought about these changes.

## 2. Pre-dam Kootenay Lake Seasonal Patterns

A 1929 submission prepared by the US Geologic Survey for the International Joint Commission (IJC 1935) stated:

> *"the flow of Kootenai[1] River follows a pronounced annual cycle of flow marked by considerable regularity. The highest waters of the year are caused by the melting of the accumulated snow in the high mountains. Usually the river becomes very low during the winter, but as spring approaches the accessions from the thawing snow cause it to rise more or less gradually, beginning in April, until the maximum flow is reached, generally in late May, or June, the exact time depending upon the cumulative influence of weather conditions. Thereafter the general trend of the flow is to become steadily less until the end of the summer, when low-water conditions are again reached, to continue with relatively minor fluctuations until the following spring."*

This pretty much describes the seasonal cycle of Kootenay Lake prior to diking, dredging and dam construction. Kootenay Lake had an average annual variation of 4.9 - 5.8 m, but in extreme years it could reach 9.75 m (IJC 1935). The highest flood year "on record" appears to have been 1894 (main lake elevation ~539.12 m; at Nelson[2] 538.74 m), with 1903 being the second (main lake ~537.12 m, 536.73 m at Nelson), and 1961 being third (537.03 m at Queens Bay). For comparison, it is estimated that the flood level in 2012 would have been ~536.64 m without the present dams (Ketchum 2013). In 1948, a major flood year on the lower Columbia River, Kootenay Lake reached 536.68 (with Corra Linn dam and dredging). Average and range of lake levels[3] from 1913 to 1938 are shown in Figure 2 below.

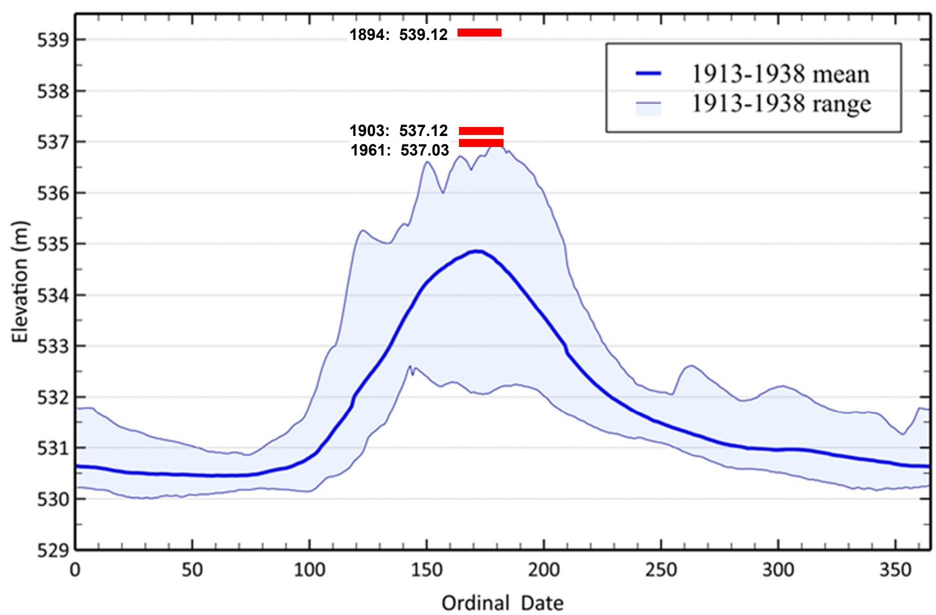



**Figure 2.** Pre-dam Kootenay Lake levels (1913-38); dark blue line mean, light blue range of values (data from ECCC 2021). Other flood levels also shown for comparison.

---

[1] In the US it is ñKootenaiò, in Canada it is ñKootenayò

[2] The main body of Kootenay Lake is ~0.385 m above the elevation at Nelson during flood stage due to the gradient in the West Arm.

[3] Lake levels are taken from ECCC data: Nelson 1913-24; Kaslo 1929-32; Proctor 1923-34; Queens Bay 1932-2019; overlapping years and interpolation were used to fill missing data; Nelson data seasonally adjusted based on correlation of overlapping data.

## 3. Early Attempts to Decrease Kootenay Lake Flood Levels and Improve Potential Agricultural Lands

In the late 1800s, W.A. Baillie-Grohman visited the Kootenays on a hunting expedition, and became interested in creating agricultural land out of the extensive wetlands at the south end of Kootenay Lake – the Creston flats. His plan had two main components, mainly focused on reducing flooding from Kootenay Lake and the upper Kootenay River. The first component was to divert a portion of the upper Kootenay River into the upper Columbia River at Canal Flats, and the second was to deepen the outlet of Kootenay Lake at Grohman Narrows (see Fig. 1). Diking in the Creston area may have also been considered for full achievement of his agricultural objectives. In 1887, in return for Baillie-Grohman's proposed works and investments, the government of the day granted him concessions for the potential agricultural lands on the Creston flats (up to ~12,150 ha). The Canal Flats diversion ditch was completed, but was soon forced to be abandoned primarily due to political pressure by the Canadian Pacific Railway, who was concerned about downstream flooding and erosion impacts to its rail line along the Columbia River. Baillie-Grohman also initiated some dredging in Grohman Narrows, but this was also abandoned due to nervous investors withdrawing support.

After Baillie-Grohman left BC in 1898, disgusted and defeated, other parties attempted to revive various aspects of the project to create agricultural developments on the Creston flats. In the early 1890s work began on diking to drain potential agricultural lands in the vicinity of where Boundary Creek entered the Creston flats. In 1905 and 1912, two engineering reports recommended that a combination of Grohman Narrows dredging, diking and channelizing tributary streams on the Creston flats would be the most effective means of developing the agricultural lands.

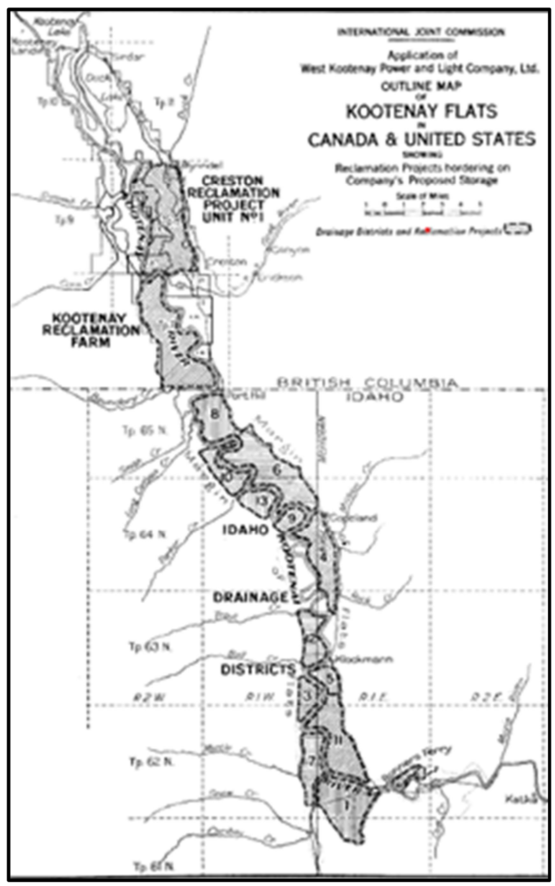



**Figure 3**. Diking projects in the Creston-Bonners Ferry area (IJC 1935).

Meanwhile in 1915 similar studies were being conducted by the US Department of Agriculture regarding potential agricultural lands near Bonners Ferry on the US side of the border, with similar conclusions, although they still recommended the Kootenay Diversion at Canal Flats. A major flood in 1916 created increased pressure to find a solution. Further studies commissioned by the State of Idaho and the BC Government in 1921 and 1922 provided more detailed analyses of dredging Grohman Narrows, and potential diking and channel modification in the Creston-Bonners Ferry area. Meanwhile extensive lands in Idaho had already been diked, and were providing profitable agricultural production – even if they were flooded in extreme years (see Fig. 3 - Idaho Drainage Districts).

In 1927, application was made to the IJC to do significant diking in the Creston flats area, and in 1928 the IJC issued an Order allowing the channelization of the Goat River and diking of a major portion of the Creston flats (see Fig. 3 – Creston Reclamation Project). In 1933, following flood damage and the bankruptcy of previous owners, the IJC approved repairs to the previous diking in the vicinity of Boundary Creek that included about 3100 ha of developed agricultural lands (see Fig 3 - Kootenay Reclamation Farm). At the hearings there was extensive discussion of how diking increased river and lake levels to the detriment of their intended purpose of reducing flood risk.

Until the 1930s, anthropogenic changes to the various parts of the Kootenay River system had limited effects on the seasonal levels of Kootenay Lake compared to those in the coming decades. The changes had consisted of various run-of–the-river hydro-electric installations on tributary streams (e.g., Kaslo, Bull River, Bonners Ferry, Cottonwood); minor dredging and blasting by Baillie-Grohman in 1890 (~13,800 m$^3$); and diking on the Kootenay River floodplain between Creston and Bonners Ferry. The diking likely increased lake levels during the freshet and decreased levels during late summer, while the dredging at least partially offset those increases, and further decreased minimum levels.  The pre-dam baseline lake levels shown in Figure 2 are the best approximation of the natural hydrology of the lake that exist, although the short period of record does not include a full range of extremes (e.g., the floods of 1894 and 1903, and potentially larger earlier ones), and it does include the effects of early diking and dredging described above.

## 4. Grohman Narrows and the Granite and Corra Linn Dams

Meanwhile, in 1929, West Kootenay Power and Light Company Ltd. (WKPL, now FortisBC) made application to the IJC to dredge Grohman Narrows and construct a dam at Granite, just downstream from Grohman Narrows, to facilitate using Kootenay Lake for increased storage for its dams downstream on the lower Kootenay River (see Figs. 1 and 4). WKPL had already received approval for the Granite Dam, with conditions, from the provincial and Federal governments. At the request of the Government of Idaho and diking districts in Idaho, the IJC put off a decision on the Granite Dam to allow for further studies of its potential impacts.

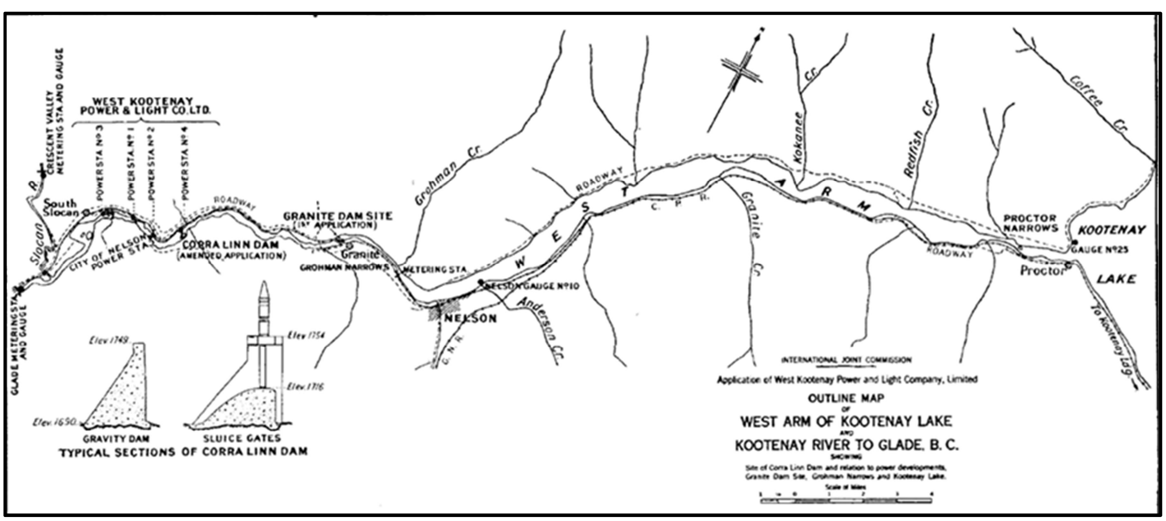



**Figure 4.** West Arm of Kootenay Lake and Lower Kootenay River (IJC 1935).

In 1931 WKPL submitted an amended application, dropping the plans to build the Granite Dam and instead making a request to control Kootenay Lake levels for storage via the Corra Linn dam further downstream. The proposal was to keep Kootenay Lake at a higher elevation during the late summer and winter, and then have it decline to the minimum by April 1 (similar to what is presently required). The amended proposal still included the dredging of Grohman Narrows (~191,000 $m^3$). WKPL argued that if dredging was to alleviate flooding, it would require a dam to control low water levels, and now Corra Linn filled that role. In subsequent presentations WKPL also pointed out this would reduce flooding and benefit agricultural interests between Creston and Bonners Ferry, and the storage would benefit US hydroelectric dams downstream on the Columbia River. Around that time the US was constructing a dam at Rock Island and drawing up plans for the Grand Coulee dam.


**Figure 5**. Dredging Grohman Narrows (Pearkes 2013 – Touchstones Nelson Archives ).

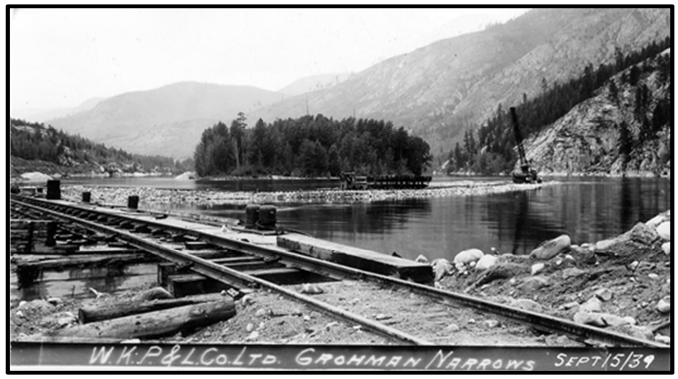



**Figure 6**. Rail line constructed to move Grohman Narrows dredging material (Pearkes 2013 – Touchstones Nelson Archives ).


**Figure 7**. Dredging spoil piles at the mouth of Grohman Creek (Pearkes 2013 – Touchstones Nelson Archives ).

The Corra Linn Dam had been constructed over the previous few years, and was built with the capability to maintain Kootenay Lake at higher water levels than those that would occur naturally. However, until rights were granted to control Kootenay Lake it was being operated as a run-of-the-river facility, limiting its storage to the area downstream of the Granite site and Grohman Narrows. It had been built quickly to supply power to the Consolidated Mining and Smelting Company (i.e. formerly Cominco, now Teck) for their new fertilizer plant in Trail. The plant utilized sulfur emissions and thereby reduced cross-border sulfur pollution, which was another international issue at the time. WKPL had also dredged and blasted six areas downstream of Grohman Narrows to facilitate better flows to the Corra Linn dam during low water periods, removing over 535,000 $m^3$ of rock, gravel and boulders.

The State of Idaho and the diking districts of Idaho and BC strongly opposed WKPL plans for water storage in Kootenay Lake, being concerned it would increase risk of further erosion and flooding. The State of Idaho actually filed an official complaint to the IJC against WKPL for constructing Corra Linn without authorization. However, during the IJC hearings, WKPL made the point that the diking districts had in fact increased their own risk of flooding. WKPL provided calculations that the diking in BC and Idaho portions of the Creston-Bonners Ferry flats had likely increased Kootenay Lake flood levels by about 0.36 m by reducing the natural storage on the floodplain. They also stated that diking likely decreased minimum lake levels due the lack of slow release from storage previously provided by the un-diked wetlands. The US Geological Survey and the US Army Corps of Engineers in general agreed with the information provided by WKPL, and recognized the potential benefits of the WKPL proposal.

In 1934, based on further objections by certain agricultural interests, WKPL withdrew their application for the dredging and water storage. Subsequently, other agricultural interests from both Canada and the US petitioned WKPL to revive the application, which they did in 1938. After hearings in Bonners Ferry, Creston and Nelson the IJC issued an Order allowing WKPL to proceed with the dredging and control of Kootenay Lake, as outlined in the Order.

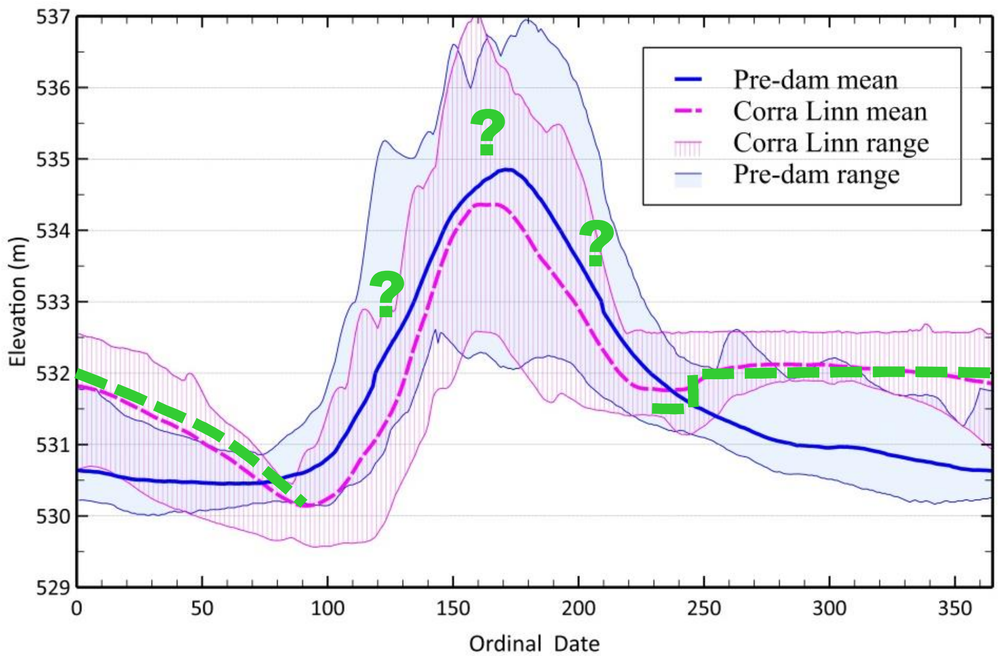



**Figure 8.** Kootenay Lake levels following Grohman Narrows dredging and the Corra Linn Dam storage implementation (1939-67, magenta; all data from ECCC 2021). IJC Order requirements shown in green.

The Order requires Kootenay Lake to remain below 531.97 m from September 1 to January 7 (see Fig. 8). Following January 7 the lake level must drop to 531.57 m by February 1, to 531.06 by March 1, and 530.14 by April 1. During the freshet the lake is controlled by outflows at Grohman Narrows, and rises as necessary, depending on inflows. As the freshet recedes, and if the lake drops to 531.36, the lake is held below that elevation until September 1 (IJC 1938).

The dredging of Grohman Narrows (see Figs. 5-7) and the new management of Kootenay Lake outflows had a significant impact on the seasonal levels of Kootenay Lake. As shown in Figure 8, on average, the dredging lowered the lake level in the early spring (~day 90, April 1), and significantly increased fall, winter and spring levels (~day 250 to 80, Sept 1 to March 20). The dredging also allowed faster evacuation of flood waters, which resulted in a slight reduction in the mean peak levels of about 0.5 m (~day 150-180 May 30 to June 29). However, extreme flood events still occurred as indicated by the peaks to ~537m in 1948 and 1961.  The timing of peak levels also became earlier, but it is unclear if this was a result of the new management regime, climate change or natural variability.

## 5. The Columbia River Treaty – Duncan and Libby Dams

After discussions that began in the 1940s, negotiations throughout 1960, and a signing in 1961, Canada and the US ratified the Columbia River Treaty in 1964. This agreement was to have profound effects on Kootenay Lake. The Treaty specified that a water storage dam was to be built on the Duncan River, the second largest inflow into Kootenay Lake. The dam was to be located approximately 9 km upstream of the north end of Kootenay Lake (see Fig. 1). The Treaty also

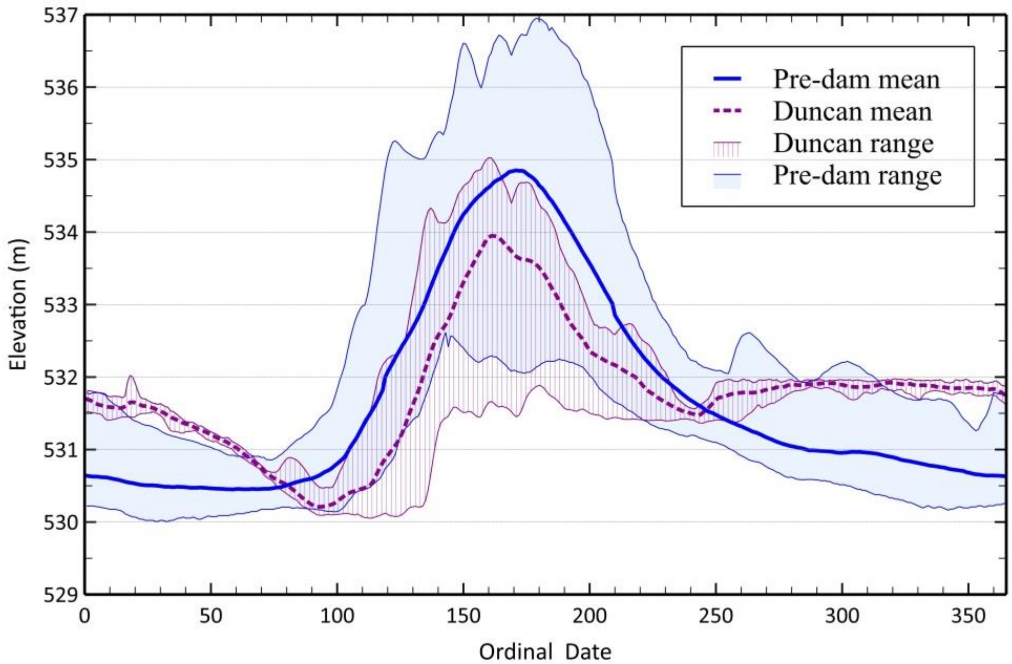



**Figure 9.** Kootenay Lake levels following construction of the Duncan Dam, but before Libby (1968-74, dark magenta); includes the impact of Corra Linn Dam as well (all data from ECCC 2021).

granted permission for the US to build a dam on the Kootenay River near Libby Montana, the largest source of inflow to Kootenay Lake (see Fig. 1). This dam would flood the Upper Kootenay River and extensive lands in both the US, and the southern Rocky Mountain Trench of Canada. In addition to providing flood protection, these dams also enabled the construction of the Kootenay Canal project on the lower Kootenay River, and provided for increased power production on all downstream Kootenay and Columbia hydroelectric installations.

The Duncan Dam was completed in 1967, and is managed to store spring runoff from snowmelt in the Duncan River watershed, reducing flood risk downstream (storage of 1.4m acre-feet - 1.7 $km^3$). The water is then released slowly over fall and winter, thereby maximizing hydroelectric production downstream as well. As shown in Figure 9 above, the addition of the Duncan Dam has further reduced the average peak in Kootenay Lake by about 0.41 m, and increased the occurrence of low summer levels. Coordinated management with the Corra Linn Dam still maintains levels for the remaining portion of the year consistent with the IJC order. Note that the variability shown in Figure 9 is limited due to the shortness of the record (only 7 years until Libby Dam was added).

In 1975 the Libby Dam was installed on the US portion of the Kootenai River upstream from the south arm of Kootenay Lake. The dam has a storage capacity of just over 6m acre-feet (7.4 $km^3$), significantly larger than Duncan or the Corra Linn dams. Libby was originally managed solely for flood control and maximizing hydroelectric production; however, subsequently flows have been modified to limit impacts on fisheries. As shown in Figure 10, operations have evolved over time, and have had a profound effect on water levels in Kootenay Lake, reducing average peak levels by almost two metres in the early years of operation (somewhat less with current operations). Coordinated operations of the Libby, Duncan, and Corra Linn still generally maintain the directives included in the 1938 IJC Order, although IJC directives do not specifically apply to operations of the the CRT dams.

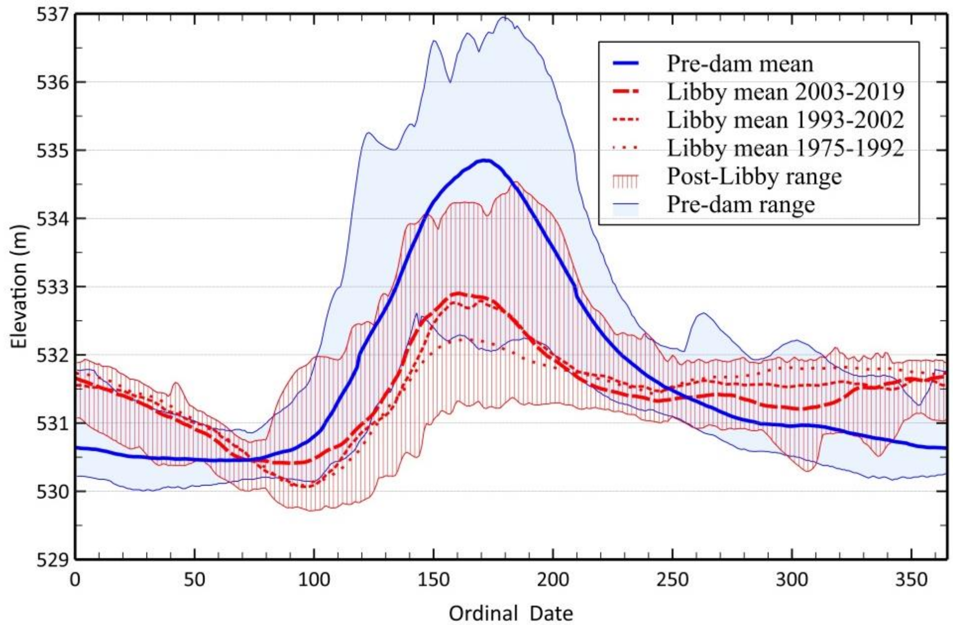



**Figure 10.** Kootenay Lake levels following construction of the Libby Dam (1975-2019, red); early flood control Libby (1975-1992); flood control and fish (1993-2002); sturgeon releases and VARQ (2003-2019); includes the impact of Corra Linn and Duncan as well (all data from ECCC 2021).

In 1993, "Standard Flood Control" management at Libby was modified to improve flows for downstream fisheries (USACE 2006), resulting in increased peak levels in Kootenay Lake. White Sturgeon that occur in Kootenay Lake and the Kootenai River downstream of the Libby Dam have not successfully reproduced since the dam's construction (USFW 2019). Subsequently, under Endangered Species Legislation in the US, spring releases of water from the Libby Dam were increased in an attempt to improve spawning success in the Kootenai River down-stream of the dam (see Fig. 11). In 2003 further changes to balance flood control and fisheries objectives ("VARQ"

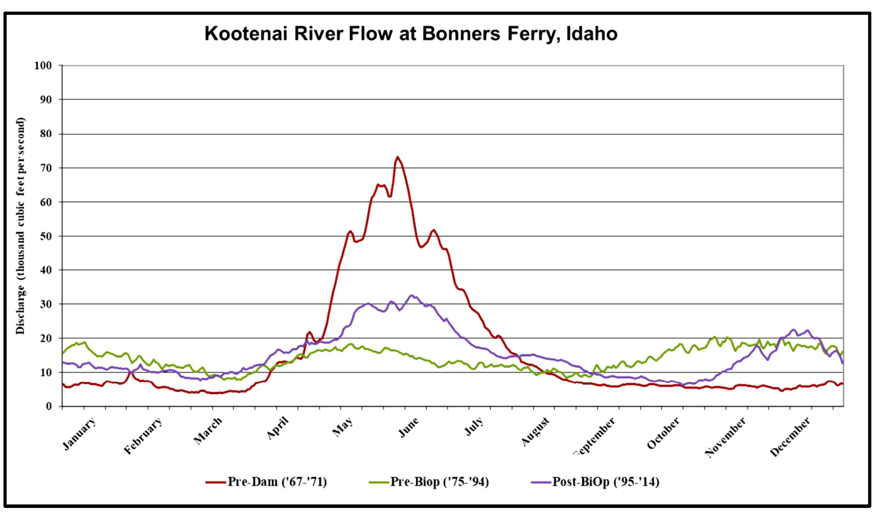



**Figure 11.** Average Kootenai River flows at Bonners Ferry (USFW 2019).

management) have resulted in further slight increases in peak levels in Kootenay Lake, and made it more difficult to meet the spring drawdown directive from the IJC. Figure 10 shows the progression of the various phases of Libby Dam management. Although they are not visible in the graphs, there have also been experiments with slightly lowering the level of Kootenay Lake in the fall, to encourage shore-spawning kokanee to spawn at lower elevations, and minimize de-watering of redds in the spring (Thorley 2019).

## 6. Current Seasonal Patterns

The current seasonal pattern for Kootenay Lake generally follows the IJC Order of 1938, although it is further modified by the operations of Duncan and Libby Dams. Duncan Reservoir begins the year in January emptying into Kootenay Lake, reaching a minimum level in late April. From May until a peak in late July or August it retains Duncan River flows, reducing Kootenay Lake peak levels. For the rest of fall and winter it empties and contributes to maintaining Kootenay Lake above its pre-dam level. Libby dam maintains a similar annual cycle, with the exception of sturgeon releases in May or June. Corra Linn Dam generally maintains Kootenay Lake levels between about 531 and 532 m during the fall and winter. The upstream dam patterns maximize winter flows into the hydroelectric generating stations on the lower Kootenay River, and downstream on the Columbia.

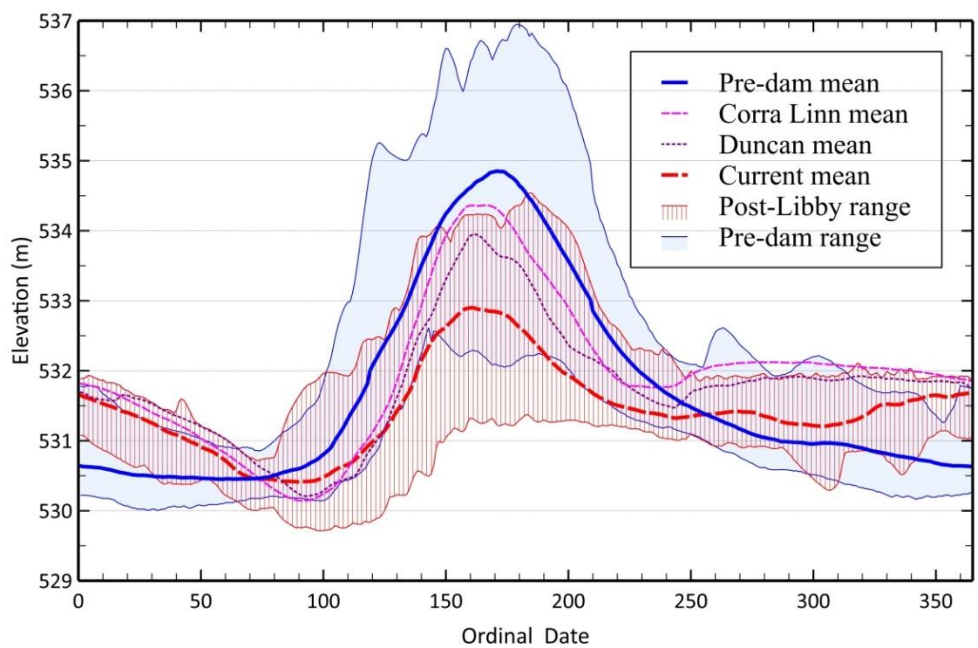



**Figure 12.** Kootenay Lake levels comparing the additive effects of diking in the Creston-Bonners Ferry floodplain, Grohman Narrows dredging and the Corra Linn Dam (1939), and subsequent construction of the Duncan and Libby Dams (1967 and 1975). The current mean includes data from 2003 to 2019 (all data from ECCC 2021) .

In mid-January Corra Linn begins to gradually lower Kootenay Lake levels until it reaches approximately 530 m on or about March 31st. This is accomplished by decreasing water levels between Grohman Narrows and the Corra Linn dam, such that Grohman Narrows becomes the control point for the lake. As the freshet flows increase, Grohman Narrows interacting with the flow rate determines the level to which Kootenay Lake will rise. As the freshet subsides in June or early July, Corra Linn eventually re-assumes control, and the lake level is held at the fall and winter range described above. Figure 12 illustrates the changes in Kootenay Lake seasonal patterns over time as the various dams have been added. The dashed red line approximates the current average levels. After exceptionally high water in 2012, BC Hydro investigated the possibility of further dredging at Grohman Narrows. Due to public opposition and a questionable cost/ benefit ratio, the proposal was abandoned in 2015 (BC Hydro 2015)

The combination of dams has not only affected seasonal water levels in Kootenay Lake and flows in the Kootenay and Duncan Rivers downstream of the dams, but the dams have also impacted fish passage. They have had profound impacts on the food web in Kootenay Lake by reducing sediment and nutrient inputs and by altering temperature regimes, the footprint of the lake during the growing season and seasonal flows within the West Arm.

There have been numerous other chemical and biological alterations that have impacted the lake environment, but they are beyond the scope of this report. These include things such as past fertilizer plant pollution, lake fertilization, introduction of alien species, sediment impacts on water clarity and primary production, destabilization of tributaries due to climate disruption and development activities, loss of riparian and foreshore habitats, and declining fish populations among others. This report has only focused on physical works that have altered flows in and out of Kootenay Lake. A more comprehensive assessment is needed to better understand lake functioning and improve lake management in the future.

## 7. References

BC Hydro. 2015. Grohman Narrows Channel Improvement Project Update – October 2015.

Environment and Climate Change Canada (ECCC). 2021. Historical Hydrometric Data - various Kootenay Lake stations: Queens Bay (08NH064), Procter (08NH067), Nelson (08NJ009), Kaslo (08NH024). Data for Nelson gauge was adjusted for the elevation gradient on the West Arm. Available at: https://wateroffice.ec.gc.ca/search/historical_e.html

International Joint Commission (IJC). 1935. A Report on certain cases involving reclamation and the development of water power in the valley of the Kootenay River, under the terms of Article IV of the Treaty of January 11, 1909. Ottawa and Washington DC. 375pp. Available at: https://legacyfiles.ijc.org/publications/ID207.pdf

International Joint Commission (IJC). 1938. 1938 Kootenay Lake Order. Available at: https://ijc.org/en/klbc/1938-kootenay-lake-order

Ketchum, K. 2013. Columbia/Kootenay flood control 3/22/13 – PowerPoint slides. BC Hydro.

Pearkes, E. Delehanty. 2013. Grohman Narrows: A Historical, Cultural and Ecological Review. Report prepared for B.C. Hydro. 12pp.

Thorley, J.L. 2019. West Arm Kokanee Shore Spawning 2019: The Percentage of Dewatered Redds of Shoal Spawning Kokanee (Oncorhynchus nerka) in the West Arm of Kootenay Lake under Historical, Current and Alternative Operations. A Poisson Consulting report prepared for FortisBC, Castlegar, BC.

US Army Corps of Engineers, Seattle District. (2006). Upper Columbia Alternative Flood Control and Fish Operations, Columbia River Basin, Final Environmental Impact Statement. Available at: https://www.usbr.gov/pn/fcrps/documents/ucaaltflood.pdf

U.S. Fish and Wildlife Service (USFW). 2019. Revised Recovery Plan for the Kootenai River Distinct Population Segment of the White Sturgeon. U.S. Fish and Wildlife Service, Portland, Oregon. vi + 35 pp. Available at: https://www.fws.gov/pacific/ecoservices/endangered/recovery/plans.html