Executive Summary – full report can be found at this link:

Laird, K.R., Boyle, J., Moyle, M., Cumming, B.F., 2025. Diatom and sedimentary phosphorus analyses for the Kootenay Lake nutrient loading paleolimnological assessment. Report to B.C. Hydro, May 2025. https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/environment-sustainability/water-use-planning/southern-interior/ddmworks-3-2025-diatom-and-phosphorus-analyses-2025-05-01.pdf

Kootenay Lake is a long, deep and large lake (length > 100km, max depth = 150 m, surface area = 395 km2) in the Upper Columbia River. It's known for its spectacular beauty and important fisheries: kokanee (*Oncorhynchus nerka*), Gerrard rainbow trout (*Oncorhynchus mykiss*) and bull trout (*Salvelinus confluentus*). To understand the impact of watershed disturbances starting in the early 1800s on the lake ecosystem and in particular the nutrient dynamics that influence the fisheries an abundance of research has been undertaken. However, most of this research occurred after the construction of Duncan Dam in 1965-1967 and not consistently until the 1990s when the fertilization program on Kootenay Lake began.

In this report we use paleolimnological data to address potential changes in nutrient retention, sedimentary P dynamics and primary production through diatom analyses to assess changes since the major dams have been constructed, particularly Duncan Dam. The paleolimnological focus provides a means to fill the gap of limited pre-and post-dam data. A detailed assessment of pre- and post-water use plan (WUP) implemented in 2008 was also carried out to assess whether there were measurable changes in nutrient retention and primary production in Duncan Lake Reservoir, and any downstream influences of the WUP on the North Arm of Kootenay Lake.

Results in this report are from the paleolimnological analyses of diatoms and sedimentary phosphorus from Duncan Reservoir, the North and South Arms of Kootenay Lake, and the reference Trout Lake on two-time frames: 1) post ca. 1990 (pre-and post- WUP), and 2) pre- and post- Duncan Dam construction. Trout Lake was chosen as a reference site which can help account for regional influences on lakes, including factors such as climate, while the South Arm of Kootenay Lake can provide reference to differential local factors between the basins. Trout Lake serves as a relatively large non-dammed system in the same biogeoclimatic region.

Anthropogenic disturbance of the Kootenay Lake watershed includes mining (mid 1800s to early 1900s, peaking in the 1920s-1930s), agriculture and forestry influences (minor in the mid 1800s to early 1900s, which intensified by the 1950s). By the 1950s large inputs of nutrients into the lake were occurring with the opening of the Cominco phosphorus fertilizer plant in 1953. Phosphorus inputs from the fertilizer plant doubled and tripled in the 1960s, declining by the late 1960s to mid 1970s with P treatment requirements until the shutdown of Cominco plant in the late 1970s. The construction of dams altered the hydrologic flow into and

out of Kootenay Lake resulting in a dampened spring freshet and higher winter flow. Dam construction on the outflow occurred in 1932 with the Corra Linn Dam (not used for storage and flood control until 1939) and on the inflows in 1967 (Duncan Dam, northern inflow) and Libby Dam (1972, southern inflow) for flood control.

Following the creation of Duncan Reservoir in 1967 estimates of both diatom-inferred total phosphorus (DI-TP) and sediment-inferred lake-water TP (SI-TP) significantly increased in Duncan Lake/Reservoir. By 1965-1975, DI-TP ~ doubled from ~ 8 µg/L to peaks of ~15 µg/L. The increase in SI-TP concentration following construction of the dam is consistent with enhanced retention in the newly formed Duncan Reservoir. The highest peaks in SI-TP occur in the 1980s, whereas DI-TP declined by this time. Post ca. 2000, SI-TP declined. The reduction of SI-TP post 2000 in comparison to models of inferred TP is consistent with a reduction of external loading. The reduction of loading is thought to be related to a decline in the supply of phosphorus (P) from the flooding of the riparian and terrestrial regions (i.e., the inundation zone) lessening over time.

The trends in DI-TP in the two cores from the North Arm of Kootenay Lake closely follow the known major influences on the nutrient status of the lake: dam construction (Corra Linn, Duncan and Libby dams), Cominco fertilizer plant (1953-late 1970s) and the fertilization program (Nutrient Restoration Program starting in 1992). Peaks in SI-TP occur at similar time to the peaks in DI-TP and are significantly related to each other in both cores from the North Arm of Kootenay Lake. An initial rise in DI-TP begins in the late 1930s, coincident with Corra Linn Dam being used for flood control and the rise of Kootenay Lake by ~2 m. Watershed disturbance from mining, logging and rising human population was also intensifying at this time. By the 1940s the lake DI-TP had more than doubled to mesotrophic conditions (DI-TP > 20 µg/L) from the pre-1930 oligotrophic conditions (DI-TP ~6-7 µg/L). By the 1960s and 1970s the lake became eutrophic (DI-TP > 30 µg/L) with peaks as great as ~70-75 µg/L in the North Arm by the late 1970s. The eutrophication of Kootenay Lake corresponds to the huge inflows of readily bioavailable P from the Cominco fertilizer plant via the Kootenay River into the South Arm. The Duncan Dam (1967) and Libby Dam (1972) were constructed during this eutrophication period. Determining the extent of P retention behind the dams on lake-water TP is difficult due to continued release of P from the fertilizer plant.