SELENIUM FAQ

Elk River Alliance
2022

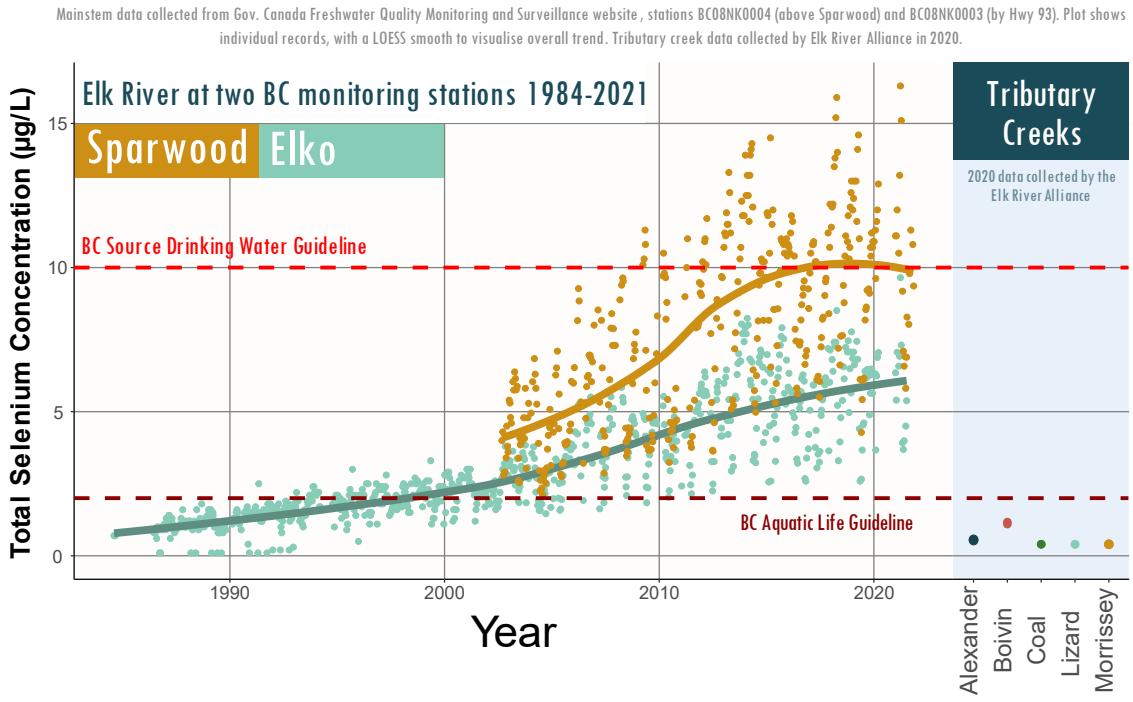
ERA disclaimer: debate over what threshold concentration of selenium results in a negative effect on fish is ongoing. Numbers reported in lab experiments or in specific areas are hard to extrapolate to natural real-world conditions. The information below has been compiled by ERA staff and reviewed by experts in the field of ecotoxicology. However, ERA is not an authority on selenium, and research and debate continues.

What is selenium?

Selenium (Se) is an element naturally found in the environment and, in small amounts, it is necessary for plant and animal life. Selenium concentrations can increase above natural levels due to human activities such as mining, agriculture (feed additives, fertilizers, pesticides), petrochemical refining, and wastewater discharge. In the Elk Valley, metallurgical coal mining is responsible for high selenium levels in the Elk River and affected tributary streams. Excess selenium is released when waste rock from metallurgical coal mines comes into contact with air and water, creating a soluble form of selenium which is released to tributaries and the Elk River via surface runoff and groundwater flow. Excessively high selenium concentrations can cause birth defects in fish and birds, and at sufficient levels they can impact human welfare.

SELENIUM AND THE ELK RIVER

How much Selenium is in the Elk River?



The graph above shows Elk River selenium concentrations since 1984 from two BC government monitoring sites, one by Elko (teal) and one by Sparwood (orange). Additionally, it shows selenium concentrations collected by ERA in 2020 from non-mine-affected tributary streams (blue shading).

According to these data, the average selenium concentration in the Elk River is about **5 µg/L by Elko**, and **10 µg/L by Sparwood.** In contrast, ERA found that **non-mine-affected tributary creeks** in the Elk Valley have an average selenium concentration of **0.4 µg/L**, indicating that **Elk River mainstem selenium concentrations are on average 12-25 times higher than natural levels**.

Over the last few years, the **rate** of selenium increase shows some signs of slowing down at the Sparwood monitoring site (orange line) but not at the Elk River outflow into Lake Koocanusa by Elko (teal line). The actual concentrations of selenium are not yet decreasing at either location. On average, selenium levels have increased by more than 4 times in the Elk River between the first and last decades of recording. Moreover, some streams closer to mine sites show higher selenium levels: for example, close to the Fording River mine a Compliance Test Point monitored by Teck (Site FR_FRCP1), had concentrations of selenium reach **674 µg/L** in 2020 (Teck 2020 FRO LAEMP). Selenium concentrations in the Elk River have not been below the BC Aquatic Life Guideline levels* (which are designed to protect all aquatic life, including the most sensitive species) since 2009, and frequently exceed the BC Source Drinking Water Guidelines at the Sparwood monitoring site.

***Note:** Water quality guidelines, such as the ones for aquatic health and drinking water, are not based on levels where adverse impacts on health have been reported. They are used as a signal threshold at which monitoring and mitigation strategies should be implemented to decrease the risk of adverse effects on aquatic life or human health.

SELENIUM AND HUMAN HEALTH

Does Elk River Selenium pose a human risk for swimming?

Mammals, including humans, are far less sensitive to selenium compared to fish or other organisms (such as birds) which feed on aquatic plants and insects. Most of the selenium intake in humans comes from diet and dietary supplements and is not absorbed through the skin. According to the BC Ministry of Environment's Ambient Water Quality Guidelines for Selenium Technical Report Update (2014, pg. 93, section 7.1.1.1) "Selenium compounds are not easily absorbed through the skin; there is little information concerning systemic effects of dermal exposure to Se compounds in humans". Because selenium is not easily absorbed through the skin, **it is highly unlikely that swimming in the Elk River would cause negative effects**.

Does Elk River Selenium pose a human risk for drinking water?

*BC Source Drinking Water guideline levels for selenium are **10 µg/L***
*Health Canada's Guidelines for Canadian Drinking Water Quality **50 µg/L***

Currently, the Elk River selenium concentrations by the Sparwood monitoring site frequently exceed the BC drinking water guideline—however, serious effects from drinking the water are

unlikely. According to the Government of Canada, the adult *recommended* daily intake of selenium is 45 µg, with the Tolerable Upper Intake Level (highest levels where adults are unlikely to experience adverse effects) being 400 µg (see link). At current average Sparwood concentrations in the Elk River (~10 µg/L) an adult would need to drink 4 liters of river water to reach their recommended intake and 40 liters to exceed the Tolerable Upper Intake Level. So far, selenium levels in the Elk River do not exceed Canadian Drinking Water Quality Guidelines of 50 µg/L. Therefore, consuming small amounts of river water is unlikely to cause problems. **Selenium concentrations notwithstanding, drinking untreated water from the river is highly discouraged.**

What about tap water?

Fernie gets most of its water supply from Fairy Creek, and tributary creeks have considerably lower selenium concentrations (~0.5 µg/L) as they are not typically affected by mining. During rare occasions when the water supply from Fairy Creek is not sufficient, a water well in James White Park is used for water. According to the City of Fernie, there have been no exceedances of selenium concentrations during regular drinking water monitoring.

Sparwood gets its water supply from three wells. When monitoring showed that one of the wells had selenium concentrations above the BC drinking water guideline at certain times of the year, a new well was installed and the well with exceedances was shut down. Concentrations of selenium at all current water supply wells are consistently below the drinking water guideline and monitoring data show that the wells have little connectivity to the Elk River or Michel Creek (see District of Sparwood website for more information).

Elkford uses water wells for its water supply. ERA has not yet received a response about Elkford drinking water testing.

In other locations in the RDEK Area A: Elk Valley residents outside of municipal water systems typically get their water from groundwater wells, and selenium levels will vary depending on location. If you get your water from a private water well, testing your water for quality (for all potential contaminants) is recommended. See the Health Canada website on water testing for more information.

If you have concerns about your water quality, you can get the water tested:

Test Kit	Price	Link
The Water Guy: Heavy Metals	$195-$250	https://www.thewaterguy.ca/catalog/view/heavy-metals-water-testing-complete-37-metals-set-245.htm
The Water Guy: Comprehensive Drinking Water Set	$550	https://www.thewaterguy.ca/catalog/types-of-water-test.htm
CARO Analytical: Essential Drinking Water Test Kit	$357.25	https://store.caro.ca/product/general-potability-drinking-water-kit/

**Please note that some tests require water to be shipped or delivered to the test facility within 24h. Therefore shipping/delivery costs will likely increase the price of testing.*

Are Elk River Fish safe to eat?

Fish populations in the Elk Valley are under strain of multiple human stressors (forestry, mining, urban pollution, agriculture, climate change). **Westslope cutthroat trout in most locations in the Elk Valley are catch-and-release only. ERA strongly encourages all anglers to practice responsible catch-and-release to preserve this important population of the species.**

Where fish consumption is permitted (for certain species, at certain locations in the watershed), the effect of selenium on dietary safety depends on how much fish you consume. The BC Ministry of Environment Water Quality Guidelines, outlines "screening values" which are thresholds at which health monitoring should be undertaken. These thresholds are designated based on the concentration of selenium in fish tissues, as well as the daily fish consumption amounts. The selenium screening value for people who have a high fish intake (220 g/day, about one fish steak per day) is 7.3 mg/kg (dry fish muscle weight). The screening selenium concentration for people who have a low fish intake (30 g/day, one fish steak every week) is 75 mg/kg. The Regional Aquatic Effects Monitoring Program report published by Teck in 2020 shows that the concentration of selenium in Westslope cutthroat trout muscle tissue in mine-affected creeks is on average ~8 mg of selenium per kg o f dry muscle tissue (i.e., mg/kg) and up to 13 mg/kg in some locations (see Table F.1). **Based on these numbers, occasional consumption of Elk Valley fish from mine-affected streams would not exceed the screening values, however daily consumption may exceed screening values.** Mountain Whitefish typically have lower concentrations of selenium (see Table F.5) and the body tissue selenium concentration of Westslope cutthroat trout in non-mine-affected streams is considerably lower: 4.36±0.55 mg/kg as reported in Kuchapski and Rasmussen (2015) and an average of 1.29 mg/kg as reported by Henderson and Fischer (2012). **Even high, subsistence level, fish consumption in non-mine-affected creeks is unlikely to trigger screening value thresholds.**

Currently there are no selenium-based fish consumption advisories in British Columbia.

SELENIUM AND FISH

Is elevated selenium bad for Elk River fish?

At high enough concentrations, selenium can cause body deformation in developing fish. This causes lower survival rates of young fish and this, in turn, can contribute to fish population decline. In the Elk River, the Westslope cutthroat trout is a species of Special Concern under the Species At Risk Act, and is affected by the cumulative effects of multiple stressors (including habitat degradation, fishing, climate change, etc.). The additional stressor of selenium pollution decreases the chances of maintaining a healthy population.

How selenium affects fish:

1. Selenium "bioaccumulates" in animal tissues:
    a. small organisms, such as benthic invertebrates (aquatic insects, worms, etc.) absorb selenium in their tissues.
    b. Fish eat many insects and thereby accumulate selenium in their own body.
2. As females lay eggs, the high selenium concentration in their body results in fish eggs with a high selenium content.
3. High selenium concentration in fish eggs interferes with fish development, and effects have been reported at relatively low water selenium concentrations of **5-10 µg/L in laboratory tests** (Lemly, 2002). Hatching time, developmental rate, hatchling survival, and hatchling deformities are some of the effects present in waters with increased selenium concentrations.

Symptoms of excess selenium on fish (from Lemly, 2002):

- Swelling/Inflammation of gills
- Spinal Deformities
- Edema (swelling due to fluid buildup)
- Deformations of the mouth and jaw
- Pathological alterations of livers, kidneys, hearts, and ovaries
- Eye deformations (including cataracts and protruding eyes)
- Reproductive disruption including lack of fertilization, lower hatchability, and higher mortalities of eggs and young fish
- Anemia

Is Selenium in the Elk River affecting Trout and other fish?

According to some sources, water with a selenium concentration of 5-10 µg/L is enough to have adverse effects on fish development (Lemly, 2002)—Elk River selenium concentrations frequently exceed these thresholds. However, it is difficult to say the extent to which high selenium levels actually affect fish populations in the Elk River Watershed because isolating the effect of only selenium is complicated. In a 2020 report released by Teck, adult and sub-adult Westslope Cutthroat Trout population suffered drastic declines: estimates in the Upper Fording River in 2019 were 93% lower than those in 2017, and juvenile density was 73% lower. An article by the Narwhal framed this decline in the context of high selenium levels; however, a subsequent 2021 Evaluation of Cause report for Teck by experts from several consulting firms concluded that this decline was likely due to a harsh winter combined with changes in stream hydrology due to mining activities. Water use, stream widening, and sediment deposition combined to degrade fish overwintering habitat and prevented fish movement and spawning,

reducing their population. Mining therefore played a role in the decline, but seemingly not by increasing water selenium concentration. Nonetheless, selenium is known to decrease the chances of fish survival, and considering all the other impacts it acts as an additional stressor on trout populations.

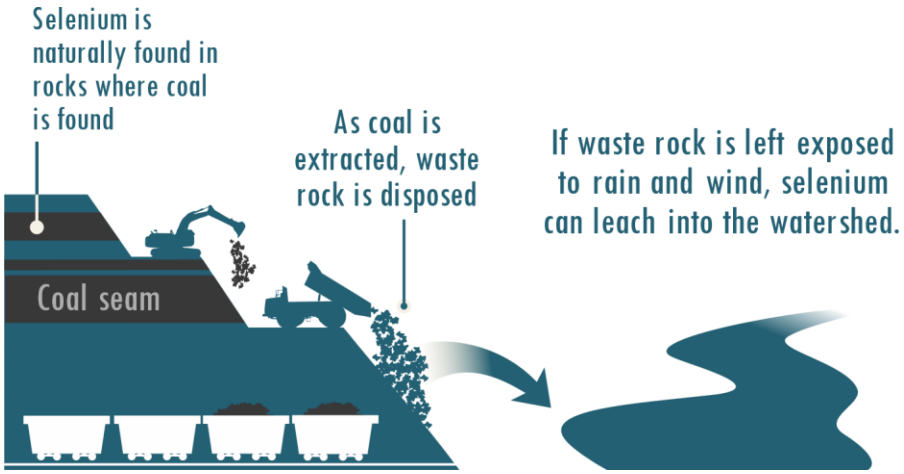
DOWNSTREAM IMPACTS

Is there a risk for watersheds downstream of the Elk River?

Ultimately, yes if selenium concentrations don't decrease. Water from the Elk River flows into Lake Koocanusa, and from there it continues to the Kootenay and Columbia Rivers. If not curbed, selenium pollution from the Elk River will continue to contribute to bioaccumulation in Lake Koocanusa and may affect fish further downstream. Currently, Lake Koocanusa selenium concentration is about 1 µg/L, which is lower than BC and the United States Environmental Protection Agency limits (2 µg/L and 1.5 µg/L, respectively), but higher than the 0.8 µg/L limit set by the State of Montana in 2020. While the Montana water quality standard is highly cautious—moderate exceedance of this standard is unlikely to have adverse effects on fish—it is a standard that **must** be met and reinforces the need to curb selenium sources from metallurgical coal mining.

SELENIUM AND MINING IN THE ELK VALLEY

How is mining related to selenium increases?



Coal-bearing rock is naturally high in selenium; as coal is extracted, waste rock is removed, and piled up. The broken-up waste rock has a higher surface area, and without proper mitigation, it the combination of air and water penetrating the waste rock piles produces conditions which lead to the formation of soluble selenium. The soluble selenium can then be flushed out of the waste pile by rain and snowmelt, entering surface water and groundwater.

What are some mitigation measures that are taken by the mining industry to decrease selenium concentrations?

The main goal of mitigation strategies is either to take out selenium after it enters the watershed or, preferentially, to design waste rock piles in ways that prevent selenium leaching into the watershed in the first place.

Some actions that can “cut selenium off at the source” include:

- Create low-oxygen, low-flow waste pile environments where selenium can be kept in less mobile forms (selenite, elemental selenium, or selenide). This can be done by engineered waste pile design (e.g., construction in layers from the bottom up) or through progressive reclamation with soil covers or other materials such as geomembranes.
- End dumping and filling stream valleys with waste rock
- Encourage the growth of microbes that reduce selenium levels inside the waste rock piles by creating low oxygen and nutrient conditions favourable for these microbes
- Divert water around and away from waste rock piles
- Reuse selenium impacted water

Water treatment is the other primary approach to selenium mitigation. Teck has active water treatment plants at their Line Creek and Fording River South locations. Teck is also using a method called “saturated rock fill”. Saturated rock fills are constructed in mine pits and are kept filled (saturated) with selenium-rich water gathered and pumped from other areas in the mine. Being covered with water keeps the rock-filled area low in oxygen. Additional nutrients are added to the rock fill to “boost” the activity of microbes needed to convert mobile selenium to less mobile selenium. The Elkview Saturated Rock Fill has been operational since 2018. Teck is currently commissioning another saturated rock fill at their Fording River North location.

Teck reports that its treatment facilities are achieving about 95% removal of selenium as well as nitrate from treated water. Total water volumes treated by both active treatment and saturated rock fill facilities are currently 46.5 million gallons per day. Teck states that it is seeing reductions in selenium and nitrate downstream in Line Creek. See **the Teck Resources** website (Date: July 18, 2022, link here).

Reductions in selenium concentrations elsewhere in the Elk River system (e.g., Fording River) are not yet apparent according to information provided by the Elk Valley Monitoring Committee (see water quality poster Figure 5); however these data pre-date the commissioning of the Fording River South treatment plant.

Given the large volume of legacy waste rock piles at Teck’s mining operations, it is not surprising that the relatively recent commissioning of treatment facilities has not yet produced a substantial, or consistent, reduction in selenium concentrations.

North Coal, who is planning a mining operation around Michel Creek (just north of Hwy 3 in the Crowsnest Pass) has plans to actively and passively mitigate selenium pollution to be in compliance with the Elk Valley Water Quality Plan. According to personal communications, North Coal’s plans to mitigate selenium concentrations include:

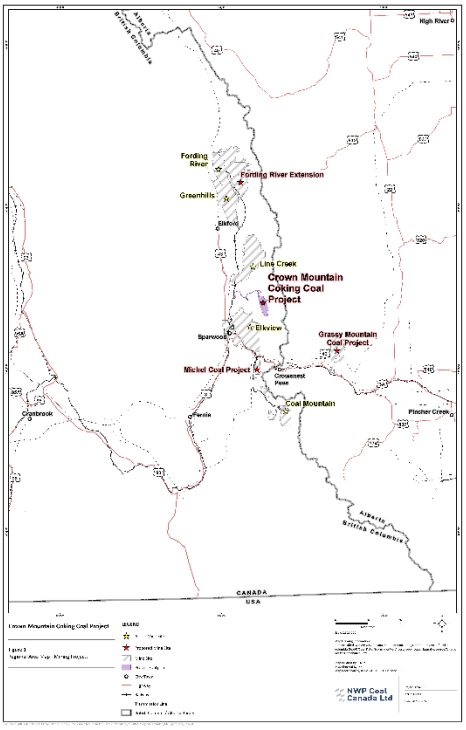
- *Keeping clean water clean through the protection of sensitive habitat and diverting clean water away from mine workings.*
- *Minimising the operational footprint or disturbance area of the mine through maximizing pit backfill.*
- *Bottom-up development of ex-pit mined rock storage facilities (MRSF) with suboxic conditions which reduce selenium release and reduce any metal leaching and acid rock*

drainage. The MRSF bottom-up development also mitigates the generation of fugitive dust.

- *The processing plant has been designed to de-water coal rejects, both coarse and fine, to eliminate the need for a tailings pond. The de-watered coal rejects are then transported and placed in the MRSF to be blended with mine rock. The coal rejects act as an additional measure to support the development of selenium and nitrate reducing bacteria within the MRSF.*
- *Rock blasting will integrate the use of blast hole liners which will reduce the amount of nitrates lost in blasting.*
- *Pit design focussed on controlling in-pit water and discharge points from the pit which allows for the management of contact water and semi-passive treatment in the saturated rock fill (SRF).*
- *Return of mined rock, to the extent possible, to engineered saturated rock fill (SRF) zones in the pits to reduce potential selenium oxidation and metal leaching.*
- *Active and semi-passive water treatment.*
- *Avoiding fish-bearing streams and minimizing flow alterations to streams.*
- *Using progressive reclamation and rehabilitation to reduce the effect on the natural environment and promote early and ongoing restoration of ecosystems.*

*Saturated Rock Fills: a rock fill contained in an enclosed impermeable rock, that is filled with water and has bacteria that turn selenium into a precipitate.

NWP Coal is proposing mining operations by Michel creek, Grassy Mountain, Crown Mountain, and Fording River.



According to the NWP website, their selenium mitigation strategies include:

- *Mine rock would be stored in-pit as much as practicable*
- *All other mine rock would be stored in a bottom-up layer-cake style facility designed for source control*
- *The dewatered tailings and plant rejects would be used as part of source control within the mine rock storage facility*

What more can be done?

The key to evaluating the success of mitigation strategies is rigorous monitoring of water quality and assessment of mitigation strategies in a collaborative and transparent manner. Unfortunately, much of the uncertainty over the concentrations and effects of selenium on Elk River stem from insufficient monitoring and lack of data sharing. In 2022 the Elk River Alliance released a discussion document on Proposed Approach for Coal Mining Effluent Regulation [link]. In it we provide several recommendations for improvements to mining effluent management:

- Monitoring not just the effluent from the mine sites but **extending rigorous monitoring all the way to Lake Koocanusa**. This would allow the assessment of **all sources of selenium** (and other pollutants) in combination (including non-mining related pollutants).
- Ensuring selenium limits are based on **accurate modelling**. Current limits were set based on modelling done by Teck; however, the modelling methodology or confidence levels have not been released to the public which makes assessing the validity of the models difficult for a third party.
- Assessing **multiple indicator species** for sub-lethal effects of pollution. Different indicator species have varying tolerance levels for specific types of pollution or disturbance. By testing only one species deemed as the most sensitive during initial tests, effects resulting from changes to the system (i.e., new pollutants, different concentrations) may be missed.
- **Frequent reviews and reports** released to the public on the current state of mining-related effluent
- **Publicly available data** released from industry monitoring
- Clear and laid out **consequences for exceeding limits**
- The Government needs to be more comfortable in approving trials with **leading edge technology** and processes.

We need more action on controlling selenium sooner. Current monitoring is not enough. The situation is urgent.

For questions comments and concerns, please contact the Elk River Alliance at info@elkriveralliance.ca