Environmental Science and Policy 96 (2019) 105–113

Contents lists available at ScienceDirect

Environmental Science and Policy

journal homepage: www.elsevier.com/locate/envsci

Environmental hazard assessment of Benga Mining's proposed Grassy Mountain Coal Project

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ABSTRACT

The Grassy Mountain Coal Project is a planned mountaintop open-pit development by Benga Mining Limited that would destroy 2,800 ha of scenic Rocky Mountain landscape in southwest Alberta, Canada. A scientific analysis of environmental hazards of the project reveals numerous flaws in both the projected environmental performance of the mine and its regulatory control. From both environmental and economic perspectives, the proposed mine will do far more damage than can be reasonably justified on any level. In this report, I present science-backed facts that show 6 specific, and grave, points of environmental hazard. If approved and made operational, the Grassy Mountain Coal Project will create a serious environmental threat from selenium pollution of high quality, high value aquatic habitats and culminate in poisoning of provincially and federally protected fish, coupled with substantial negative economic impacts. Prudent, timely, and decisive action by the Alberta Energy Regulator can eliminate the selenium risk and protect the environment.

1. Introduction

A plan to develop extensive open-pit mountaintop coal mining operations in the Crowsnest Pass area of southwest Alberta near the town of Blairmore, approximately 70 km north of the USA-Canada border (Fig. 1), has been submitted by Benga Mining Limited to the Alberta Energy Regulator (NRC, 2018; Riversdale, 2018). As part of the evaluation process for the proposed Grassy Mountain Coal Project (GMCP), AER required Benga to prepare an Environmental Impact Statement (EIS). That document was recently made available to the public (Government of Canada, 2018). Prior to its release, the Canadian Environmental Assessment Agency (CEAA) reviewed an earlier draft EIS and found several deficiencies, requiring additional information. According to CEAA, those deficiencies were addressed in the revision (CEAA, 2018a), and a formal government review of the final EIS is in progress. A public comment period was announced by CEAA to provide interested parties the opportunity to submit their thoughts on the proposed coal mining operations. CEAA's Joint Review Panel with AER will examine those comments and related information and make a determination as to whether a formal public hearing is warranted (CEAA, 2018b). I conducted a scientific review of the EIS, evaluated its merits, and compiled findings and conclusions in the present document. My report is an environmental hazard assessment that brings information from the EIS together with case examples from other open-pit mountaintop coal mines in Canada and the United States that have been in operation for as long as the projected life of the GMCP (25 years), and which utilize the same methods and techniques for handling solid and liquid residuals (surface disposal of waste rock, retention pond treatment of wastewater, etc.). The result is a revelation of what can be expected to occur if the Grassy Mountain Project is approved and put into motion.

2. Specific hazards of the Grassy Mountain Coal Project

(1) Exposure of waste rock to leaching

The process of open-pit mining requires surface disposal of residuals, that is, the waste rock removed to gain access to the desired coal seam. This creates a stockpile of material which has the potential to produce large volumes of contaminated wastewater due to precipitation-induced leaching of toxic heavy metals, trace elements and other materials from the mineral matrix of the rock. Of particular importance is the trace element selenium, which bioaccumulates in aquatic habitats and poisons fish and wildlife (Lemly, 2002b, 2008, Environment Canada, 2014). Leaching of selenium and resultant biological impacts is an undisputed fact of open-pit mountaintop coal mining, and has been demonstrated repeatedly in field case studies (Palmer et al., 2010; WVDEP, 2010; Lindberg et al., 2011; Environment Canada, 2014; Hendry et al., 2015). Case evidence clearly shows that this source of aquatic pollution will not, and cannot, be mitigated even with the application of advanced, high-cost treatment procedures (Linnett 2017, Scott, 2017a, 2017b). It will inevitably happen. The magnitude of pollution and its environmental impact depends on the extent of the waste rock stockpile. To date, there has been no demonstration of effective treatment of leachate wastewater to render it safe to aquatic life in receiving waters at the scale and flows emanating from

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https://doi.org/10.1016/j.envsci.2019.03.010
Received 4 December 2018; Received in revised form 18 March 2019; Accepted 19 March 2019
Available online 25 March 2019

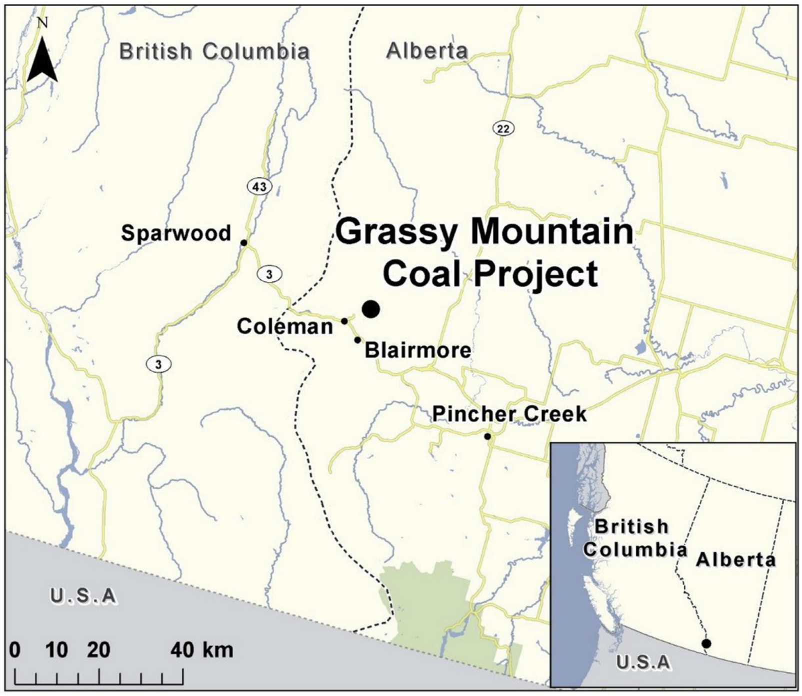

Fig. 1. Location of the proposed Grassy Mountain Coal Project in southwest Alberta, Canada (Graphic from Riversdale 2018).

coal mines. Pilot-scale experimental models of bioreactor treatment in Alberta (Luek et al., 2014) showed an ability to reduce selenium, but effluent concentrations remained above aquatic toxic levels (in excess of 5 ug/L, toxic threshold = 1.5 ug/L, USEPA, 2016, Alberta provincial and Canada federal guideline = 1 ug/L, CCME, 2018; Alberta Government, 2018b), and flows treated were a maximum of 2250 L/day, which is less than one-tenth of one percent of even a small waste stream tributary, thus offering little insight as to its practical application on the scale needed for coal mines. Moreover, there were also issues with release of fecal coliform bacteria in the bioreactor outflow that raised human health concerns. As a follow-up to the pilot model work, a field experiment was conducted on a 7.2 ha abandoned end-pit mine lake (Luek et al., 2017). It involved nutrient enrichment treatment using nitrogen and phosphorus fertilization to stimulate high primary productivity, create a eutrophic system, and maximize associated selenium uptake from water. Several critical weaknesses are evident in the conclusions of that study: (1) the pit lake was deep (45 m), anaerobic (absence of oxygen), and had no surface outflow (a stagnant system with retention time greater than 1 year), thus yielding results that are not transferable or applicable to the shallow (< 5 m), aerobic (oxygen-rich), flow-through retention ponds intended for Grassy Mountain (Hatfield, 2017); the selenium chemistry and cycling in those two systems are totally different, (2) waterborne selenium concentrations at the start were only 6.5 ug/L and, while elevated above background, were far lower than the 100–200 ug/L levels expected to be present in Grassy Mountain waste streams (Government of Canada, 2018), so the removal efficiency at those levels was not tested or demonstrated and, thus, remains unknown, (3) selenium speciation indicated a preponderance of selenate at the start (67%) with far less of the more highly toxic selenite form (13%), yet no speciation of selenium was reported for the rest of the study so it is unknown as to whether selenium was removed in equivalent amounts, or whether selenate was preferentially removed and the most toxic form remained, and at potentially elevated levels relative to what was present at the start, (4) end pit lakes having circumneutral pH, as was the case in the test, are known to be an attractive nuisance to wildlife, that is, they offer a desirable aquatic habitat for colonization, feeding and breeding of everything from insects to frogs and fish to ducks, raptors, and mammals, but their attractiveness belies the fact that they will be exposed to toxic levels of pollutants (USFWS, 2004). Aquatic birds are especially at risk, and migratory waterfowl are a primary concern, both for their own health, and because of the Canada-USA Migratory Bird Treaty Act (MBTA), which specifically prohibits "knowing take" due to environmental pollution (USFWS, 2017). These experiments, while interesting, mean little considering the scale of operations and wastewater stream hydrology that will result from the Grassy Mountain Project. If anything, they demonstrate why they won't work rather than why they will. Experimental selenium treatment through use of similar high primary productivity systems (eutrophic wetlands or lakes), has been shown to fail repeatedly, and, importantly, also infer MBTA liabilities (Lemly and Ohlendorf, 2002). Much can be learned by examining the case-example outcome of attempts to remove selenium on a mine-level scale through the installation of a $45 million dollar state-of-the-art treatment facility in British Columbia (Giffels Westpro, 2014). It failed, and to the contrary, this elaborate technology, which included both passive (bioreactor) and active (chemical) treatment, caused the release of a more toxic form of pollutants, resulting in the death of provincially and federally protected fish (westslope cutthroat trout and bull trout), and a $1.4 million dollar fine for violation of the Canadian Federal Fisheries Act (Linnitt, 2017; Scott, 2017a, 2017b). In addition to the waste rock leaching source of selenium, there is also the "leachate" that will result from the preparation of "clean coal" as the final product of the mine that would be exported to Asia for use as coking coal to make steel. According to the EIS, Grassy Mountain would produce millions of tons of "clean coal" per year. The cleaning process will be done on-site at the mine, and entails washing to remove soil and extraneous rock, crushing, screening and gravity separation, and dewatering (Riversdale, 2016; Wikipedia, 2017; RPM, 2018). There may also be application of various chemicals, notably MCHM (4-methylcyclohexane methanol), to enhance the cleaning process (Biello, 2014; Riversdale, 2016; RPM, 2018). The addition of chemicals escalates the toxic risk of wastewater to humans as well as aquatic life (Biello, 2014; WVU, 2015). There is also the major problem of calcite deposition in receiving waters as a by-product of coal cleaning, which coats the stream bottom and, in effect, turns it into concrete that is uninhabitable to invertebrates that form the base of the aquatic food chain, and also eliminates the loose gravels necessary for successful fish spawning (Environment Canada, 2014). The sum total of cleaning results in an additional "leachate" wastewater stream that finds its way into aquatic systems and is a significant, yet relatively unknown, source of coal mining-related pollution.

(2) Fish and wildlife poisoning

Leachate wastewater from coal mines contains numerous pollutants that pose a threat to aquatic life, including various salts and acid-forming materials, heavy metals, and trace elements (USEPA, 2010, 2017, Lindberg et al., 2011; Lemly, 2008, 2013). Key among these contaminants is the trace element selenium. It has a strong ability to bioaccumulate and biomagnify, that is, to progressively increase in concentration as it is absorbed from water by primary producers (plankton and algae) and passed up the food chain through successive trophic levels, culminating in greatest concentrations in the tissues of fish and wildlife. This leads to a highly dangerous situation because even very low, seemingly innocuous levels of waterborne selenium can result in toxic amounts in fish and wildlife. The end result is selenium poisoning, which consists of a variety of developmental deformities and death in offspring, and ultimately, complete reproductive failure if concentrations reach sufficient levels. Fish and aquatic birds are especially at risk of poisoning (Ohlendorf et al., 1988; Lemly, 1993, 1996, 1998, 2002a, 2002b, 2014, 2018b). Even at minimal toxic threshold levels, migratory aquatic birds (spotted sandpiper, *Actitis macularius*) experienced reduced hatchability of eggs downstream of mountaintop open-pit coal mines in British Columbia (Harding et al., 2005). Anything above that threshold just escalates the magnitude and severity of impacts. Moreover, such poisoning of migratory birds invokes the Canada-USA Migratory Bird Treaty Act, which carries strict penalties for any "take" due to pollution (USFWS, 2017). Fig. 2, Fig. 3, Fig. 4, Fig. 5 show examples of selenium poisoning deformities in fish that were caused by coal waste. Selenium poisoning can be insidious, that is, not readily apparent, due to the fact that it can cause reproductive failure and death of larval fish and embryonic birds while adults remain relatively unaffected. This is because selenium is consumed in the diet, then passed from parents to offspring in eggs, where its toxicity is expressed during development or just after hatching. At first glance, things may appear fine, with adults seemingly healthy and numerous, yet, reproductive failure can be taking place without visual evidence, that is, a massive die-off of fish or birds. Things can get very bad at a population level with little or no overt, outward indication. This has happened repeatedly, as evidenced by such landmark cases as the Belews Lake fish poisoning, and the Kesterson Reservoir waterfowl poisoning (Lemly, 1985, 2002a, Ohlendorf et al., 1988). Just because

Fig. 2. An abnormal bluegill (*Lepomis macrochirus*, top) from Lake Sutton, North Carolina, USA, with deformities that resulted from teratogenic effects of selenium poisoning due to coal waste. This individual has multiple defects of the mouth (which is less than 20 percent of its normal size and permanently distended) and other craniofacial structures including "gaping" permanently deformed gill cover. Bottom individual is normal. (Photo from Lemly, 2014).

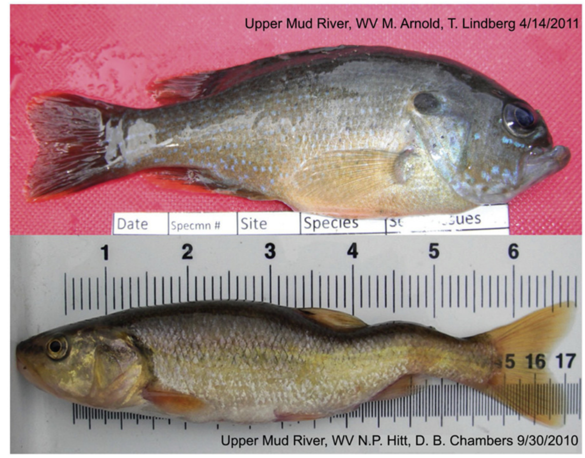

Fig. 3. Effects of selenium toxicity on two species of fish collected from the Upper Mud River, which is impacted by mountaintop coal mines in West Virginia, USA. (Upper) A sunfish (*Lepomis* sp,) showing cranial-facial deformities typical of selenium toxicity. This individual is missing its entire upper jaw and also exhibits compressed front head, a condition known as "pugnose". (Lower) Female creek chub (*Semolitus atromaculatus*) with lordosis deformity of the spine (dorso-ventral curvature), also a typical teratogenic deformity caused by selenium poisoning. (Photo from Lindberg et al., 2011).

Fig. 4. Recently hatched westslope cutthroat trout (*Oncorhynchus clarki lewisi*) from the Upper Fording River, British Columbia, Canada, showing marked spinal deformities expressed as lordosis, kyphosis, and scoliosis. These deformities are reliable biomarkers of selenium poisoning. (Photo from Environment Canada, 2014).

Fig. 5. Deformity (missing gill cover) in a westslope cutthroat trout (*Oncorhynchus clarki lewisi*) captured in Coal Creek, a tributary stream polluted by selenium from an open-pit mountaintop coal mine in British Columbia, and discharging to the Elk River. Gill cover deformities are a common type of craniofacial abnormality that is caused by selenium poisoning (Photo from Environment Canada, 2014).

adults are present doesn't mean there is no selenium poisoning taking place. One has to look closely at the base source of poisoning – death and deformities in developing and newly hatched fish and birds – to determine actual toxic impacts. Because of the nature of the selenium cycle – low water concentration, bioaccumulation, and insidious mode of toxicity – selenium is a "ticking time-bomb" (Lemly, 1999b). Once waterborne concentrations reach levels that begin to bioaccumulate, the fuse is lit. Then, a cascade of events is set in motion, ultimately resulting in reproductive failure and population-level impacts (Ohlendorf et al., 1988; Lemly, 1997, 1999b). Even if selenium sources are curtailed and waterborne selenium levels eventually reverse, the time-bomb explosion results in long-term impacts – on the order of decades – due to the retention of selenium residues in aquatic sediments, where it can be cycled back into the ecosystem and food chain (Lemly and Smith, 1987; Lemly, 2002b). Some major regulatory authorities have responded to the field case study evidence of the selenium threat. For example, the US Environmental Protection Agency conducted an in-depth review of its national selenium criteria and issued revised levels in 2016. Those criteria reduced the maximum waterborne selenium concentration by 70% over the previously permissible level for lentic – or passive – waters (5.0 ug/L reduced to 1.5 ug/L), and by 38% for lotic – or flowing – waters (5 ug/L reduced to 3.1 ug/L). The Agency also issued a first-ever tissue criterion for fish as an attempt to prevent bioaccumulative poisoning and associated reproductive impacts (USEPA, 2016). The waterborne selenium criteria in Canada are even more restrictive, as reflected by the 1 ug/L federal and Alberta provincial guideline (CCME, 2018; Alberta Government, 2018b). In addition to toxicity risks for fish and wildlife, there are also concerns for human health due to the accumulated selenium in edible fish and bird tissues. There are numerous examples of consumption advisories issued by state and federal authorities to limit intake of fish due to selenium contamination from coal waste (SNC, 2000; ATSDR, 2009a, 2009b, WVDNR, 2012).

(3) Pollution of aquatic habitats

Receiving waters for liquid waste that would be released from the Grassy Mountain Project are high quality, high value aquatic ecosystems in the Crowsnest Pass area. These include Gold Creek and its tributaries, Blairmore Creek and its tributaries, and the Crowsnest River. These waters are teeming with fish and other aquatic life, and are designated critical habitat for westslope cutthroat trout (*Oncorhynchus clarki lewisi*), which is a provincially and federally listed threatened species (Fisheries and Oceans Canada, 2013; ECCC, 2017; AEP, 2018). Westslope cutthroat trout have been shown in both field and laboratory studies to be highly sensitive to selenium pollution from coal mining. Teratogenic deformities and reproductive failure develop quickly, and without warning once an aquatic habitat is polluted (Rudolph et al., 2008; Elphick et al., 2011; Environment Canada, 2014; Soloway, 2014). Because of their sensitivity and status as a threatened species, these trout require special attention if they are to be maintained and preserved as a thriving, not just persisting, component of the Alberta fauna. There are major steps already underway to this end; the Alberta Recovery Plan (Cove et al., 2013) and the federal Recovery Strategy for this fish (DFO, 2014), which are two significant documents describing the problems it faces and the general approach to recovering the species. Substantial employee hours and funds have been expended preparing them, and much more is earmarked for carrying them out. Expanded industrial damage to critical habitat, as would occur if the Grassy Mountain Project proceeds, would impede the success of recovery, resulting in a serious setback for the fish and also a tragic waste of effort and taxpayer money. In fact, elaborate recovery efforts have already been undertaken in Alberta, involving helicopter transport of fish, in an attempt to rescue some of the remaining fish and establish new populations (Derworiz, 2015). Moreover, it is expected that numerous other fish and aquatic-dependent species would be poisoned as well, including migratory waterfowl and shorebirds (Ohlendorf et al., 1988; Harding et al., 2005), which would bring the Canada-USA Migratory Bird Treaty Act into play (USFWS, 2017). Degradation of these waters by selenium and other pollutants would result in poisoning and loss of valuable fishery resources – valuable from several perspectives, including the direct ecological cost of habitat and fish replacement value (possibly including fines of up to $1 million for each count of habitat destruction or poisoning of a threatened species, Government of Canada, 2018b), recreation and sport fishing value, real estate value, human health value, and aesthetic value (Lemly and Skorupa, 2012a, 2012b, Lemly, 2014, 2015b). Based on numerous case examples of coal waste aquatic pollution and resultant fish and wildlife poisoning and associated losses, the aggregate economic impact of these costs could easily exceed $30 million dollars per year, and deal a devastating blow to the local and regional economy. A cost analysis of the projected 100–250 digging/hauling/production jobs that would be gained from the Grassy Mountain mining operation at its peak (Nichols, 2016; Government of Canada, 2018), at an average pay rate of $38 per hour ($78,000 per year, Payscale, 2018), translates to a total annual employee payout of between $7 and $19 million – which is completely offset by the economic losses resulting from environmental impacts of the project. Moreover, most of those jobs are expected to be filled by immigrant workers, not by existing local permanent residents (Nichols, 2016). Thus, claims made by Benga Mining that it needs to gain quick approval and start mining because of the anticipated value of overseas investment to the Alberta economy and local residents (Stephenson, 2018) are, at best, misleading.

(4) Lack of proven mitigation measures and regulatory compliance

Selenium pollution from coal mine waste is a global environmental safety issue (Lemly, 2004, Lemly, 2007; 2008, 2013, 2014, 2018a). The methods and techniques proposed for waste management at Grassy Mountain pose grave environmental hazard and have been demonstrated to fail to protect the environment. This is especially true because of a lack of proven mitigation that would effectively eliminate those risks. For example, no treatment precautions or post-mining reclamation steps specified in the Waste Management Plan (WMP), the EIS or Addenda sufficiently address selenium pollution. How does Benga mitigate this risk? It doesn't, and can't. This is a critical weakness and literally a fatal flaw with respect to fish and wildlife health. As was mentioned in Item 1, exposure of waste rock to leaching will take place consistently during active mining, and continue indefinitely after mining ceases. This source of selenium cannot be effectively stopped. Statements in the EIS, WMP, and Addenda offer no realistic hope of success and reveal a shallow understanding of selenium cycling in the aquatic environment. They are not backed up by case examples demonstrating that the proposed waste management methods have resulted in effective control of selenium. That is because there are no case examples. Effective treatment doesn't exist, only case after case of selenium pollution and resultant poisoning of fish and wildlife. The "treatment" discussed in the WMP is focused is on physical habitat quality, that is, stream sedimentation, not remediation of changes in water chemistry from selenium and other chemical pollutants. Even the habitat statements are contradictory and highly suspect. For example, Addendum Consultant Report #6, Aquatic Ecology Effects Assessment (Hatfield, 2017, page 57) states "Gravel deposition [sedimentation] will likely be enhanced in some locations", and following," the likelihood and extent of physical habitat to be altered in terms of quantity and suitability is considered negligible". Both of these cannot be true, that is, a dual contention that on the one hand Benga Mining is going to sediment the streams but on the other hand there won't be any effects. By Canadian law under Section 58(1) of the Species at Risk Act, (Government of Canada, 2018b), destruction of any part of habitat that supports a listed threatened species, in this instance westslope cutthroat trout, is strictly prohibited and, therefore, cannot simply be decreed "negligible" and dismissed by a consulting firm. With absolutely no case study evidence to support their claim, it seems clear that the consultant reports have simply "wished away" detrimental, and illegal, impacts by invoking unverified model projections, not actual documentary data, in order to draw the conclusion that likely effects are "considered negligible". SARA does not allow *any* habitat destruction. Quote "No person shall destroy any part of the critical habitat of any listed endangered species or of any listed threatened species if (b) the listed species is an aquatic species". The only mention of selenium "treatment" in the EIS refers to the use of rudimentary methods for passive removal. Quote "All process water with elevated selenium will be treated in surge ponds and saturated zones with sufficient water residence time" (Hatfield, 2017, page 57). This is simply use of retention ponds, with the hopes that selenium will either settle out or be biologically removed. It won't, as has been shown repeatedly in case examples. Moreover, these ponds are notorious for breaching, which is not acknowledged as a possibility or accounted for in the EIS. With no contingency plan, this is analogous to allowing a speeding car to proceed with no brakes. The equivalent of an accident waiting to happen. Retention ponds, even when coupled with enhanced active treatment steps (Giffels Westpro, 2014), have not been demonstrated to work and will not work in this instance either. In fact, documented evidence shows that the contrary will happen. Selenium will not be removed, but will be altered into a chemical form that is even more toxic to westslope cutthroat trout (Environment Canada, 2014; Linnitt, 2017; Scott, 2017a, 2017b). In addition to fatal flaws in the proposed treatment methods, there is a serious regulatory issue as well. There are no specifications for selenium monitoring, selenium treatment and removal, or selenium water quality criteria, in the Alberta Coal Mining Wastewater Guidelines (AER, 2014; Alberta Government, 2018), despite the fact that there is a well-established and defined limit for selenium (1 ug/L) in both federal and provincial water quality regulations (CCME, 2018; Alberta Government, 2018b). This limit was established as a result of extensive case study evidence from Canada and elsewhere over the past four decades showing how dangerous selenium is to aquatic life. Current policy by AER reveals an extremely poor understanding and recognition of the key aquatic pollutant emanating from coal mines, and reflects very poorly on the credibility and performance of AER. This lack of adequate regulatory oversight and enforcement will lead to pollution that is seemingly "legal" in the sense that AER guidelines were being met, at the same time that fish and wildlife are being poisoned. Even if regulations are in place, past and current performance of the mining industry in Canada strongly suggests that there is little hope that Benga Mining will comply. For example, a recent government-conducted environmental audit of the mining sector in British Columbia revealed that surface open-pit mountaintop coal mines are almost never in compliance with regulations. Quote "We conducted this audit to determine whether the regulatory compliance and enforcement activities of the Ministry of Energy and Mines (MEM) and the Ministry of Environment (MoE), pertaining to mining, are protecting the province from significant environmental risks. We found almost every one of our expectations for a robust compliance and enforcement program within MEM and the MoE were not met" (Bellringer, 2016). The mining sector was essentially getting a "free pass" to do as it pleased while the regulatory community consistently failed in their responsibility to enforce the law, year after year. This seems to be a clear case of regulatory capture, that is, "A form of government failure which occurs when a regulatory agency, created to act in the public interest, instead advances the commercial or political concerns of special interest groups that dominate the industry or sector it is charged with regulating" (Carpenter and Moss, 2014; Wikipedia, 2018). Regulatory capture was identified as an evident government flaw in the first recommendation for needed reform offered by the British Columbia audit (Bellringer, 2016), and was exposed as a pervasive problem influencing regulatory decisions made by the National Energy Board of Canada, as stated by its own deputy energy minister (Wilt, 2017). Moreover, despite a wealth of scientific evidence showing the poisoning impacts of coal mining in BC, all of the requests for mine expansion were granted permits by government regulators. Although this documented regulatory collapse in BC is a tragic, landmark example, there are similar cases of coal-mine selenium pollution impacts on aquatic life in Alberta with no indication of adequate regulatory intervention by AER. Clear evidence of this regulatory failure can be found by examining the scientific literature regarding impacts in the McLeod River headwaters and Grande Cache area, and subsequent lack of regulatory action. For example, research studies by Holm et al. (2003, 2005), Kuchapski and Rasmussen (2015a, 2015b), Mackay (2006); Palace et al. (2004); Wayland et al. (2006, 2007), and Wayland and Crosley (2006) all show selenium bioaccumulation, high risk, and toxic effects to fish and aquatic invertebrates, including the provincially and federally listed threatened bull trout (*Salvelinus confluentus*). Yet, no regulatory intervention was undertaken in response to these documented risks and impacts. Coal mining remained unimpeded and was issued permits for expansion. Despite the scientific documentation of detrimental pollution impacts, it seems that this has been a long-running case of "don't ask, don't tell" by government regulators in Alberta. In effect, we won't go looking for problems, therefore, we won't find any, so continue mining. It's not that there is a lack of regulations promulgated under statutory authority *of* government, there is a lack of enforcement of those statutory laws *by* government. Today, with the large body of scientific information and case study evidence available demonstrating the selenium threat from coal mining in Alberta and elsewhere, there is no longer plausible deniability. There is no legitimate basis for the claim" we didn't know better", either on the part of the mining industry or the regulatory community in which it operates. Benga's consultant models and resultant conclusions of "negligible" impacts have no basis in fact. This is simply a ploy to gain AER approval and make money for Benga and its investors, without commensurate benefits to Albertans. Case evidence from Canada and elsewhere, over and over, time and time again, reveals the truth about pollution and impacts from open-pit coal mines. The tragedy that took place in BC and, in fact, already in Alberta, should not, and need not, be repeated with the Grassy Mountain Project.

(5) Downsteam transport of contaminants

One of the greatest hazards resulting from selenium pollution of flowing waters is downstream transport. Not only can aquatic life in the immediate vicinity of the input source be poisoned, but also in habitats far from it, perhaps hundreds of kilometers away. Selenium is a chemical element. It doesn't biodegrade and magically disappear. It travels intact and unaffected. This aspect of selenium cycling is known as the Hydrological Unit Principle (HUP, Lemly, 1999a, 2002b). The HUP is quite simple, low concentrations of waterborne selenium that are seemingly innocuous can be transported to aquatic systems where the propensity for bioaccumulation and risk of poisoning is even greater, that is, into lentic, or standing/impounded waters. The greater risk is due to generally greater primary productivity in lentic systems (growth of algae and other microorganisms that accumulate selenium directly from water) which “fuels” the base of the aquatic food chain and then subsequent trophic-level increases in tissue concentrations result in toxicity to fish and wildlife. A Hydrological Unit is the segment of aquatic habitat that experiences elevated waterborne selenium sufficient to cause bioaccumulation to hazardous levels. It is determined by the input source selenium concentration and the magnitude and spatial distribution of downstream inputs of low-selenium water. Thus, the length of a HU can be quite short, if dilution is sufficient and quick, or very long, if the volume and selenium concentration of wastewater discharge are large relative to the receiving waters. The latter case occurred from open-pit mountaintop coal mining in the Fording River area of British Columbia, resulting in downstream transport from the Fording River into the Elk River and ultimately, deposition of toxic levels of selenium into Lake Koocanusa, some 165 km away (Scott, 2014, 2015a, 2015b, 2016, Selch, 2014; Lavoie, 2018; Pollack and Moy, 2018). The HUP has particular importance for the Grassy Mountain Project because the scale of mining and amount of waste rock subjected to selenium leaching (2,800 ha, billions of tons), and the relatively small size of receiving waters (Gold Creek and Blairmore Creek), the flow of these streams will be overwhelmed by wastewater flow. This means there will be little dilution afforded by the immediate receiving waters, thus, downstream transport will come into play and be a big factor in cumulative impacts. Aquatic systems that would be affected include the Crowsnest River and Oldman River Reservoir, which support a world-class rainbow and brown trout sport fishery. Importantly, long-term risks exist, even decades after mine closure, because of the fact that waste rock piles cannot be effectively mitigated or reclaimed, as shown in the BC case studies (Environment Canada, 2014), and the reservoir of waste rock selenium prone to leaching is huge (Hendry et al., 2015).

(6) Compelling evidence from British Columbia shows how dangerous the Grassy Mountain Project will be

Teck Coal Limited has five open-pit mountaintop mines in the Elk River Valley of southern British Columbia in fairly close proximity to the proposed Grassy Mountain Project, only about 30 km away (Riversdale, 2018). The mining techniques and basic waste disposal methods used by Teck are the same as proposed by Benga for Grassy Mountain, although advanced treatment for selenium removal was attempted by Teck, but failed. The BC mines produce metallurgical-grade coal that is shipped to Asia for use as coking coal to make steel. This is the same end-product and marketing that is proposed for coal coming out of Grassy Mountain. The mines are located along the Fording River and its tributaries (Environment Canada, 2014; Teck, 2018). Selenium-laden leachate from waste rock piles and coal processing wastewater are discharged into the Fording River, which flows into the Elk River near Fernie. Water quality in both of these rivers has steadily declined over the past 4 decades. Selenium levels increased to the point that significant bioaccumulation began to occur in fish and the aquatic ecosystem of the Fording, such that by the 1990′s selenium poisoning of fish was evident, including the listed as special concern westslope cutthroat trout and listed as threatened bull trout (*Salvelinus confluentis*, Wood and Berdusco, 1999; McDonald, 2013; Environment Canada, 2014; British Columbia, 2018). Toxic impacts steadily escalated to the point that most of the historic westslope cutthroat trout population in the Upper Fording River (above Josephine Falls) was eliminated (Environment Canada, 2014). The remnant population that remained was, and still is, severely impacted. Estimates indicate that at least 180,000 newly hatched trout perish each year due to selenium poisoning, and even adults carry the scars of selenium toxicity they incurred as hatchlings (Lemly, 2015a, Fig. 5). Toxic impacts are not confined to the Upper Fording, they extend far downstream, including the Lower Fording and Elk. Figs. 4 and 5 illustrate these toxic effects. Recent evidence has emerged showing that not only are fish being affected, but also aquatic invertebrates are being poisoned, which deals a death blow to the aquatic food chain, upon which westslope cutthroat trout and other species depend to survive (Pollack and Moy, 2018).

Teck Coal attempted to reduce selenium levels in the Fording River by constructing a $45 million dollar wastewater treatment plant on West Line Creek, a primary selenium-releasing tributary (Giffels Westpro, 2014). The facility was promoted as state-of-the-art, and was designed to utilize both biological and chemical treatment steps. Long-term plans were to construct several of these facilities within the Fording-Elk River mining footprint in the hopes of providing an effective remedy to the selenium problem. However, within 6 months after the Line Creek Plant became operational, a fish kill was detected, consisting of both westslope cutthroat trout and bull trout, the former of which is a listed species of special concern under Canadian federal law (Government of Canada, 2018b). Investigations revealed that the plant had not only failed to achieve the desired water quality in its effluent discharge, but also had actually made things worse by producing and releasing a more toxic selenite form of selenium (Linnitt, 2017; Scott, 2017a, 2017b, Lavoie, 2018; Pollack and Moy, 2018). Although fines were levied against the mining company for violating the Canadian Federal Fisheries Act, the magnitude of fines ($1.4 million total) was nothing more than a slap-on-the-wrist compared to the multi-billion dollar annual profit made by the coal mines ($12 billion in 2017, Teck, 2017). Moreover, permits for mine expansion were always granted by government regulators despite the overwhelming scientific evidence of significant environmental impacts and concurrent legal violations. Even more tragically, there has been no resolution of the selenium pollution issue. It continues unabated and poisoning of fish continues. This case example shows that available treatment measures to protect water quality from selenium in coal mining waste are ineffective, despite their elaborate technical design and high cost. There has been no demonstrated success for selenium removal on the scale needed to treat mountaintop open-pit coal mine waste. There is also a grave environmental danger due to the legacy effects of pollution, that is, continued contamination and poisoning long after mining operations stop. For example, it is estimated that the reservoir of selenium in waste rock piles will release toxic levels of selenium in leachate for centuries (Hendry et al., 2015; Pollack and Moy, 2018). To date, there has been no demonstrated effective mitigation measure, physical or chemical, for eliminating this pollution threat. Another compelling piece of evidence as to how dangerous Grassy Mountain will be is the downstream transport of selenium and bioaccumulation in aquatic systems far from its source. For many years, research has documented increasing levels of selenium in waters and fish in Lake Koocanusa, an impoundment of the Kootenai River that straddles the USA-Canada border between BC and Montana (Selch, 2014; Scott, 2014, 2015a, 2015b). Downstream transport of pollution from coal mines 165 km away is responsible for these increases. Concentrations of selenium in Koocanusa water now exceed USEPA criteria for the protection of aquatic life (Scott, 2016; Pollack and Moy, 2018) and fish tissue amounts are at toxic levels (Selch, 2014; Lavoie, 2018). The Hydrological Unit Principle is clearly in play, that is, downstream transport of relatively low levels of waterborne selenium that become hazardous due to bioaccumulation in a lentic ecosystem. With respect to the proposed Grassy Mountain Project, this would mean that severe downstream effects would be expected in Oldman River Reservoir due to transport of selenium by the Crowsnest River. The reservoir is only some 40 km away from the mine site, far less than the 165 km between the BC coal mines and the “impact zone” of Lake Koocanusa. Moreover, fisheries that would be impacted include threatened westslope cutthroat trout and the internationally recognized rainbow and brown trout sport fishery in the Crowsnest River. Ecosystem values that would be affected run the full range of potential damage costs involving habitat and fish replacement value, recreation and sport fishing value, real estate value, human health value, and aesthetic value (Lemly and Skorupa, 2012a, 2012b). These costs could easily run into the tens of millions per year, and deal a substantial blow to the local and regional economy.

3. Conclusions

If approved and made operational, the Grassy Mountain Coal Project will create a grave environmental threat from selenium pollution of high quality, high value aquatic habitats in a scenic Rocky Mountain landscape. The magnitude of impact will depend on extent and duration of mining, amount of waste produced, and exposure of fish and wildlife in the surrounding area and downstream, including Crowsnest River and Oldman River Reservoir, and perhaps beyond. Aquatic species that would be poisoned include the westslope cutthroat trout, which is a provincially and federally listed threatened species. Beyond its protected status, the cutthroat it is a sentinel species that reflects the high environmental quality that now exists in the Crowsnest Pass area. Case studies from coal mining in the McLeod River and Grand Cache area of Alberta and the Elk River Valley of nearby British Columbia clearly show the environmental hazard of Grassy Mountain. There is no need for history to repeat itself. The proposed methods and techniques to protect water quality are simply hollow promises that carry no legitimate demonstration of prior success. A large body of scientific evidence clearly shows the high degree of environmental hazard which will accompany the Grassy Mountain Project. Moreover, the metallurgic coal produced will be sold to Asia. Resultant monetary benefits will accrue to Benga Mining and Asian investors, yet, apart from a few local jobs, the vast majority of Albertans will see no financial benefit but will collectively bear the cost of environmental damage and chronic pollution. The risk trade-off is unacceptable to maintain the high environmental quality that now exists in the Crowsnest Pass area. It would be an environmental, public, and political nightmare if the coal mining tragedy that has unfolded in British Columbia, and already in Alberta, were to repeat itself. The overwhelming weight of scientific information and case study evidence indicates that this outcome is inevitable if the mining takes place. Perhaps most importantly, there is a definite, dangerous risk of corporate regulatory capture coming into play which would control policy and prevent decisions necessary to protect the environment. Prudent, timely, and decisive action by Alberta Energy Regulator and CEAA is needed in order to eliminate the selenium threat.

Acknowledgments

I thank David Mayhood and Environmental Science and Policy anonymous reviewers for constructive comments that improved the manuscript.

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