Science of the Total Environment 557–558 (2016) 502–509

Contents lists available at ScienceDirect

Science of the Total Environment

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

Initial environmental impacts of the Obed Mountain coal mine process water spill into the Athabasca River (Alberta, Canada)

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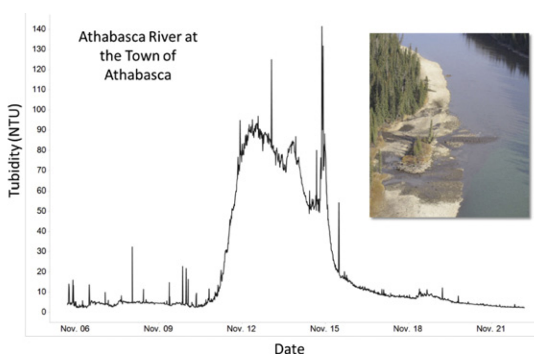
HIGHLIGHTS

- High inputs of suspended sediment, nutrients, metals, and PAHs due to a coal mine spill
- Dilution and elongation of the released plume decreased the threat to water quality
- Physical, biological, and chemical implications for the Athabasca River watershed

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 20 November 2015
Received in revised form 9 March 2016
Accepted 9 March 2016
Available online 24 March 2016

Editor: D. Barcelo

Keywords:
Heavy metals
Coal spill
PAH
Water quality
Athabasca River

ABSTRACT

On October 31, 2013, a catastrophic release of approximately 670,000 m^3 of coal process water occurred as the result of the failure of the wall of a post-processing settling pond at the Obed Mountain Mine near Hinton, Alberta. A highly turbid plume entered the Athabasca River approximately 20 km from the mine, markedly altering the chemical composition of the Athabasca River as it flowed downstream. The released plume traveled approximately 1100 km downstream to the Peace-Athabasca Delta in approximately four weeks, and was tracked both visually and using real-time measures of river water turbidity within the Athabasca River. The plume initially contained high concentrations of nutrients (nitrogen and phosphorus), metals, and polycyclic aromatic hydrocarbons (PAHs); some Canadian Council of Ministers of the Environmental (CCME) Guidelines were exceeded in the initial days after the spill. Subsequent characterization of the source material revealed elevated concentrations of both metals (arsenic, lead, mercury, selenium, and zinc) and PAHs (acenaphthene, fluorene, naphthalene, phenanthrene, and pyrene). While toxicity testing using the released material indicated a relatively low or short-lived acute risk to the aquatic environment, some of the water quality and sediment quality variables are known carcinogens and have the potential to exert negative long-term impacts.

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http://dx.doi.org/10.1016/j.scitotenv.2016.03.058

1. Introduction

The Athabasca River is a physically and ecologically diverse river that flows from its glaciated headwaters in Jasper National Park's Rocky Mountains to its terminus in the Peace-Athabasca Delta - a Ramsar Wetland of International Significance located within Wood Buffalo National Park - and Lake Athabasca, in the northeast corner of Alberta. Its basin (~159,000 km^2) comprises almost one-fourth of Alberta's area, and it is the longest unregulated river in the Canadian Prairies. Water quality in the river ranges from ultra-oligotrophic in its mountainous headwaters to eutrophic at its lowland deltaic terminus. The river flows through a large number of ecozones, flowing from Alpine, Subalpine and Montane ecoregions, through the Boreal Foothills ecoregion, and entering the Boreal Mixedwood region, which comprises the lower ~75% of the basin (Bradford and Hanson, 1990). The Athabasca River is a source of water for many communities, businesses, agricultural, industrial, and private users, and supports a significant fishery in the region.

On the evening of October 31, 2013, a dyke failure of the Red/Green pit on the Obed Mountain Mine site in the Hinton region of Alberta, Canada (Fig. 1) released an estimated 670,000 m^3 of coal slurry. Coal slurry, or process water, is the by-product of processing and cleaning coal that contains a mixture of water, sediment, and fine particulate coal (i.e., coal fines). Coal deposits and interbedded sediments can be enriched relative to background soils in a suite of organic and inorganic contaminants including hydrocarbons, heavy metals and coal-cleaning chemicals (e.g., acrylamide was used as a flocculant at the Obed mine) that may pose a threat to aquatic ecosystems (Gentzis and Goodarzi, 1997; Aken et al., 2014). The released slurry flowed downslope into the Main Tailings Pond, rapidly filling the pond to its capacity. The Main Tailings Pond then overflowed the coal slurry into a constructed spillway, after which it flowed downstream into Apetowun Creek, then Plante Creek and eventually into the Upper Athabasca River. The release caused substantial scouring of additional sediment and stream bank and was sufficiently powerful to break off or clear away mature pine trees and forests soils substantially beyond historical bank and riparian zone limits, in the upper ~5 km of the Apetowun Creek (Fig. S1). At the time of the spill, flows in the Athabasca River were near annual lows. Over the next two months, an elongating plume of noticeably turbid water, which eventually reached >100 km in length, flowed down to the length of the Athabasca River and made its way into the Peace-Athabasca Delta, ~1100 km downstream of the initial spill location.

The Obed mine release appears to have been the largest coal slurry spill in North American history, exceeding the magnitude of the 1972 Buffalo Creek flood in West Virginia (USA) that killed 125 people. A much larger spill of coal fly ash, a by-product of coal combustion, occurred in 2008 at the Tennessee Valley Authority's Kingston Fossil Plant in Roane County, Tennessee, USA when approximately 4,200,000 m^3 of coal fly ash were released into the Emory River (Ruhl et al., 2009). Here we summarize the results of an emergency monitoring program implemented immediately after the Obed mine spill by the Government of Alberta's Department of Environment and Sustainable Resource Development (now Alberta Environment and Parks) and Coal Valley Resources Ltd., the owner of the Obed mine. The main objectives of this monitoring program were to both track and characterize the coal slurry as it flowed downstream and to perform an initial assessment of the potential environmental impacts resulting from the spill. Samples of water, sediment, soil, and spill material were collected from the Apetowun and Plante creeks, the Athabasca River, and from the mine itself, and were analyzed for a range of chemical parameters with special reference to compounds subject to regulatory limits or requirements. This initial assessment provides important context for understanding the long-term impacts of the spill on the receiving terrestrial and aquatic environments, and for informing the design of the long-term impacts assessment and monitoring program.

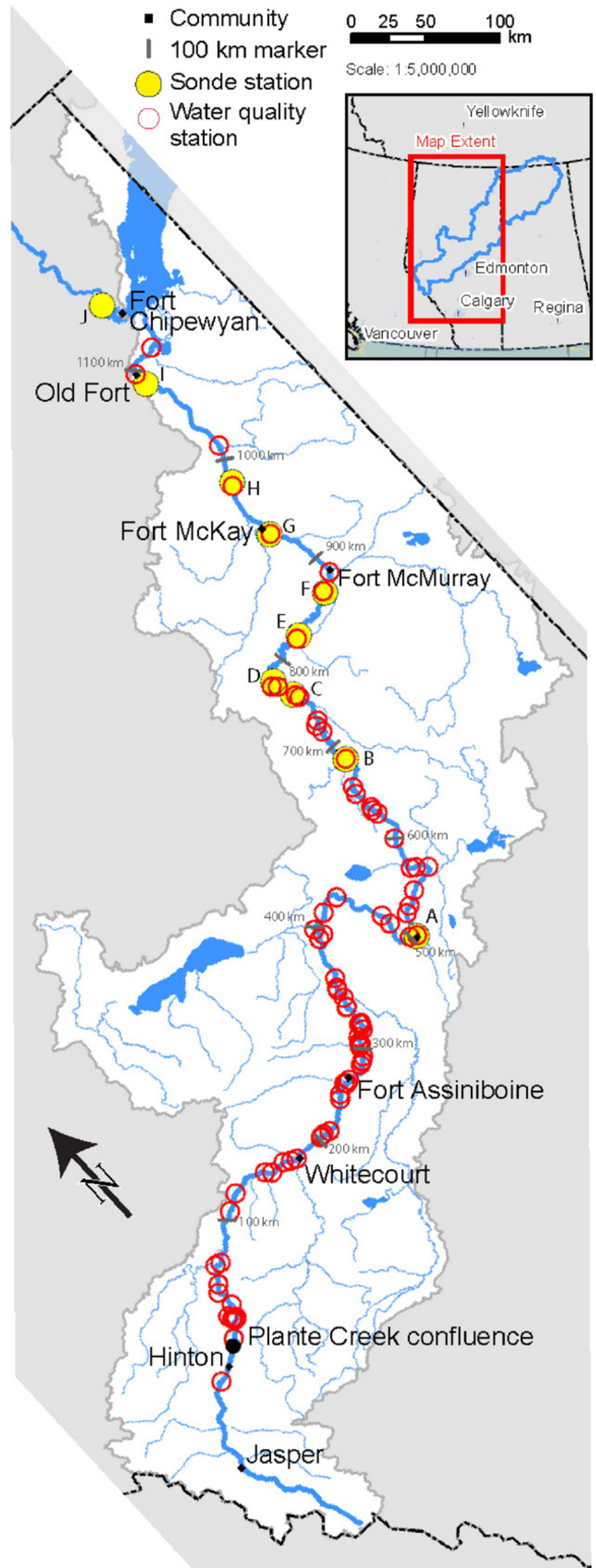

Fig. 1. Map of water quality sample collection locations and the sites where near real-time data sondes (labelled A–J) were deployed. Multi-probe sonde stations are indicated by filled yellow circles while water quality sample collection locations are indicated by open red circles.