Peterson Creek and Aquifer - Review of Ajax Mine Permit 3904 for Reliably Characterizing and Preventing Water Contamination by Existing Mine Wastes

prepared for:

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P.Geo. Notice

This study is based on detailed technical information interpreted through standard and advanced chemical and geoscientific techniques available at this time. As with all geoscientific investigations, the findings are based on data collected at discrete points in time and location. In portions of this report, it has been necessary to infer information between and beyond the measured data points using established techniques and scientific judgement. In our opinion, this report contains the appropriate level of geoscientific information to reach the conclusions stated herein.

This study has been conducted in accordance with British Columbia provincial legislation as stated in the Engineers and Geoscientists Act.

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Short Summary of This Review

The old Ajax Minesite is located along and on either side of Peterson Creek, below the outlet of Jacko Lake.

KAPA asked MDAG to determine if the current monitoring requirements under Permit 3904 are adequate to detect and identify contamination that might be migrating from this old minesite.

No, the Permit requirements:

- are woefully inadequate and ambiguous,
- lead to wrong interpretations and conclusions, and
- do not explain the dramatic increasing contamination of Peterson Creek by minesite-derived elements.

This is confirmed by the detailed baseline studies that KGHM Ajax Mining conducted for its Ajax Environmental Impact Statement (EIS).

As of November 2019, the provincial government said that KGHM is out of compliance with Permit 3904.

As of February 2020, KGHM monitoring data continue to show increasing contamination of Peterson Creek below the old minesite.

Long Summary of This Review

The Kamloops Area Preservation Association (KAPA) has asked the Minesite Drainage Assessment Group (MDAG) to undertake a review of Permit 3904. This Permit regulates the environmental impact of the old Ajax Minesite near Kamloops.

Specifically, KAPA asked MDAG to determine if the current monitoring requirements under Permit 3904 are adequate. According to the British Columbia Ministry of Environment and Climate Change Strategy (MOE), KGHM is currently out of compliance with this permit as of November 2019.

Besides monitoring required by the Permit, another important source of environmental information on the old minesite is the Ajax Environmental Assessment / Environmental Impact Statement (EIS). It contains "baseline" studies of the old minesite components and of Peterson Creek and its Aquifer. Due to the inadequate and ambiguous requirements of Permit 3904, the Ajax EIS turns out to be the key document for understanding the ongoing contamination of Peterson Creek and its Aquifer.

According to British Columbia Minfile, the old Ajax Minesite contains rock with pyrite that can oxidize upon mining, and release acidity, metals, sulphate, and heat. This is consistent with the Ajax EIS designating at least some of the old rock as "PAG" (potentially acid generating). Other minerals in Ajax rock release metals like copper and molybdenum. It turns out that sulphate, molybdenum, and some other elements act as "tracers" showing the old minesite is contaminating Peterson Creek. Other contaminants like selenium, arsenic, uranium, and mercury are also migrating from the old mine wastes.

The most recent mining at the old site started in 1989 and ended in 1997. Two pit areas (Ajax West and Ajax East) were mined, with Ajax West consisting of two smaller pits. Although not as well documented, mining also began at this location in 1898, apparently involving many hundreds to thousands of meters of shafts, adits, and other underground workings.

As a result of this past mining, several minesite components exist at the site and represent sources of contaminated water. These components are:

- two waste-rock dumps,
- two overburden stockpiles (with documented contaminated seepage),
- two leaky seepage ponds,
- two pits areas,
- smaller disturbances like mine roads, rock spills, and creek crossings, and
- historical underground workings.

These minesite components have no observed surface pathways to Peterson Creek. This has led to past statements and conclusions that Peterson Creek is not receiving any contamination from the old minesite. However, these minesite components have subsurface pathways that can (and do) deliver contamination to Peterson Creek.

Unfortunately, Permit 3904 only requires monitoring of surface waters, and only for a few of the components. There is no required monitoring of subsurface groundwater flows or chemistries. This has lead biologists hired by KGHM, with no legal permission to examine subsurface hydrogeologic flowpaths in British Columbia, to incorrectly conclude Peterson Creek is not being contaminated because there are no surface connections.

Some past estimates of total mine waste rock at the old site were around 15 million tonnes. However, the Ajax EIS updated that estimate to nearly 50 million tonnes of waste rock, plus another 7 million tonnes of water-contaminating overburden. This includes some low-grade ore, which could be more reactive than waste rock, left on site near Peterson Creek after closure. Nevertheless, the volumes or tonnages of other components remain unknown. In any case, it is now clear that many tens of millions of tonnes of old mine wastes remain at the site, and are now delivering contaminated water to Peterson Creek and its Aquifer.

With the ongoing contamination, Permit 3904 should focus on groundwater pathways. Instead, it ignores them entirely with no monitoring of groundwater required. Moreover, the wording of the Permit conditions is ambiguous and contradictory. Here are two contradictions.

Contradiction 1) Contaminated water is allowed to seep into the ground, but it may not bypass containment structures like ponds, etc., from which it seeps into the ground.

Contradiction 2) Contaminated water is allowed to seep into the ground at an average of 25 m^3/day, but there is no groundwater monitoring in Permit 3904 to determine the discharge rate or whether the seepage is typical of runoff from waste-rock dumps and open pits.

KGHM and its consultants do not say anything about these contradictions. There is no surface discharge, so there is silence. But where do the rain and snowmelt go? MOE correspondence on this issue shows that MOE is also confused. Also, how can Peterson Creek above the old minesite be basically dry as it was in the fall of 2019, yet have flow downstream of the old minesite? Where did that flowing water come from?

Despite the lack of groundwater monitoring under the Permit, surface water samples are required. Thus, aqueous concentrations in Peterson Creek downstream of the old minesite can be compared to those upstream of the minesite near Jacko Lake. KGHM consultants have indicated aquatic life in the creek cannot be affected by the old minesite because there are no surface-water tributaries flowing into it. That is wrong.

The comparison of upstream and downstream concentrations reveal dramatic and alarming increases in contaminant concentrations in Peterson Creek. This contamination of the creek is particularly strong during seasonal peak levels that occur each year. This increasing contamination is continuing up to the latest monitoring data through 2019. KGHM Ajax Mining agreed, but only for another permit not related to Permit 3904, saying,

> *"With the exception of molybdenum, increased concentrations are not attributed to mining activity."*

However, the contamination is certainly not limited to molybdenum as shown in this review.

These substantial increases in creek concentrations lead to several important observations.

Observation 1) Peterson Creek concentrations downstream of the old minesite are notably higher than upstream concentrations. This applies to aqueous elements like sulphate and molybdenum and others, which act as tracers for minesite-derived contamination.

Observation 2) Due to Observation 1, there is at least one subsurface pathway through the Peterson Creek Aquifer carrying contamination from at least one component at the old Ajax Minesite.

Observation 3) Creek concentrations downstream of the old Ajax Minesite show major seasonal variations. As a result, monthly or more frequent monitoring of flows and chemistries, both in the creek and in groundwater, is required to reliably define and characterize the ongoing contamination of Peterson Creek.

Observation 4) Peak concentrations in Peterson Creek downstream of the old minesite have been generally increasing and thus worsening since 2013 and continues to the end of 2019. Upstream concentrations are generally lower and are mostly remaining relatively stable or decreasing. This should be taken as a warning. However, some high levels of water contamination measured downstream since 2013 have disappeared in the 2019 annual report, so monitoring data should be used cautiously.

Observation 5) The previous observations are not dependent on "background" or "baseline" concentrations in the area. In fact, any elevated "baseline" concentrations could simply be widespread contamination from the old mining operations that have occurred for many decades to centuries.

Additional monitoring under the Permit of a few of the old minesite components confirm they could also be the sources of contamination observed in Peterson Creek and Aquifer. Monitoring in the Ajax EIS further confirms that other minesite components not monitored under the Permit could also be the sources of creek contamination. Insufficient information is available to figure this out, and the Permit provides no information to help with this.

An important issue has been resolved with information from the EIS. A common assumption in Permit monitoring is that most of the unmonitored contaminated groundwater at the old Ajax Minesite flows towards and into the old Ajax West pits, because of their apparently lower water elevations (occasionally reported only as arbitrary water heights). As a result, little if any contamination from the old minesite could theoretically reach Peterson Creek.

However, in the Ajax EIS, maps of shallow and deep groundwater, and of groundwater levels in dozens of piezometers and monitor wells, show this assumption is wrong. Those pits have very limited effect on groundwater flow. Thus, most contaminated groundwater from the old minesite enters the Aquifer and at least part of this continues towards and into Peterson Creek.

KAPA asked MDAG to determine if the current monitoring requirements under Permit 3904 are adequate. Therefore, no, the Permit requirements:

- are woefully inadequate and ambiguous,
- lead to wrong interpretations and conclusions, and
- do not explain the dramatic increasing contamination of Peterson Creek by

minesite-derived elements.

It is only through the detailed baseline monitoring in the Ajax EIS that the contamination of Peterson Creek and Aquifer can be understood. That baseline monitoring apparently has ended, so the increasing contamination of Peterson Creek and its Aquifer is once again poorly monitored and understood.

The current Permit 3904 fails to identify and track contamination from the old minesite components, into the Peterson Creek Aquifer and into Peterson Creek itself. Therefore, major revisions to the Permit are needed. The revisions should include the following.

Recommendation 1) Monthly measurements of creek flows and chemistry, and of groundwater levels and chemistry, are needed. This is due to the highly variable seasonal fluctuations that cannot be reliably understood by the current twice-a-year, chemistry-only sampling in the Permit.

Recommendation 2) At least 20 surrounding monitor wells and piezometers should be monitored under the Permit. It is difficult to choose these additional points now, because at least some of those used in the Ajax EIS may no longer be functional. An inventory of functioning piezometers and monitor wells should be compiled as the first step to this revision.

Recommendation 3) All elements and parameters with water-quality guidelines for drinking, irrigation, wildlife, and aquatic life should be analyzed in dissolved (filtered) and total forms. Due to seasonal peaks, annual averages should not be compared to guidelines, but each monthly value should be compared to guidelines.

1. INTRODUCTION

The Kamloops Area Preservation Association (KAPA) has asked the Minesite Drainage Assessment Group (MDAG) to undertake a review of Permit 3904, administered by the British Columbia Ministry of Environment and Climate Change Strategy (MOE), issued under the British Columbia Environmental Management Act. This Permit regulates the environmental impact of the old Ajax Minesite near Kamloops. According to MOE, KGHM is out of compliance with this permit as of November 2019.

Specifically, KAPA asked MDAG to determine if the current monitoring requirements to measure water contamination under Permit 3904 from the 14.6 million tonnes of waste rock stored at the Ajax mine site are adequate. As a result of this review, total water-contaminating old mine wastes at the Ajax site is likely greater than 50 million tonnes, not 14.6 million, but no detailed inventory of mine wastes and components could be found. One was created for this review, but it may underestimate the total volumes and tonnages.

Most of this mine waste is capable of contaminating water as shown by company monitoring programs for the Permit. However, what is not documented is where this contaminated water goes. Although not part of the Permit, the Ajax EIS explains this, and shows most of this contaminated water flows into Peterson Creek and its Aquifer.

Relevant documents to be reviewed include:

- the 2018 Ajax Permit 3904 Assessment Report (Knight Piesold, 2019), reviewing at least the previous five years of monitoring and annual reclamation reports;
- the annual Ajax mine reclamation reports including the latest one for 2019 (Knight Piesold, 2020); and,
- any other documents the consultant deems relevant, such as Ajax Mine Environmental Assessment/Environmental Impact Study (EIS) report and appendices (KGHM, 2015).

Due to the inadequate and ambiguous requirements of Permit 3904, the Ajax EIS turns out to be the key document for understanding the ongoing contamination of Peterson Creek and its Aquifer. This is explained in detail in Chapter 5 of this review.

2. THE OLD AJAX MINESITE

The official database of the British Columbia government for mining, exploration, and mineral-showing sites is called Minfile (https://minfile.gov.bc.ca/). Minfile indicates there are several locations around Jacko Lake that have elevated metal levels (Figures 2-1). These could be future minesites if large enough and if approved. However, most mineral showings are likely so small they would not be economical to mine individually under current economic conditions.

2.1 Later Mining Starting in 1989

Just east of Jacko Lake and close to Peterson Creek, open-pit mining started in 1989 (Figures 2-1 and 2-2). This occurred at "Ajax West" as two pits within one larger perimeter (Minfile Number 092INE012) and "Ajax East" with one pit (Minfile Number 092INE013).

Some Minfile information on these two locations is repeated here. This information is important for understanding why Permit 3904, issued by the British Columbia Ministry of Environment and Climate Change Strategy (MOE), fails to ensure Peterson Creek and Aquifer are safely protected against contamination from the past mine wastes.

Minfile described the minerals that exist in rock at Ajax West and East. For example, "Pyrite is ubiquitous . . . " Pyrite is a mineral that reacts when exposed to air and water, that is, when mined. The reaction releases acidity, sulphate, various metals, and heat into surrounding waters.

If this pyrite oxidation causes pH to decrease to acidic levels, the water draining from the site is called, "acid mine drainage" (AMD) or "acid rock drainage" (ARD). If the pH remains near neutral levels, this reaction still releases sulphate, metals, and heat to surrounding waters. The Ajax EIS (KGHM, 2015) has identified at least some of the past mine waste as "PAG" or potentially acid generating.

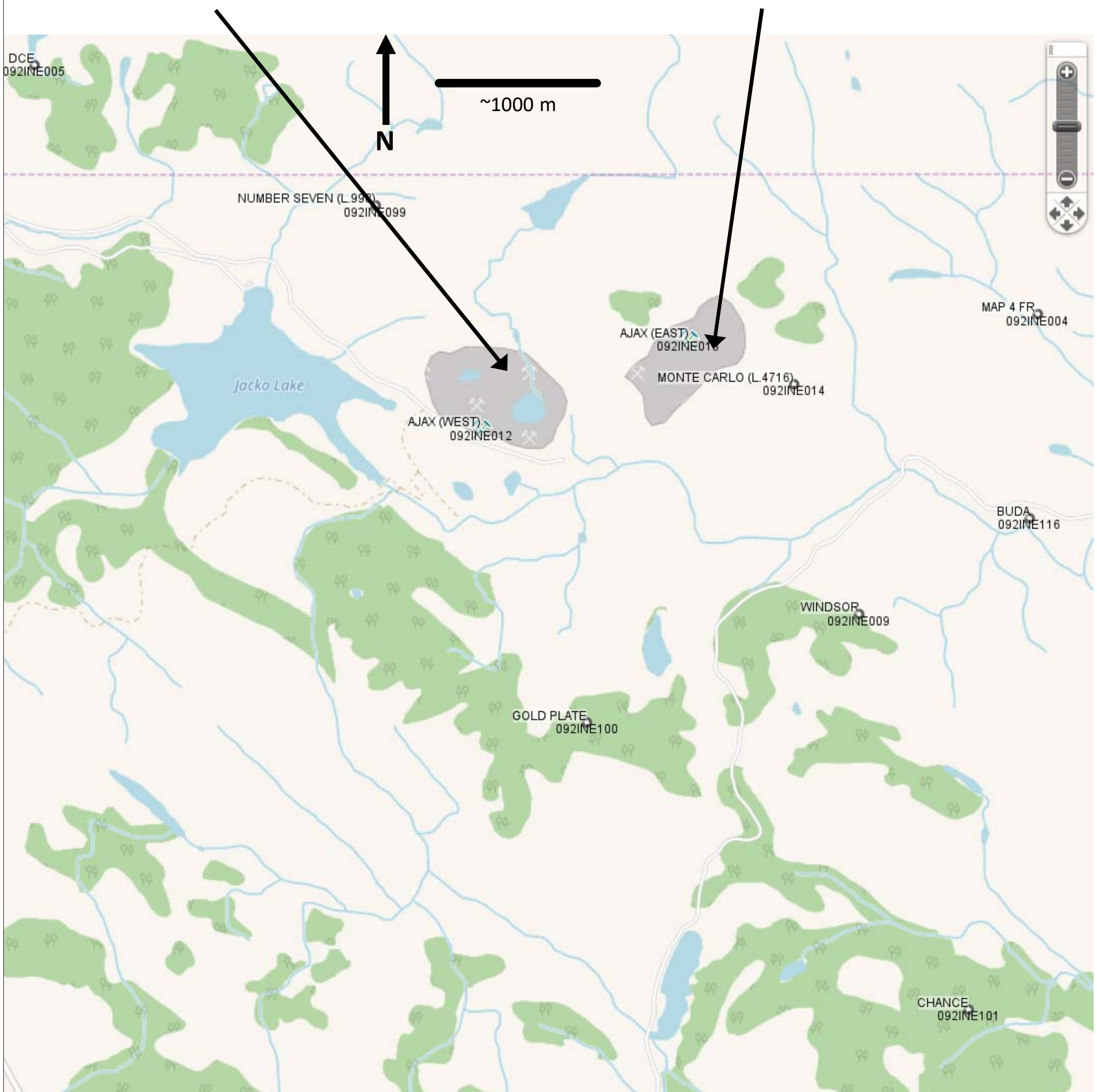
It is important to remember that the mine materials remaining at Ajax West and East are releasing elevated levels of sulphate and some metals into water due to the minerals in the rock. They will likely continue to do so for many decades to centuries. This fact will be used later in this review as a tracer of water from Peterson Creek back to these Ajax mine wastes (see Chapter 4).

Minfile also points out some other relevant minerals in Ajax rock include:

- chalcopyrite (which contains copper, iron, and sulphide),
- bornite (which also contains copper, iron, and sulphide),
- chalcocite (containing copper and sulphide),
- malachite (containing copper, carbonate, and hydroxide),
- azurite (also containing copper, carbonate, and hydroxide), and
- molybenite (containing molybdenum and sulphide).

Ajax West (Minfile 092INE012) was mined as two pits from 1989 to 1997, with waste rock and/or low-grade ore backfilled into the Ajax East pit. The two pits still contain water.

Ajax East (Minfile 092INE013) was mined as one pit and then backfilled with waste rock and/or low-grade ore from the Ajax West pits. This pit has no surface water, but the porewater in the backfilled rock is elevated, causing it to flow into the Peterson Creek Aquifer and towards Peterson Creek.



From British Columbia MapPlace showing Minfile locations,
https://www2.gov.bc.ca/gov/content/industry/mineral-exploration-mining/british-columbia-geological-survey/mapplace

Figure 2-1. Map showing the locations of Minfile locations east of Jacko Lake, including two pits at Ajax West and one pit at Ajax East.

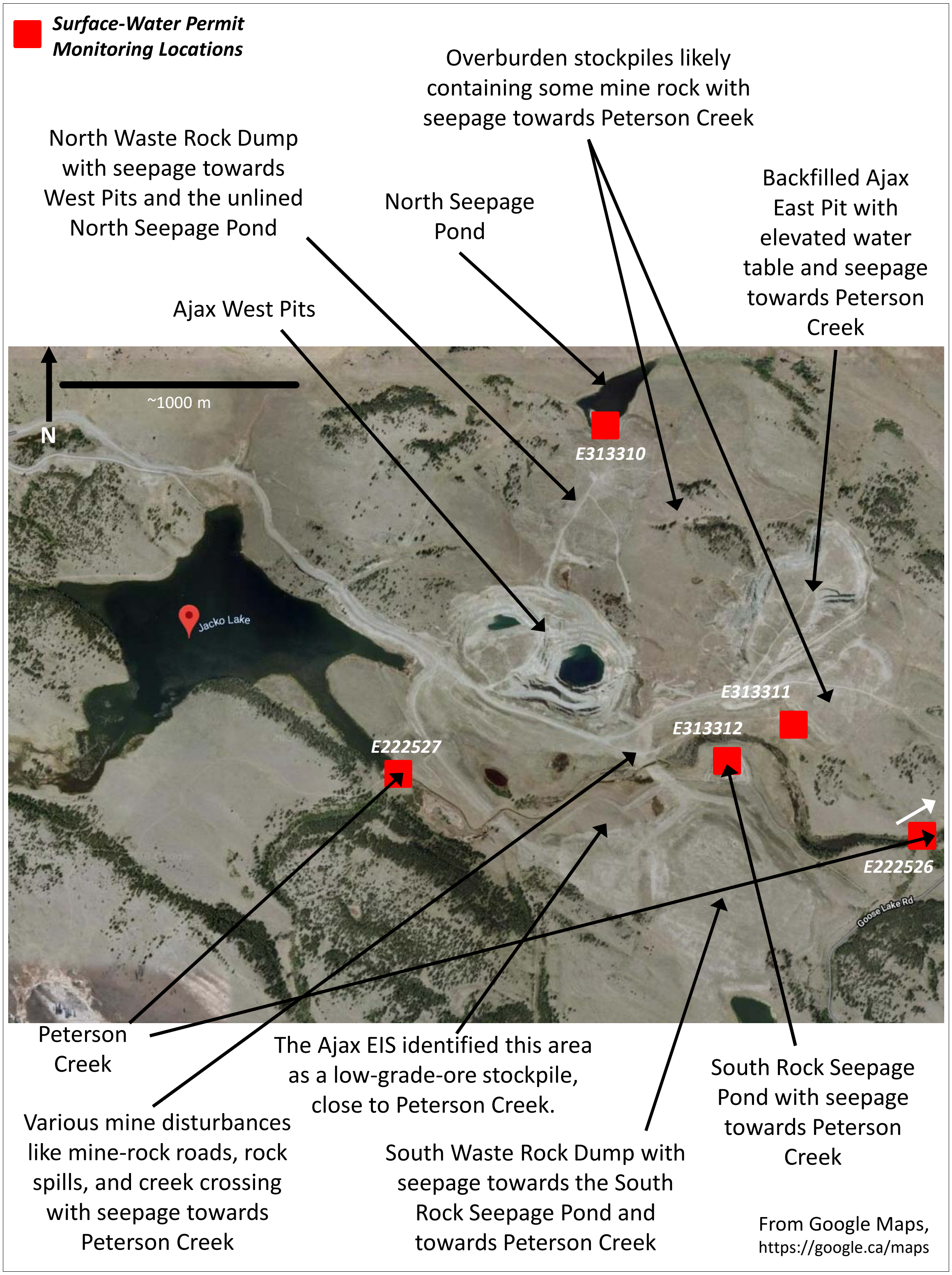


Figure 2-2. Google Earth map showing existing components from the old Ajax Minesite and the surface-water monitoring stations required by Permit 3904.

The leaching of copper from these minerals is more of a concern for aquatic life which is more sensitive to copper than humans. On the other hand, humans can be more sensitive to molybdenum than some aquatic life. Monitoring of water quality under Permit 3904 has shown exceedances of water-quality guidelines for copper, molybdenum, sulphate, and other elements. This will be discussed later in Chapter 4.

Minfile provides this short history of mining at Ajax West and East starting in 1989. Note that Minfile's history focusses on the ore mined, while the waste left behind is not well documented. Also, note that the Ajax East pit was backfilled with waste rock from the two Ajax West pits towards the end of mining in 1996. According to the Ajax EIS (KGHM, 2015), evaluations of the rock backfilled into the East Pit "designate this rock as PAG [potentially acid generating]."

> Mining of the Ajax deposit began after the depletion of economic open pit reserves at Afton in early 1989. In June 1989, mining commenced at the Ajax deposit (West and East pits), 10 kilometres to the south-southeast of the Afton open pit. Ore was hauled via a new road to the Afton mill complex. The Ajax mining operations ceased in August 1991.
>
> Afton Operating Corporation, a subsidiary of Teck Corp., resumed production in September, 1994 after a three-year suspension in operations because of depressed metal prices. Production from the Ajax East pit, which contained approximately 3.63 million tonnes of ore grading 0.46 per cent copper and 0.34 gram per tonne gold, totalled 3600 tonnes of copper and 245 kilograms of gold from 931,000 tonnes milled at a daily throughput of 8700 tonnes.
>
> Reserves for the Afton-Ajax deposits estimated by the company at January 1, 1995 were 13.2 million tonnes grading 0.42 per cent copper and 0.34 gram per tonne gold.
>
> In 1995, Afton announced that it would re-open the Ajax West pit, with about 9 million tonnes of the same grade as Ajax East, extending the mine life from December 1996 to about December 1998. Pushback stripping of the Ajax West pit began, and ore was milled.
>
> Production in 1995 from the Ajax East pit totalled 11,824 tonnes of copper, 830 kilograms of gold and 1559 kilograms of silver from 2,928,922 tonnes milled at a daily throughput of 8770 tonnes.
>
> During 1996, mining took place in the Ajax West pit; much of the Ajax East pit was backfilled with waste from the West pit. Closure of the West pit operation was June 1997 due to low copper prices and the low grade of the remaining ore.

Although Minfile states that the Ajax East pit was backfilled with "waste" rock, it also says low-grade ore was left behind on the site due to low copper prices. As a result, "waste rock" should be understood to include low-grade ore (at 1997 prices) that could be more reactive. Part of the South Waste Rock Dump has been identified as a "low grade stockpile" in one Ajax EIS document (Lorax Environmental, 2016).

2.2 Earlier Mining Starting in 1898

Long before 1989, Minfile also reports underground exploration in the Ajax area with shafts and drifts. This underground work began in 1898 on the Ajax West, Ajax East (apparently then called

Wheal Tamar), and the Monte Carlo mineral "showing" to the east of Ajax East (Figure 2-1). Similar exploration work was also undertaken at many other close-by mineral claims, such as Kamloops Queen, Tamar Fraction, Blizzard Fraction, Sultan, Anaconda, Whitecap Fraction, Hercules, Jupiter, Neptune, and Mars.

The lengths and depths of these underground workings around the Ajax area, likely many hundreds to thousands of meters in total based on Minfile, are not well documented. Also, there have likely been many hundreds of unsealed exploration holes drilled in the area, since at least 1916 according to Minfile.

These underground workings and drillholes can still substantially influence (1) the directions and flow rates of groundwater movement in this area and (2) the interactions between groundwater and Peterson Creek. Therefore, the bedrock in this area to the east and northeast of Jacko Lake should be considered disturbed and altered from pristine background conditions.

I could find no information on existing shafts and adits currently open at the surface that would represent human hazards. Any known or discovered open shafts and adits should be reported to the British Columbia Ministry of Energy, Mines and Petroleum Resources.

2.3 Remaining Minesite Components and Potential Sources of Water Contamination

Again, Minfile does not provide good documentation on volumes and tonnages of reactive mine wastes left at the old Ajax Minesite. Nevertheless, the types of mine materials remaining at the site with the capability of degrading water quality are obvious from Minfile reports and other documents. They include unlined or till-lined waste rock, low-grade ore, pit walls, and seepage ponds (Table 2-1 and Figure 2-2) as existing sources that can contaminate water. An important aspect of these components is their volumes or tonnages, which is discussed below.

This list in Table 2-1 is important, because Permit 3904 does not recognize and does not require monitoring of many of these potential sources of water contamination.

Additionally, there are likely pathways through the subsurface groundwater system for contaminated water to reach Peterson Creek from these sources (Table 2-2). In fact, due to the lack of continuous surface-water channels from these components into Peterson Creek, the groundwater pathways ARE the major pathways, but none are monitored under Permit 3904 (Table 2-2).

Due to the lack of groundwater monitoring at the old minesite components, no reliable information on subsurface contaminant pathways is collected under Permit 3904. In turn, no contaminant transport from the old minesite components has been identified, which in turn leads to the false conclusion that no subsurface contaminant transport is occurring.

For example, the 2018 five-year-summary Assessment Report (Knight Piesold, 2019) under Permit 3904, written by a "Junior Scientist" and two biologists on behalf of KGHM, states,

> *". . . it should be noted that there is no surface connection between these ponds and nearby streams; therefore, the mine waterbodies are not affecting natural aquatic life."*

Table 2-1. Existing contaminant sources at the Ajax Minesite

	Based on existing information, the component likely contains . . .			
Component	reactive rock walls	reactive waste rock	potential reactive low-grade ore	contaminated water
North Waste Rock Dump	NO	YES	YES	YES
North Seepage Pond	NO	NO	NO	YES
Ajax West Pits	YES	NO	NO	YES
Ajax East Pit	YES	YES	YES	YES
Overburden Stockpiles	NO	YES	YES	YES
South Waste Rock Dump	NO	YES	YES	YES
South Rock Seepage Pond	NO	NO	NO	YES
Disturbances like mine roads, rock spills, and creek crossing	NO	YES	YES	YES
Historical shafts and adits	YES	YES	YES	UNKNOWN

Table 2-2. Contaminant pathways at the Ajax Minesite through subsurface groundwater and surface water

	Likely pathways from the component . . .			
	as subsurface groundwater . . . [1]		as surface water . . .	
Component	into and through Peterson Creek Aquifer and towards Peterson Creek	monitored by Permit 3904	towards Peterson Creek	monitored by Permit 3904 (MOE Station)
North Waste Rock Dump	YES	**NO**	NO	**NO**
North Seepage Pond	YES	**NO**	NO	YES (E313310)
Ajax West Pits	NO	**NO**	NO	**NO**
Ajax East Pit	YES	**NO**	NO	**NO**
Overburden Stockpiles	YES	**NO**	NO	YES, East Only (E313311)
South Waste Rock Dump	YES	**NO**	NO	**NO**
South Rock Seepage Pond	YES	**NO**	NO	YES (E313312)
Disturbances like mine roads, rock spills, and creek crossing	YES	**NO**	YES	**NO**
Historical shafts and adits	UNKNOWN	**NO**	NO	**NO**

[1] Subsurface pathways do not exist according to monitoring under Permit 3904 and MOE. Two biologists who certified the 2018 five-year monitoring report for Permit 3904 (Knight Piesold Consulting, 2019) wrote, ". . . it should be noted that there is no surface connection between these ponds and nearby streams; therefore, the mine waterbodies are not affecting natural aquatic life". However, later chapters in this review show the subsurface pathways exist, are active, and can strongly affect Peterson Creek and thus aquatic life.

Similar statements are made in the 2019 annual report (Knight Piesold, 2020). For example,

> *"The water quality monitoring locations of the effluent sites associated with these facilities are seepage and runoff collection ponds that are non fish-bearing and have no surface connection to any fish-bearing waterbodies."*

These reports by KGHM's consultants, Knight Piesold, were written by biologists. Under the British Columbia Engineers and Geoscientists Act and Professional Governance Act, biologists are not legally permitted to assess and evaluate subsurface hydrogeologic pathways. Therefore, the Knight Piesold documents avoid discussions of subsurface contaminant migration. However, that does not mean it is not occurring.

There is no observed surface connection with the old minesite components, so there is no contamination entering Peterson Creek? This is so very wrong, as later chapters in this review will show. Permit 3904 and its requirements simply cannot reliably tell us which sources are releasing contaminated water that flows through the Peterson Creek Aquifer and reaches Peterson Creek.

An important aspect to the contaminant sources of Table 2-1 is their volumes or tonnages. In general, the larger the volume or tonnage, the more water that can become contaminated.

Surprisingly, there is apparently no reliable and comprehensive inventory of the volumes or tonnages of the minesite components. For example, in response to questions from the British Columbia Environmental Assessment Office during the Ajax EIS (Lorax Environmental, 2016), all that was available were "preliminary estimates of the quantity of material in the existing mine rock and overburden stockpiles":

- North Waste Rock Dump = 3,000,000 m^3 or 6,600,000 tonnes

- South Waste Rock Dump (presumably include a low-grade-ore stockpile) near Peterson Creek= 19,000,000 m^3 or 42,000,000 tonnes

- North Overburden ("Till") Stockpile likely including some rock = 2,400,000 m^3 or 3,800,000 tonnes

- East Overburden ("Till") Stockpile likely including some rock = 2,200,000 m^3 or 3,500,000 tonnes.

Other volumes and tonnages were not estimated. Nevertheless, this underestimate of more than 50 million tonnes greatly exceeds previous reports of approximately 15 million tonnes of mine wastes.

3. PERMIT 3904 UNDER THE ENVIRONMENTAL MANAGEMENT ACT OF BRITISH COLUMBIA

Under the Environmental Management Act of British Columbia, the Ministry of Environment and Climate Change Strategy (MOE) issued Permit 3904 to KGHM Ajax Mining Inc. located in Vaughan, Ontario.

Permit 3904 was originally issued in April 1976 and was most recently amended in September 2018.

In November 2019, MOE informed KGHM Ajax Mining Inc. that it was out of compliance with Permit 3904. This was primarily due to missing monitoring data and reporting.

The main concern of Permit 3904 is runoff and seepage from some, but not all, of the old Ajax Minesite components (Table 2-1 above). It is important to note that "runoff" is surface water, and "seepage" is water that appears at the surface. Thus, only surface water is monitored (Table 2-2).

For the physical movement of water leaving the old Ajax minesite components, clauses in Permit 3904 state:

> "1.1.1 The average rate of discharge is 25 cubic metres per day.
> 1.1.2 The authorized discharge period is continuous.
> 1.1.3 The characteristics of the discharge is typical of runoff from waste rock dumps and open pits.
> 1.1.4 The authorized works are till blanket, containment ponds, dykes, interceptor ditches and related appurtenances.
> . . .
> 2.2 Bypasses. The Permittee must not allow any discharge authorized by this authorization to bypass the authorized works, except with the prior written approval of the Director."

These clauses seem reasonable, but they are ambiguous and not monitored, as explained in Chapter 4 below.

For the chemistry of water leaving the old Ajax minesite components, Section 4.1 of Permit 3904 specifies that five surface-water sites will be sampled for chemistry (shown above as red boxes in Figure 2-2 of this review and listed below in Table 3-1). As explained in Chapter 4 below, these are insufficient to characterize contaminant release and transport from the old Ajax Minesite components.

Subsurface groundwater moving towards Peterson Creek through the surrounding Aquifer is not monitored as part of Permit 3904. However, as Chapter 4 of this review shows, the comparison of (a) Peterson Creek upstream of the old Ajax minesite to (b) downstream Peterson Creek shows contamination is entering Peterson Creek at the old minesite. By not monitoring subsurface groundwater connections between Peterson Creek and the old mine components, the most recent monitoring reports under Permit 3904 (Knight Piesold 2019 and 2020) suggest that no contamination from the old mine components is entering Peterson Creek because there is no direct surface-water connection:

". . . it should be noted that there is no surface connection between these ponds and nearby streams; therefore, the mine waterbodies are not affecting natural aquatic life."
"The water quality monitoring locations of the effluent sites associated with these facilities are seepage and runoff collection ponds that are non fish-bearing and have no surface connection to any fish-bearing waterbodies."

Later chapters of this review describe information collected by KGHM and its consultants, showing direct subsurface contaminant pathways between the old minesite components, Peterson Creek, and the Aquifer. Monitoring currently required under Permit 3904 cannot show or characterize these pathways.

Table 3-1. Water-quality monitoring sites and parameters as specified in Permit 3904 (see Figure 2-2 of this review for locations)

Site EMS Number	Location	Monitoring Type	Parameters
E313310	North Seepage Pond	Effluent	pH, turbidity, hardness, Major ions, Nutrients, Total metals including selenium
E313311	Overburden Seep		
E313312	Waste Rock Seepage Pond (WR-Seep)		
E313313	South Catchment		
E222526	Peterson Creek downstream of [at outlet of] Jacko Lake	Surface water	
E222527	Peterson Creek upstream of Goose Lake Road [but downstream of the old Ajax Minesite]		

4. RESULTS OF ENVIRONMENTAL MONITORING IN ACCORDANCE WITH PERMIT 3904

Monitoring required by Permit 3904 involves both the volume and the chemistry of water draining from some of the components of the Ajax Minesite (Chapters 2 and 3 above). This permit is administered by the British Columbia Ministry of Environment and Climate Change Strategy (MOE).

4.1 Volume of Water Discharged from the Old Ajax Minesite

As explained in Chapter 3 above, Permit 3904 authorizes a physical discharge of water from the old minesite at an “average rate of discharge of 25 cubic metres per day”. The characteristics of this discharge must be “typical of runoff from waste rock dumps and open pits”, which is surface water. No unauthorized bypassing of water is allowed beyond the “authorized works” of “till blanket, containment ponds, dykes, interceptor ditches and related appurtenances.”

Surprisingly, there is no estimated discharge in the latest five-year Assessment Report (Knight Piesold, 2019) or Annual Report for 2019 (Knight and Piesold, 2020). Why is this important permit requirement not addressed by the required monitoring? This is where it gets confusing and ambiguous.

The beginning of the permit states that KGHM “is authorized to discharge effluent to ground from a closed copper mine located near Kamloops”. “To ground” means to seep into, and disappear into, the ground to the underlying groundwater system.

Notice the contradictions in the Permit.

- Contaminated water is allowed to seep into the ground, but it may not bypass containment structures like ponds, etc., from which it seeps into the ground.
- Contaminated water is allowed to seep into the ground at an average of 25 m^3/day, but there is no groundwater monitoring in Permit 3904 to determine the discharge rate or whether the seepage is typical of runoff from waste-rock dumps and open pits.

KGHM and its consultants do not say anything about this Permit condition. There is no surface discharge, so there is silence.

There is some rain and snowmelt at the old minesite. Where does that water go and how much is there? In the fall of 2019, no water upstream of the old minesite was collected at Station E222526, because there was negligible flow, yet flow below the old minesite was sampled. Where did that water come from? Groundwater is not monitored and reported because Permit 3904 does not require groundwater monitoring. This means that there could be a substantial unidentified contaminated flow of subsurface groundwater leaving the old Ajax Minesite and flowing towards Peterson Creek through the Aquifer.

Even MOE has shown some confusion on this issue. In its Notice Letter of inspection dated October 19, 2018, the MOE inspector explains:

> *"As reported in Section 4.1.1 of the 2017 Annual Report, 'The pond has no discharge but seepage has been noted on the westerly side of the dam on several occasions.' There is no permit requirement to monitor the rate of discharge from this source, therefore compliance with this section could not be determined."*

In 2015, KGHM Ajax Mining submitted its Ajax Project Environmental Impact Statement (KGHM, 2015). As explained in the next chapter, this EIS plays a critical role in explaining the groundwater pathways from the minesite components to Peterson Creek through the Aquifer. The EIS tells us what this Permit 3904 and its monitoring cannot.

At this point, it is important to see that the Ajax EIS recognizes the unmonitored loss of water at the old minesite, with Appendix 6.3-A saying, ". . . seepage losses are suspected from the seepage collection ponds." Is this an unauthorized "bypass" under Permit 3904?

4.2 Chemistry of Water Discharged from the Old Ajax Minesite

There are several sources of water contamination at the old minesite (Table 2-1). These sources can release contaminated water into surface ponds and into subsurface groundwater pathways (Table 2-2).

Only a few surface pathways are monitored under Permit 3904, although there is no direct surface discharge, and no groundwater pathways are monitored. This emphasis on surface water can be seen in the Permit monitoring requirements where "sampling and analysis are not required during periods of no-flow". Groundwater beneath the old minesite is always flowing, but the Permit ignores this.

We know the water must be going somewhere. And we can expect significant contamination from it. For example, the KGHM EIS (2015) pointed out that evaluations of the rock backfilled into the East Pit "designate this rock as PAG [potentially acid generating]."

In the five-year Assessment Report for 2018 (Knight Piesold, 2019), Peterson Creek Monitoring Station E222526 located at the outlet of Jacko Lake and upstream of the old minesite (Figure 2-2) had this description of water quality:

> *"Iron was the only parameter to exceed the aquatic life short-term maximum BCWQG [British Columbia Water-Quality Guidelines]; exceedances occurred in the Spring of 2008, and the Autumns of 2007, 2008, 2013, and 2015. No other parameters exceed the aquatic life, wildlife, or livestock water quality guidelines at this location."*

As this same report states,

> *". . . it should be noted that there is no surface connection between these ponds and nearby streams; therefore, the mine waterbodies are not affecting natural aquatic life."*

This implies that downstream Peterson Creek Monitoring E222527, downstream of the old minesite (Figure 2-2) and approximately 3 km downstream of E222526, should have about the same water chemistry. It does not, and creek concentrations are higher:

"Sulphate concentrations are generally below guidelines; however, intermittent exceedances of the aquatic life 30-day BCWQG are seen, with four of the five exceedances occurring within the last five years. Iron exceeded the aquatic life short-term maximum BCWQG in the fall 2017 and 2018. Selenium exceeded the wildlife and aquatic life BCWQGs in the fall 2018 sample; the aquatic life exceedance shown for the sample collected in April 2008 is an artefact of the high MDL [method detection limit meaning an unreliable detection limit was used]. Molybdenum exceeded the livestock and wildlife guidelines intermittently."

This proves there is at least one pathway of subsurface contamination entering Peterson Creek between these two stations. The contaminants include sulphate and molybdenum which have been confirmed for Ajax rock (see Chapter 2 above). This also explains why flow in the creek below the old minesite was seen (and sampled) in the fall of 2019, but not above the old minesite.

However, this verbal comparison does not show the true, dramatic effect of the old Ajax Minesite on Peterson Creek. To show this, the water analyses between 2007 and 2018 were plotted for selected analyses (Figures 4-1 to 4-4), particularly sulphate and molybdenum which is expected from Ajax rock (see Chapter 2 above). As an example of comparisons to water-quality guidelines, downstream peak molybdenum concentrations exceed the Short-Term Acute British Columbia Water Quality Guideline for Wildlife and Irrigation (0.05 mg/L). Also, the most recent molybdenum peak exceeds the Maximum Acceptable Human Source Drinking Water Quality Guideline of 0.25 mg/L.

Alarmingly, many of the downstream molybdenum peaks above 0.05 disappeared in the 2019 report (Knight Piesold, 2020) which is copied in Figure 4-5. Therefore, there are discrepancies in water analyses among the permit reports, which raises uncertainty on the actual degree of contamination.

These plots reveal several important observations.

Observation 1) Peterson Creek concentrations downstream of the old minesite are notably higher than upstream concentrations. This applies to aqueous elements like sulphate and molybdenum, which act as tracers for mine-derived contamination.

Observation 2) Due to Observation 1, there is at least one subsurface pathway through the Peterson Creek Aquifer (Table 2-2) carrying contamination from at least one component (Table 2-1) at the old Ajax Minesite.

Observation 3) Creek concentrations downstream of the old Ajax Minesite show major seasonal variations. As a result, monthly or more frequent monitoring is required to reliably characterize the ongoing contamination of Peterson Creek. Unmonitored creek flows likely vary substantially throughout the year, and shallow groundwater levels vary by up to 3 m throughout the year (see Chapter 5 below). As a result, the major seasonal variations in chemical concentrations likely reflect the seasonal differences between (a) the inflowing contaminated groundwater and (b) the creek flows that dilute the inflowing groundwater.

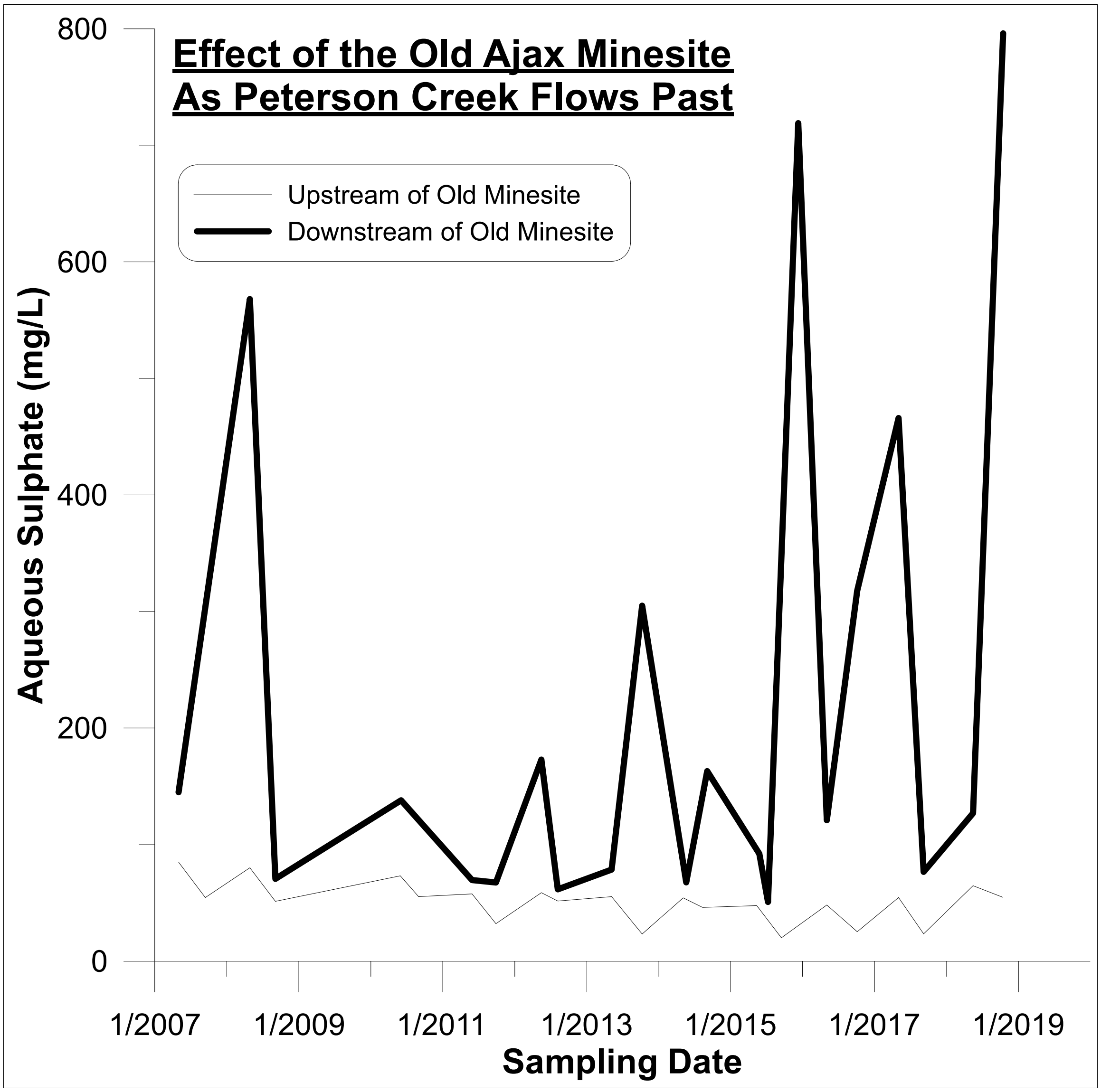


Figure 4-1. Aqueous concentrations of sulphate in Peterson Creek upstream and downstream of the old Ajax Minesite, showing substantial increases downstream.

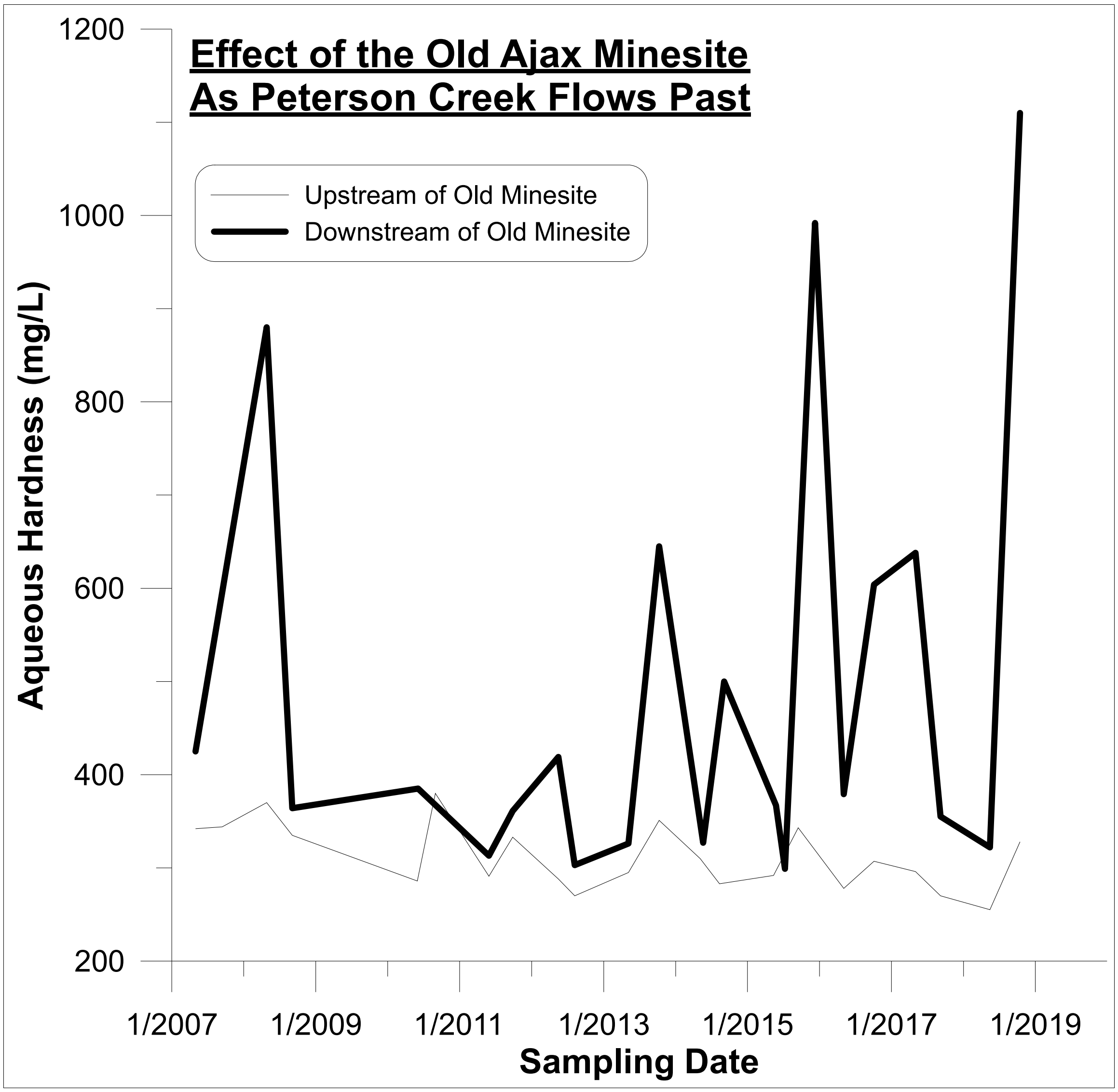


Figure 4-2. Aqueous concentrations of hardness in Peterson Creek upstream and downstream of the old Ajax Minesite, showing substantial increases downstream.

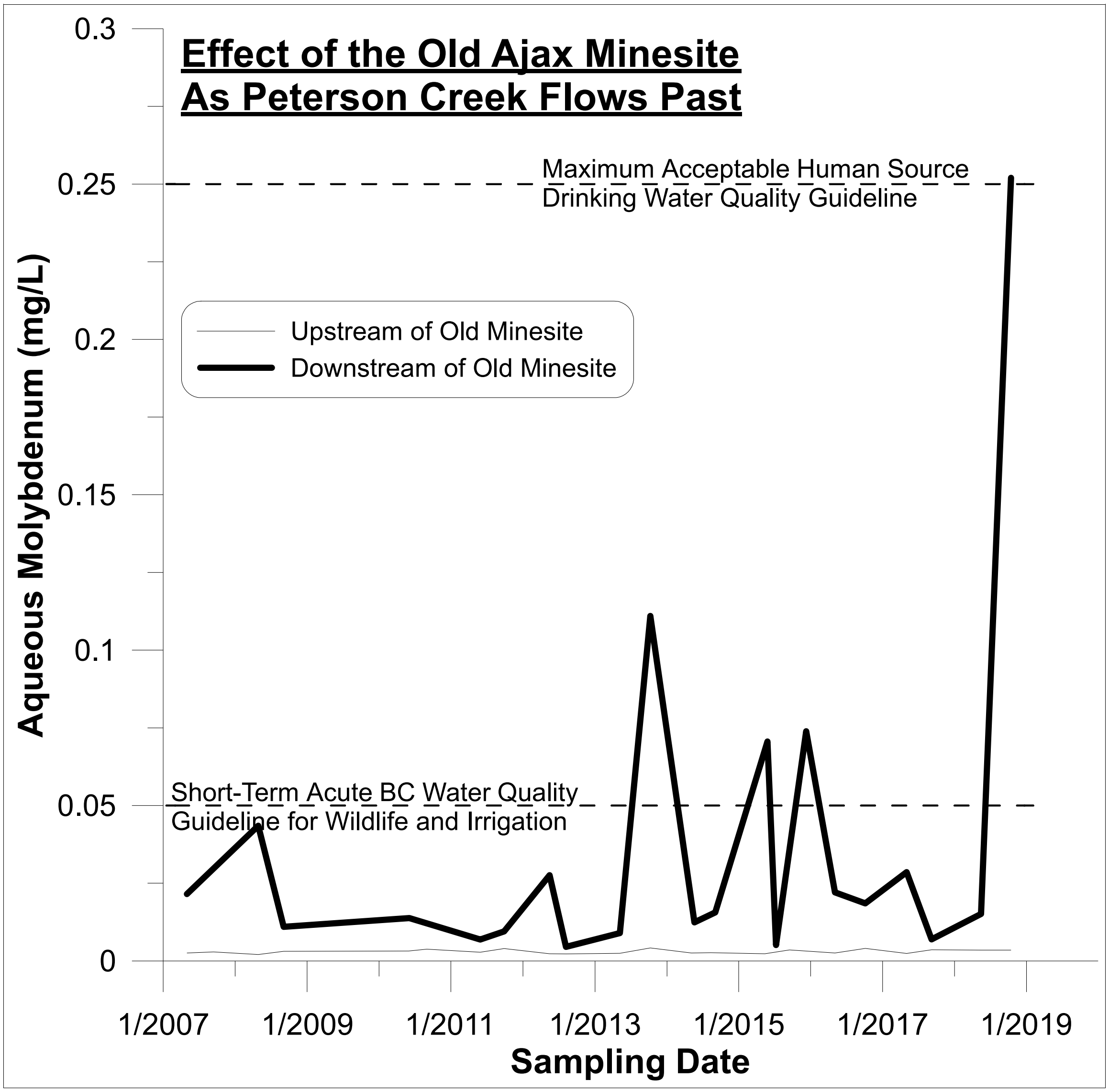


Figure 4-3. Aqueous concentrations of molybdenum in Peterson Creek upstream and downstream of the old Ajax Minesite, showing substantial increases downstream and exceedances of water-quality guidelines.

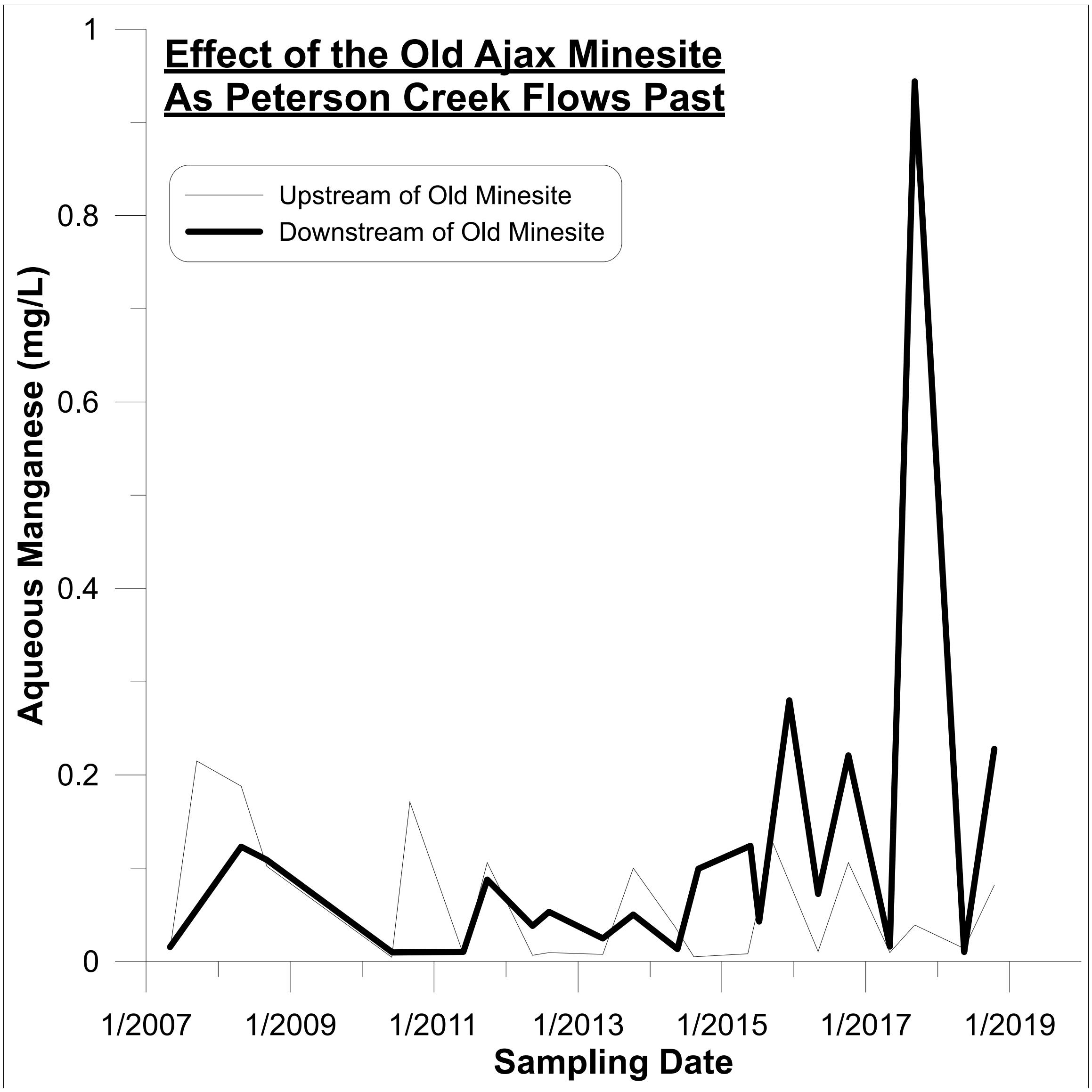


Figure 4-4. Aqueous concentrations of manganese in Peterson Creek upstream and downstream of the old Ajax Minesite, showing substantial increases downstream.

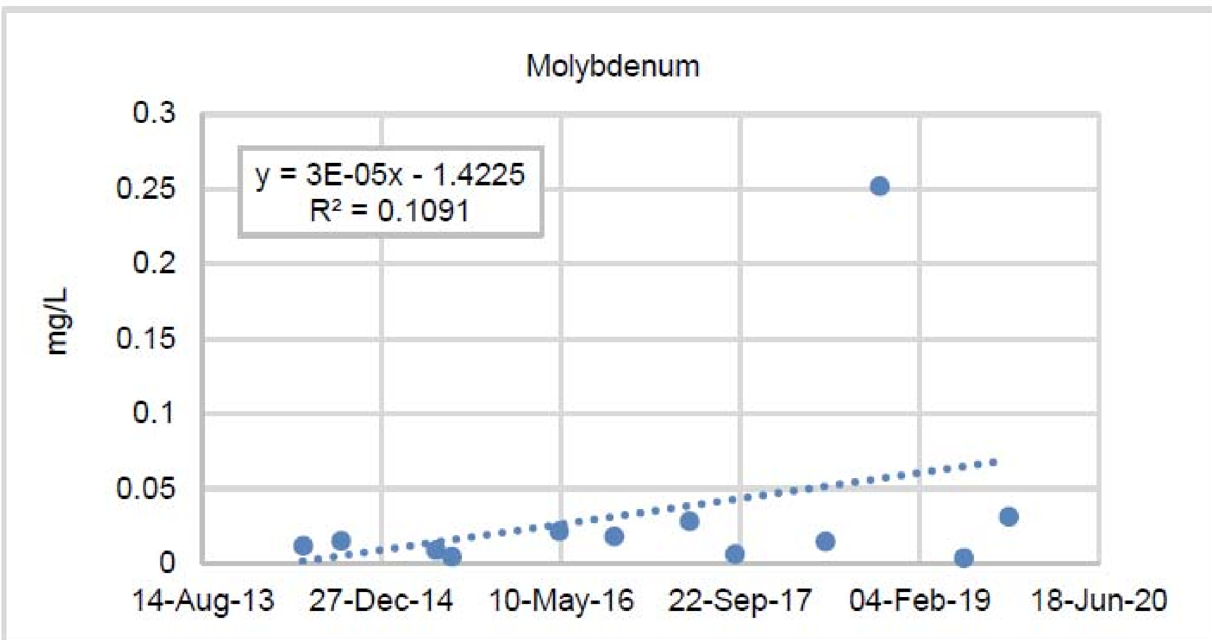


Figure 4-5. Aqueous concentrations of molybdenum in Peterson Creek downstream of the old Ajax Minesite, copied directly from a permit monitoring report (Knight Piesold, 2020), which should match the heavy line in Figure 4-3 exactly but instead shows errors in the KGHM monitoring database.

Observation 4) Peak concentrations in Peterson Creek downstream of the old minesite have been generally increasing and thus worsening since 2013 and continues to the end of 2019. Upstream concentrations are generally lower and are mostly remaining relatively stable or decreasing. This should be taken as a warning. However, some high levels of water contamination measured downstream since 2013 have disappeared in the 2019 report, so monitoring data should be used cautiously.

Observation 5) The previous observations are not dependent on "background" or "baseline" concentrations in the area. In fact, any elevated "baseline" concentrations could simply be widespread contamination from the old mining operations that have occurred for many decades to centuries.

For additional confirmation, we can look at the similar surface-water chemistry at the other Permit monitoring locations that represent contaminant sources (Figure 2-2 and Tables 2-2 and 3-1). Here are the summaries for those locations from the five-year Assessment Report (Knight Piesold, 2019), and watch for the additional contaminants like selenium and uranium at some locations.

North Seepage Pond (E313310, Figure 2-2):

"The water sample was neutral to basic, and extremely hard (2180 mg/L dissolved CaCO3). Sulphate exceeded the freshwater aquatic life 30-day BCWQG; however, the hardness value is outside the established threshold. The sample does exceed the static livestock BCWQG for sulphate. Arsenic exceeded the freshwater aquatic life short-term maximum BCWQG of 0.005 mg/L. Selenium exceeded the aquatic life and wildlife long-term average BCWQG (both set at 0.002 mg/L)."

East Overburden Seep (E313311):

"The Overburden Seep water sample was basic and extremely hard (2,060 mg/L dissolved $CaCO_3$). Sulphate, nitrate, selenium, and uranium exceeded the aquatic life long-term average BCWQGs. Selenium also exceeded the wildlife long-term average guideline. Molybdenum exceeded the wildlife and livestock short-term maximum BCWQGs, which are both set at 0.05 mg/L."

NOTE: Overburden (reportedly till in this case) is often considered innocuous because it can be thought of as soil. However, as mentioned in Chapter 2, the old Ajax overburden likely contains some reactive rock. The water chemistry of this overburden seep is worse than waste-rock seepage for some parameters.

South Waste Rock Seepage Pond (E313312):

"The Waste Rock Seepage Pond water was basic and extremely hard (1,770 mg/L dissolved CaCO3). Sulphate exceeded the aquatic life 30-day average guideline and the livestock guideline. Molybdenum exceeded short-term maximum guidelines for wildlife and livestock (both set at 0.05 mg/L)."

Moreover, the 2019 annual report (Knight Piesold, 2020, Appendices E1 and E2) used the statistical procedure of linear correlation to evaluate whether aqueous concentrations were generally increasing or decreasing over the years. Upstream of the old minesite (Station E222526), 41% of plots showed increasing levels, whereas 85% of plots showed increasing levels downstream of the old minesite

(E222527). Therefore, not only are downstream concentrations typically higher, more of them are worsening through time.

Finally, for another permit not related to Permit 3904, KGHM Ajax Mining (2018) itself has concluded the old minesite is contaminating Peterson Creek,

> *"With the exception of molybdenum, increased concentrations are not attributed to mining activity."*

However, the contamination is certainly not limited to molybdenum, as shown here.

In summary, Permit 3904 fails to specify monitoring at the old Ajax Minesite for surface flows, groundwater flows, groundwater chemistry, and flows in Peterson Creek. As a result, it is not possible to calculate contaminant mass balances or to trace flowpaths back to their sources. All we can tell from Permit monitoring is that there are sources and pathways, and the water quality of Peterson Creek downstream of the old minesite is worsening.

This would normally be the end of a Permit review. However, the Peterson Creek and Aquifer have been studied in detail for another reason: the Ajax Project EIS (KGHM, 2015).

That EIS focussed on the effects of proposed future mining, including a large pit that would consume most of the old minesite components in Table 2-1 and Figure 2-2. In order to predict possible future impacts in the EIS, the current "baseline" conditions had to be characterized.

This EIS baseline work, summarized next in Chapter 5, explains the details of groundwater movement that Permit 3904 fails to require. Because of the baseline studies, we now know and understand Peterson Creek and Aquifer much better. This includes the effects of the West Ajax Pits which were thought to draw most groundwater towards them, but that is now shown to be wrong.

5. BASELINE GROUNDWATER ASSESSMENT IN THE AJAX PROJECT ENVIRONMENTAL ASSESSMENT

The Ajax Project Environmental Assessment Certificate Application / Environmental Impact Statement for a Comprehensive Study (EIS) was a huge, sprawling document with dozens of technical appendices (KGHM, 2015). Within this document, a few portions discussed the existing (baseline) water flows and water chemistry of Peterson Creek and Aquifer. It is important to note that KGHM Ajax Mining is referring to existing water chemistry as "baseline" and "pre-mining", whereas in reality this "baseline" is after decades of contamination from previous mining.

The most prominent document in the EIS on the physical movement of groundwater in the area was Appendix 6.6A, *Baseline Groundwater Hydrology Assessment*, by BGC Engineering Inc. (2015). Most of this chapter is based on that Appendix 6.6A, but others are used also for additional information such as groundwater chemistry.

5.1 Peterson Creek Aquifer

Within the immediate area of the old Ajax Minesite, there are five mapped aquifers:
- Sugarloaf Hill (No. 0276) bedrock aquifer,
- Knutsford (No. 0275) bedrock aquifer,
- part of the Brigade Lake (No. 0274) bedrock aquifer,
- Davidson Creek (No. 0277) sand and gravel aquifer surrounding Davidson Brook, and
- Peterson Creek (No. 0278) sand and gravel aquifer surrounding Lower Peterson Creek.

Due to the way that the provincial government identifies and maps aquifers, this gives the false impression that these aquifers are distinct from, and not connected to, some others.

Additionally, ground mapping and inspection for the EIS showed that the Peterson Creek Aquifer extends much farther westward, almost to Jacko Lake, than suggested by government office mapping. Ground mapping also confirmed scattered "anthropogenic material" (mine wastes from the old Ajax Minesite) just to the east of Jacko Lake and along Peterson Creek. This is called "Disturbances like mine roads, rock spills, and creek crossing" included in Tables 2-1 and 2-2 of this review.

The focus here is on the sand-and-gravel Peterson Creek Aquifer, which extends virtually from Jacko Lake as far as several kilometers to the east, and on Peterson Creek that flows along the top of it. Nevertheless, there are adjacent bedrock aquifers on the north and south sides of the Peterson Creek Aquifer (and underneath it) that are hydraulically connected to it. These connections are probably helped by the historical underground mining in the area (Section 2.2 of this review). Combined, these aquifers and the creek represent one single, hydraulically linked, system of water flow and movement. Thinking of them separately and not linked can lead to misunderstandings.

Figure 5-1 is taken from Appendix 6.6A (BGC, 2015). It shows the conceptual formation of the Peterson Creek Aquifer, the bedrock aquifers surrounding it, and Peterson Creek flowing on top.

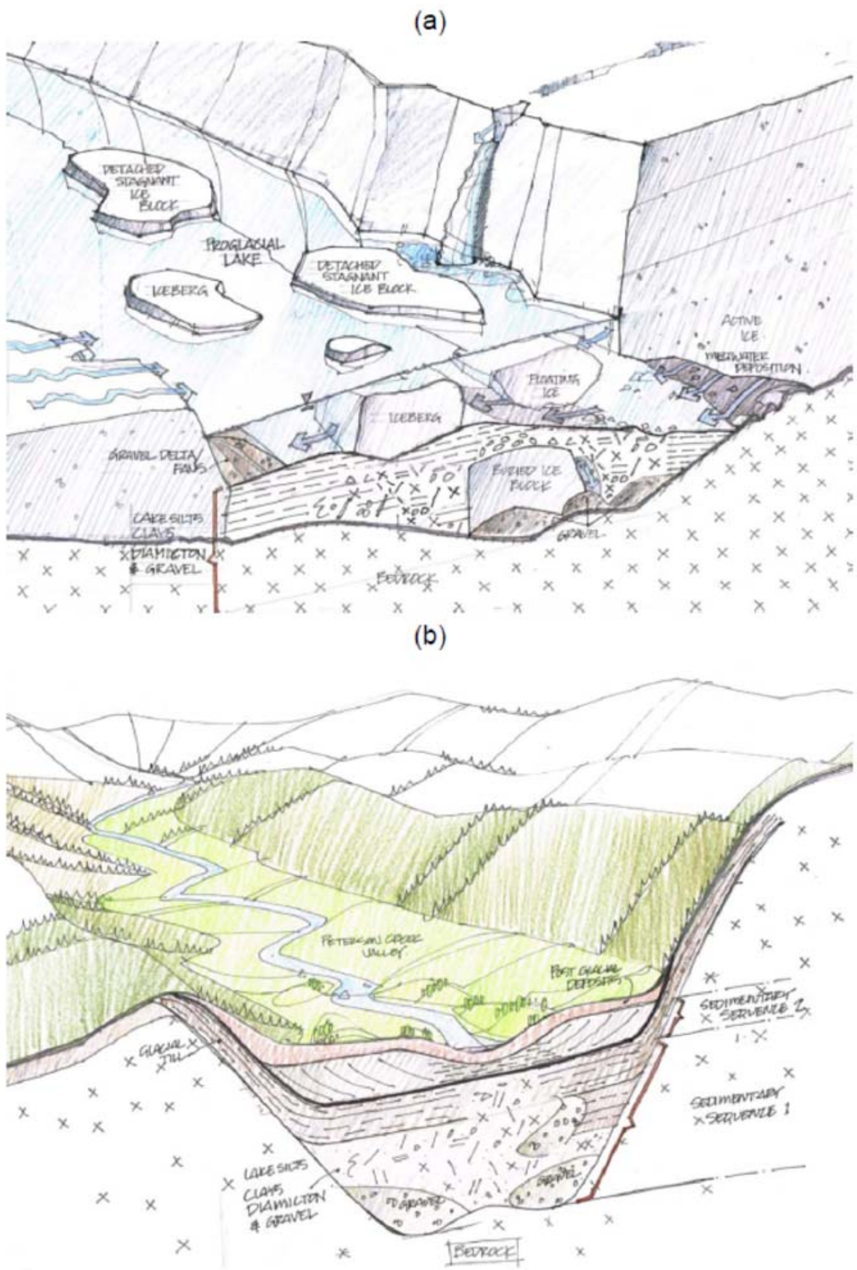


Figure 8. Conceptual Depositional Model for Surficial Materials within the Peterson Creek Valley.

Figure 5-1. A conceptual diagram of the Peterson Creek Valley during glaciated times (top) and now (bottom) (taken from BGC, 2015).

For the Ajax EIS, the aquifers had been investigated and monitored with dozens of monitor wells and piezometers, various testing for hydraulic conductivity, and water sampling for chemistry. This work was important for estimating future inflows into a proposed, very large pit that would affect groundwater flows and chemistries, the aquifers, Peterson Creek, and Jacko Lake.

While the details of the aquifers can be complex, this review needs only a very simple vertical cross-section to explain general water movement as it relates to the old Ajax Minesite (see Figure 5-2), with the Ajax EIS providing a larger-scale version (Figure 5-3). In a way, Peterson Creek can be thought of as the "tip of an iceberg", the top of a large water flow system most of which is not visible.

There are months when groundwater flows into Peterson Creek from the groundwater system (Figure 5-2), and months when the opposite may occur or the inflow is at least reduced. Appendix 6.6A of the EIS explains,

> *"Groundwater levels near the Project vary from less than 0.1 m to approximately 4 m, annually. Groundwater elevations typically decline from September to March and are highest from June to September. This seasonal variation is consistent with climatic trends. Some groundwater monitoring locations near the Ajax Project show rapid water level recoveries following precipitation events. These locations are interpreted to receive localized recharge due to higher permeability near surface sediments or fractured bedrock. Monitoring locations where groundwater levels reach seasonal maxima in September or October may receive recharge from distant sources in addition to delayed surface infiltration caused by near surface lower permeability sediments."*

This may account for the seasonal peak contaminant concentrations detected downstream in Peterson Creek (Figures 4-1 to 4-4). However, monitoring under Permit 3904 is inadequate to characterize this variability and even to reliably show it is happening.

5.2 Directions of Groundwater Flow in the Vicinity of the Old Ajax Minesite

There is an important issue that should be resolved here. In various documents like Permit 3904 monitoring reports, MOE emails, and portions of the Ajax EIS, people have noted that the water levels in the Ajax West Pits are lower than the ground surface and lower than the surrounding water table.

Actually, the water elevations in these pits are not reported. Instead, "height of water" in these pits has been measured, apparently based on an unreported elevation of the base of each pit, which might now be filled with collapsed rock from the pit walls. Nevertheless, visual estimates of pit-water elevations show they are relatively low.

As a result, a common assumption is that most of the unmonitored contaminated groundwater at the old Ajax Minesite would flow towards and into these pits. In turn, little if any contamination from the old minesite could theoretically reach Peterson Creek.

Section 4.2 of this review and Figures 4-1 to 4-4 already show this common assumption is wrong. However, there is more conclusive evidence.

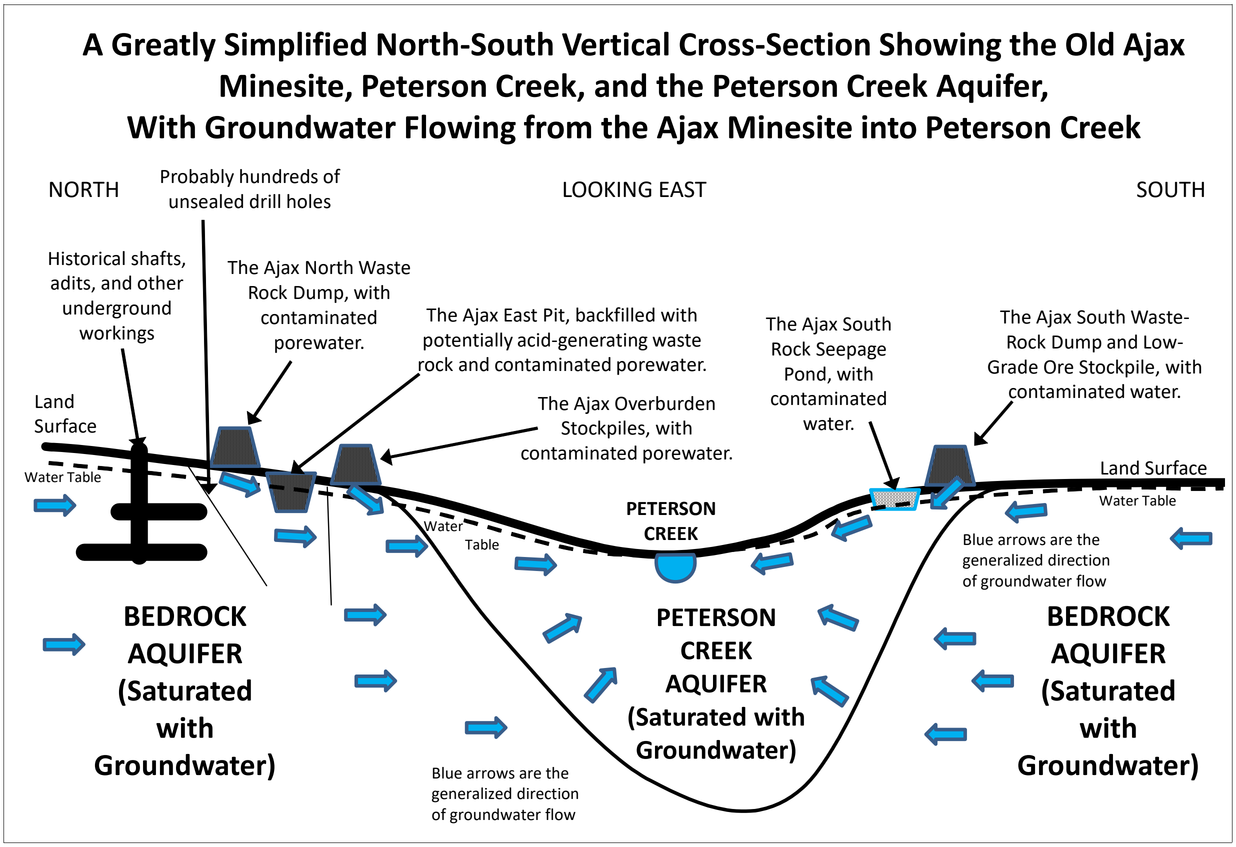


Figure 5-2. A greatly simplified vertical north-south cross-section through Peterson Creek and its Aquifer, the surrounding bedrock aquifers, and components of the old Ajax Minesite.

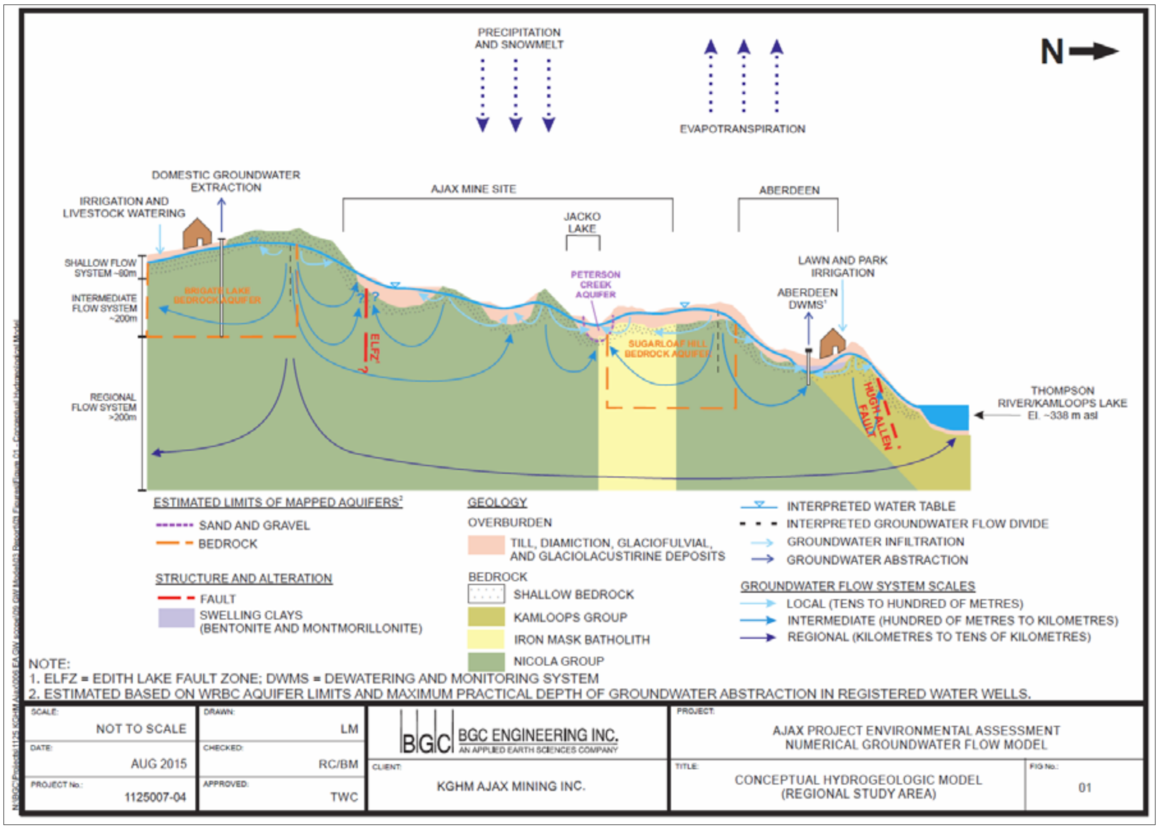


Figure 5-3. A larger-scale, regional version of Figure 5-2 from the Ajax EIS, but with North to the right.

Monitoring under Permit 3904 cannot help here, because it ignores groundwater. Fortunately, the Ajax EIS once again provides valuable information on this issue.

Dozens of monitor wells and piezometers, some measured for groundwater elevation hundreds of times over two years, show these pits have no detectable effect on groundwater flow through the old minesite, at least 150 m outside their perimeters. This applies to both shallow groundwater (Figure 5-4) and deeper groundwater (Figure 5-5).

For further evidence of this in this review, groundwater levels were taken from the EIS to create two vertical cross-sections through the old minesite area (Figures 5-6 and 5-7, which are not parallel to flow directions but cut across). These again show no significant effect of the Ajax West pits on groundwater movement through the old Ajax Minesite towards Peterson Creek.

Therefore, the common assumption that the Ajax West Pits can capture most groundwater contamination at the old minesite is false. Also, this common assumption is inconsistent with creek monitoring (Figures 4-1 to 4-4 of this review).

The reason why the pits capture relatively little groundwater, at least from 150 m and more away from their perimeters, is not clear. Appendix 6.6A of the Ajax EIS says,

> *"Groundwater converges towards the existing Ajax West Pits and feeds a small water body occupying the pit floor. The groundwater monitoring data suggest that the groundwater system has not reached equilibrium, as groundwater levels in monitoring wells installed around the perimeter of the existing pits are considerably higher than the existing pit lake levels (e.g., approximately 902 masl at AJGW07-D/S, compared to approximately 875 and 837 masl for the existing Ajax West W and West E Pits, respectively). Some water entering the pit is lost to evaporation."*

These two pits have been open for about a quarter century. If they are not yet in equilibrium with the surrounding groundwater, they will likely continue to be out of equilibrium for many more decades. In any case, this is not a likely explanation considering hydraulic conductivities, but a likely one is not apparent without significantly more monitoring. This additional monitoring will not come from current Permit 3904 and will not come from the ended EIS studies.

In conclusion, the Ajax West Pits do not act as significant capture zones for contaminated groundwater beneath the old Ajax Minesite. As a result, contaminated groundwater moves towards Peterson Creek. This is shown by groundwater-elevation maps from dozens of shallow and deep monitor wells and piezometers in the Ajax EIS. This is also shown by substantially elevated downstream creek concentrations relative to upstream concentrations.

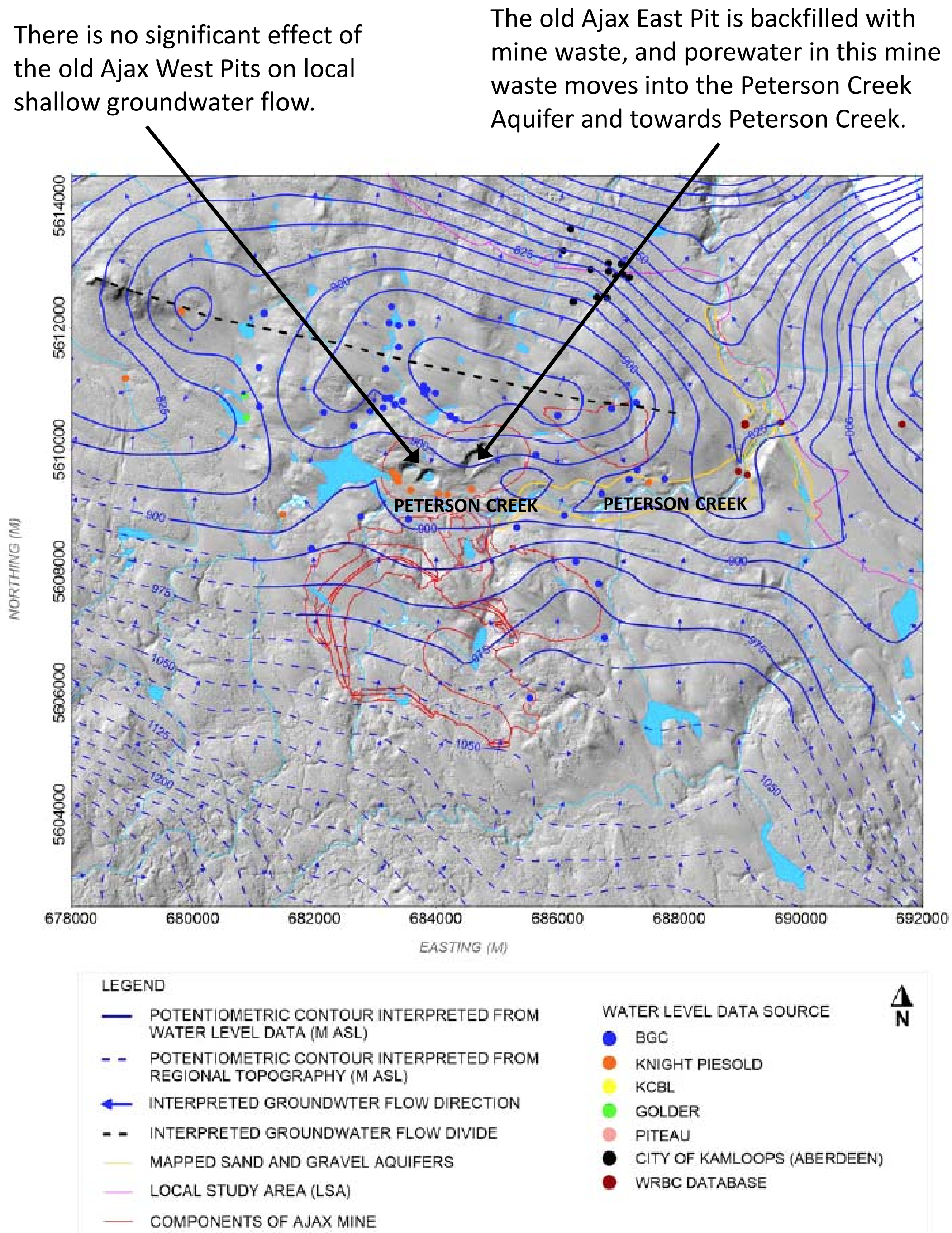


Figure 15. Interpreted LSA Water Table Configuration and Groundwater Flow Directions – Surficial Deposits.

Figure taken from Appendix 6.6A of the Ajax Project Environmental Impact Statement

Figure 5-4. Map of the shallow water table around the old Ajax Minesite, showing groundwater moving towards Peterson Creek and not being captured by the Ajax West pits (adapted from BGC, 2015).

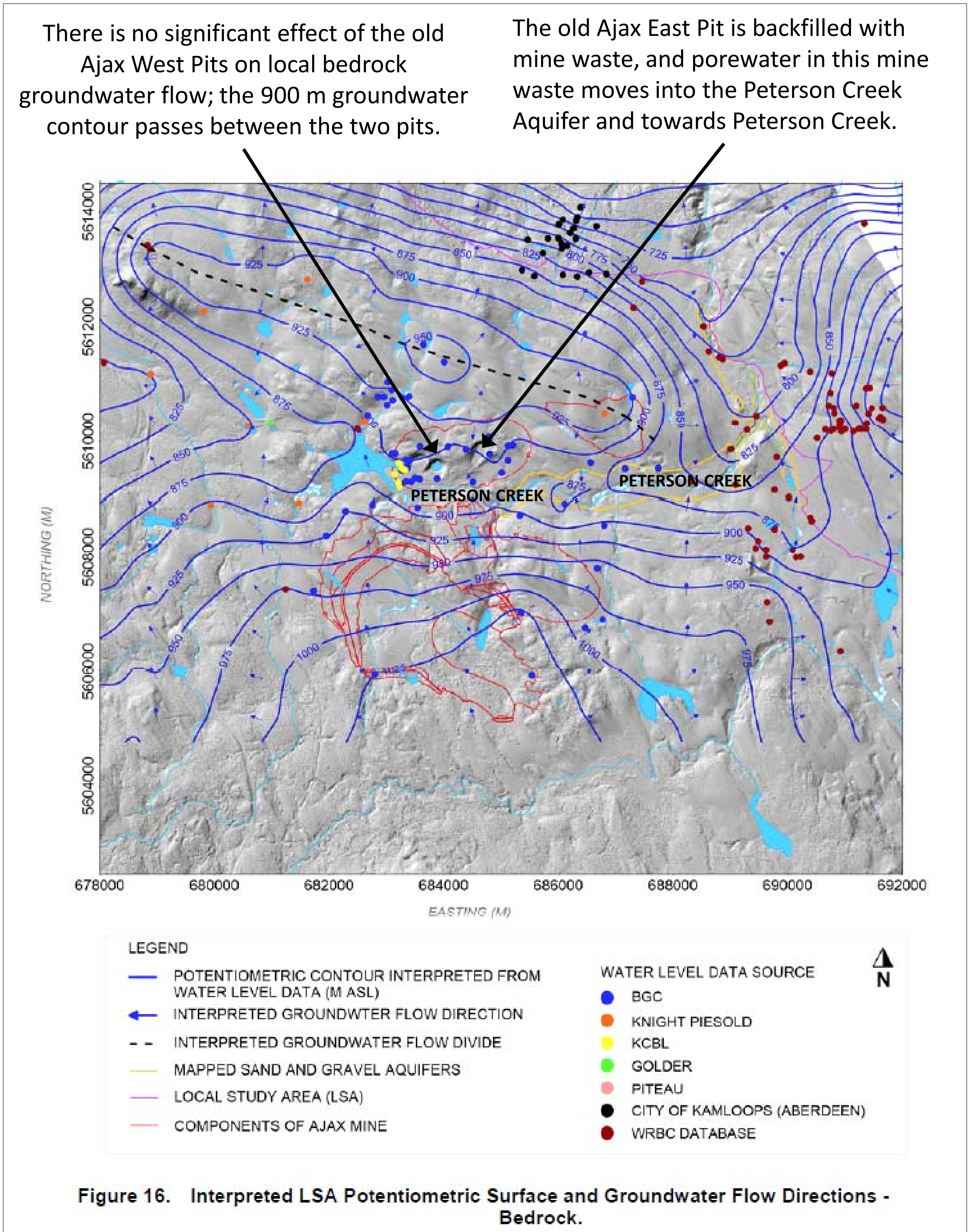


Figure 16. Interpreted LSA Potentiometric Surface and Groundwater Flow Directions - Bedrock.

Figure taken from Appendix 6.6A of the Ajax Project Environmental Impact Statement

Figure 5-5. Map of the deeper groundwater elevations around the old Ajax Minesite, showing groundwater moving towards Peterson Creek and not being captured by the Ajax West pits (adapted from BGC, 2015).

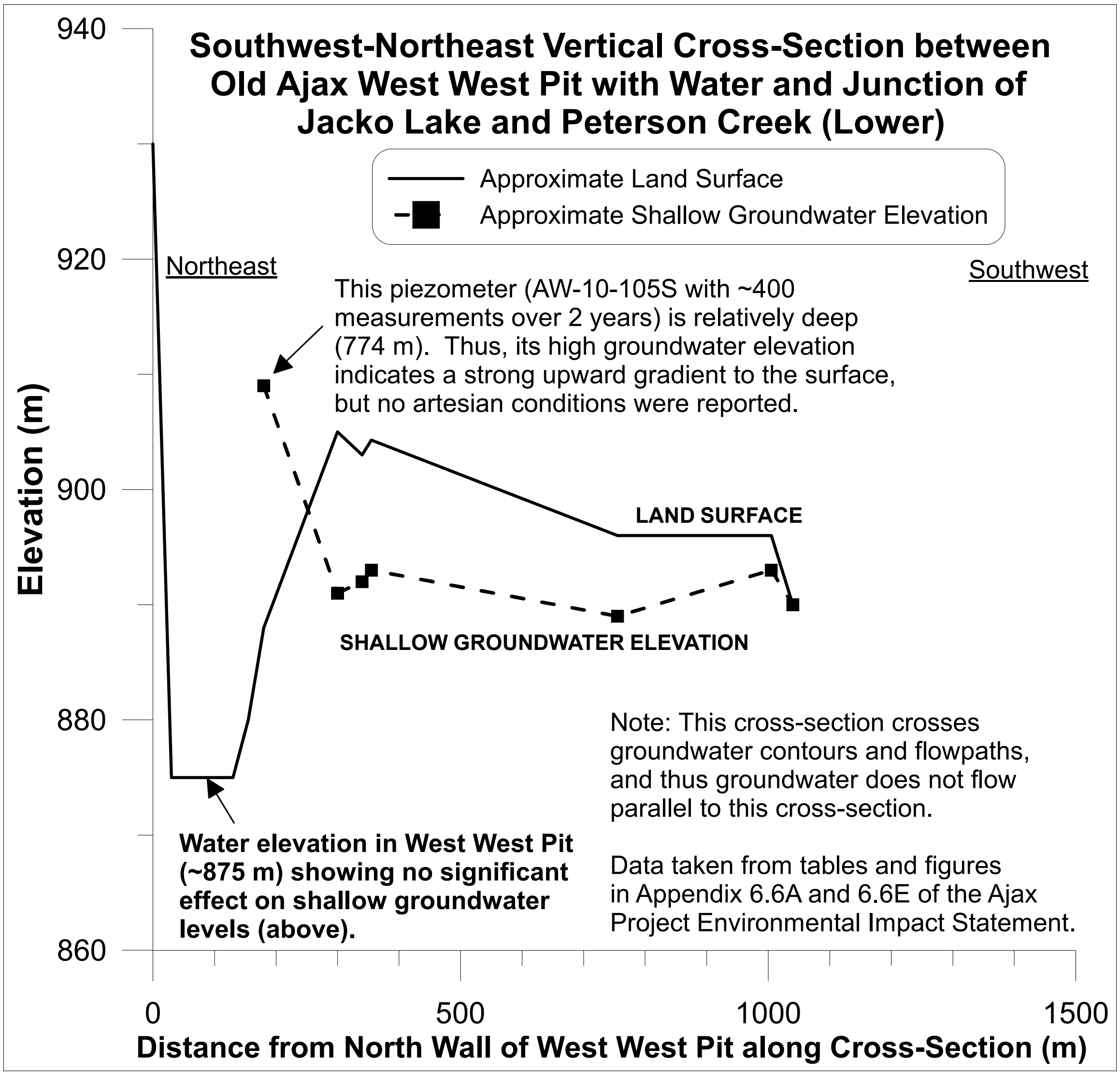


Figure 5-6. Vertical cross-section through the Ajax West West Pit in the northeast to Peterson Creek in the southwest, showing no significant effect of the West West Pit on groundwater elevations.

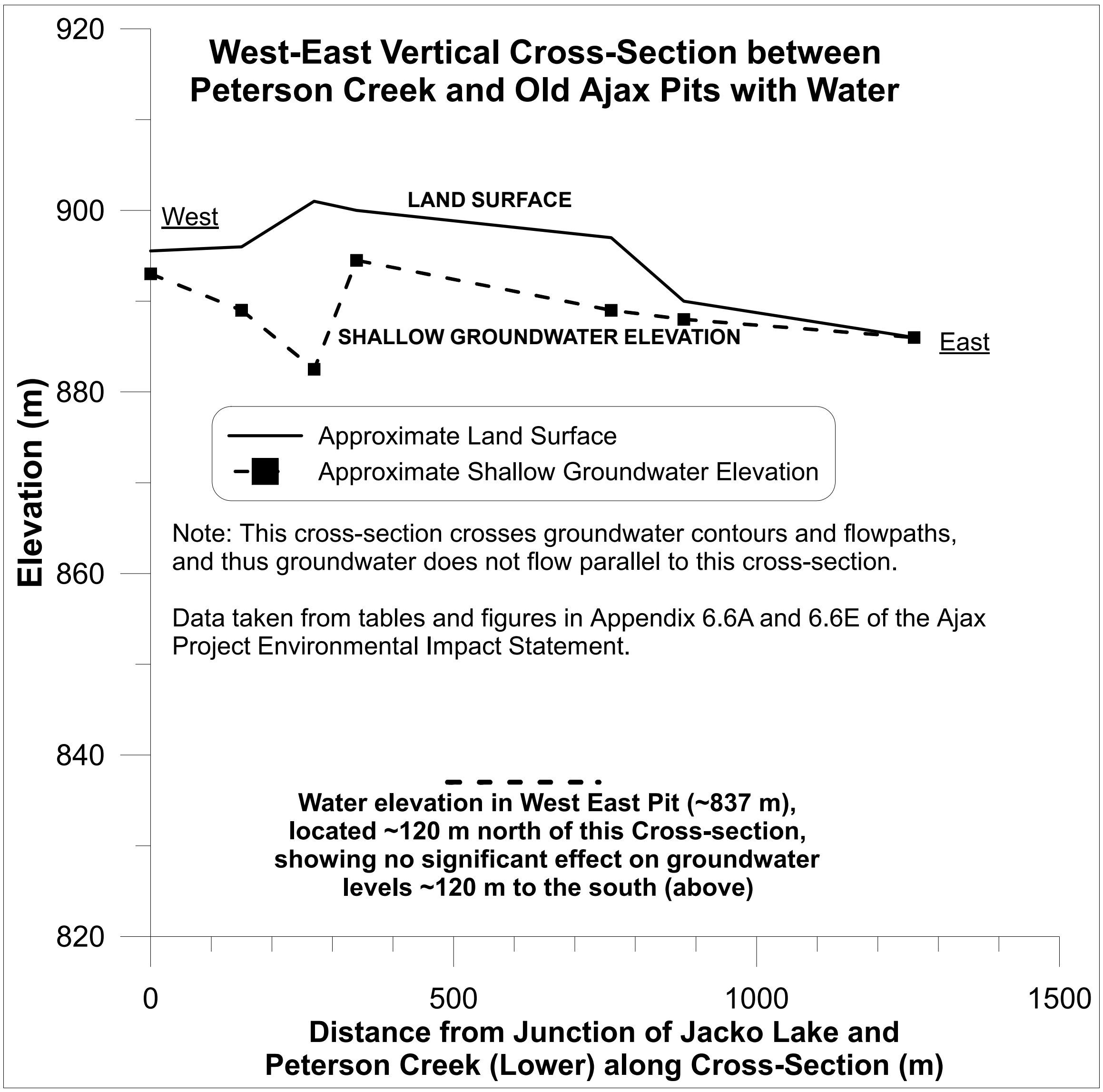


Figure 5-7. Vertical cross-section approximately 120 m south of the Ajax West East Pit, showing no significant effect of the West East Pit on groundwater elevations.

5.3 Additional Water Chemistry for the Old Ajax Minesite

The Ajax EIS also included additional water-quality stations not included in Permit 3904 (Tables 2-1 and 2-2). These are described in Appendix 3-A, Ajax Geochemical Characterization Study (Lorax Environmental, 2015)

The additional monitoring at the old minesite was (Table 5-1):

- water from the ponds in the West West and West East Pits (Stations AJWW and AJWE),
- porewater in the rock backfilled into the East Pit, collected from newly installed piezometers (Piezometers MW 12-01 and MW-12-02), and
- a seepage pond adjacent to the South Waste Rock Dump (Station WR-seep).

Table 5-1. Average aqueous concentrations of sulphate, hardness, molybdenum, and manganese in the additional sampling locations included in the Ajax EIS but not monitored as part of Permit 3904 (for comparison to Figures 4-1 to 4-4 in this review)

	Average concentration (mg/L) from water analyses in Lorax Environmental (2015)			
Location	Sulphate	Hardness	Molybdenum[1]	Manganese[1]
West West Pit - Shallow	1700	1730	3.61	0.0073
West West Pit - Deep	1760	1740	3.56	0.023
West East Pit - Shallow	1390	1200	2.15	<0.015
West East Pit - Deep	1470	1280	2.23	<0.015
East Pit Backfill - MW12-01	1720	1810	3.40	0.065
East Pit Backfill - MW12-02	1730	1800	3.31	0.10
South Waste Rock Pile Seepage - WR-Seep	1290	1180	0.52	0.092

[1] Dissolved (filtered) concentrations; as an example of water quality, concentrations of molybdenum far exceed the Short-Term Acute British Columbia Water Quality Guideline for Wildlife and Irrigation (0.05 mg/L) and the Maximum Acceptable Human Source Drinking Water Quality Guideline of 0.25 mg/L.

Section 4.2 of this review showed that the few minesite components and contaminant sources that are monitored under Permit 3904 (Table 2-1) could account for the contamination entering Peterson Creek (Figures 4-1 to 4-4). Table 5-1 shows that the other contaminant sources at the old minesite not monitored under Permit 3904 can also account for the creek contamination.

The detailed tracking of flowpaths from the contaminant sources, through the Peterson Creek Aquifer, and into Peterson Creek requires more monitoring of flows and chemistries than is currently available from Permit 3904 and the Ajax EIS.

6. CONCLUSION

KAPA asked MDAG to determine if the current monitoring requirements under Permit 3904 are adequate.

No, the Permit requirements:

- are woefully inadequate and ambiguous,
- lead to wrong interpretations and conclusions, and
- do not explain the dramatic increasing contamination of Peterson Creek by minesite-derived elements.

This is confirmed by the detailed baseline studies that KGHM Ajax Mining conducted for its Ajax Environmental Impact Statement (EIS).

The current Permit 3904 fails to identify and track contamination from the old minesite components, into the Peterson Creek Aquifer and into Peterson Creek itself. Therefore, major revisions to the Permit are needed. The revisions should include the following.

Recommendation 1) Monthly measurements of creek flows and chemistry, and of groundwater levels and chemistry, are needed. This is due to the highly variable seasonal fluctuations that cannot be reliably understood by the current twice-a-year, chemistry-only sampling in the Permit.

Recommendation 2) At least 20 surrounding monitor wells and piezometers should be monitored under the Permit. It is difficult to choose these additional points now, because at least some of those used in the Ajax EIS may no longer be functional. An inventory of functioning piezometers and monitor wells should be compiled as the first step to this revision.

Recommendation 3) All elements and parameters with water-quality guidelines for drinking, irrigation, wildlife, and aquatic life should be analyzed in dissolved (filtered) and total forms. Due to seasonal peaks, annual averages should not be compared to guidelines, but each monthly value should be compared to guidelines.

7. REFERENCES

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