Science Unit: ***Resource Extraction and the Environment***

Lesson 4: ***Ecological Impact of Cyanide Heap-Leaching***

School year:	2008/2009
Developed for:	Trafalgar Elementary School, Vancouver School District
Developed by:	Luana Avila (scientist), Nana Hashimoto and Rowshanak Vessali (teachers)
Grade level:	Presented to grades 4 - 5; appropriate for grades 4 – 7 with age appropriate modifications.
Duration of lesson:	1 hour and 20 minutes

Objectives

1. Learn the importance of mining to our society
2. Learn how heap leaching with cyanide is detrimental to the environment when heavy rains occur

Background Information

Mining is essential for our modern society. Every object we use was either grown or mined. As with the extraction of any resource, mining metal, oil, sand or gas carry some degree of damage to the environment. *Success in mining, like any business, requires that the minerals extracted by a mine produce more value over its operating life than was consumed in developing and operating it.* Therefore, where a company finds an area rich in ore, which are rocks *that* contain an economically significant quantity of a valuable mineral, it will most likely proceed to extract it in a profitable rather than sustainable way. Extraction of metals usually requires the removal of tons of rocks from the ground, creating an open-pit mine. Once the ore is stripped of the metal of commercial interest the rock, along with the water and reagents used to strip the metal become waste.

Modern extraction techniques allow the extraction of metals even from low-quality ore, which is ore that don't have a high concentration of metal. Currently, a process called Heap Leaching is the mining industry standard. Heap leaching requires a leaching reagent, which will combine with the metal of interest removing it from the rock. This method is capable of removing amounts of metal that are really tiny; it is invisible to the naked eye.

Cyanide is a commonly used leaching reagent for the extraction of gold from low-quality ore. The problem with the use of cyanide is its highly poisonous nature. The water is mixed with the cyanide and poured onto the ore dug from the ground. This solution leaches the gold from the rock and is dumped in a dam to become further concentrated. This concentrated solution, called the pregnant solution, is then purified to contain only gold. Cyanide leaching can yield a profitable return of about one gram of gold for every ton of ore.

During the process of cyanide leaching, spent ore (tailings) and cyanide are stored in ponds with liners that are intended to contain the contaminated waste. However, history can testify that many of these ponds can leak or break. heavy snowfall or rainfall can also cause spilling due to pond overflow and break. An accident caused by heavy snowfall occurred in Romania in 2000, which dumped 130,000 cubic metres of cyanide-tainted water into the river system.

The spilling of cyanide alone is a short-term problem, as it degrade reasonably fast; the long term problem is the spilling of cyanide accompanied by heavy metals. Cyanide is able to immobilize heavy metals, so that if the solution is let out into the aquatic environment then you have heavy metals which persist for a much longer period of time.

Natural Resources Canada stated that in 2004 (the last year for which a statistic could be found) there were 66 metal mines in operation. The Dublin Gulch is one recent mine in the Yukon Territory that uses cyanide heap-leaching.

Vocabulary

Word:	Brief definition.
Ore	Rock that contains metals of commercial interest
Cyanide	A poisonous compound that can strip metal from ore
Mining	The process of extracting resources from the ground
Heap-Leaching	A procedure used to strip very small amounts of gold from ore
Tailings	Ore that had its metal stripped

Materials: (per group)

- 4 cups (paper or Styrofoam)
- 1 cup water
- 2 tbsp of flour
- 1 cup of gravel
- 1 plastic bag
- Scissors
- Marker
- Spoon
- 5 drops of food colouring (red)
- Tarp to cover the floor (or do activity outside)

General materials

- A wide variety of materials that come from petroleum, sand, metals, wood, cotton, wool..anything that you know the origin of the material)
- watering can filled with water

In the Classroom

Introductory Discussion

1. Review society's need to extract resources
    - Why do we need to extract resources?
    - Which resources have we talked about so far?
    - How does extraction affect the environment?
2. What other resources can you think about?
3. Introduce the concept of mining
    - What resources are mined? (metals, sand, gas, oil)
    - What resources are grown? (food, wood, fabric)
4. Can you think of any object around us that wasn't mined or grown?

Activity #1: Mined or Grown?

Students will learn the importance of mining to our society

1. Bring as many objects to the class as there are students (any object is fine as long as you know the origin of the material)

2. Give each student an object and ask them to decide whether their object was grown, mined or other
3. Setup in front of the class a space for them to sort the objects into those 3 categories
4. Go over each object and briefly explain its origin
5. Ask the same question: is there any object around us that wasn't either mined or grown?

Students should realize that mining is essential for modern life.

Transition to experiment:

We have been loggers and dam builders; today we are going to be miners! You will use a method called heap-leaching to extract gold from rock. This method uses cyanide to remove the gold bits stuck in the rock. The cyanide sticks to the gold and makes it dissolve in water, and then the gold is purified from the cyanide and made into jewellery, coins, electronic parts, etc...

Our problem: cyanide is VERY poisonous and if spilled will kill fish, other water animals and poison our drinking water supply.

Solution: don't ever spill it!

Research question: Can we prevent our cyanide heap-leach mine from spilling even when we have heavy rainfall?

Science experiment: Ecological Danger of Gold Mining

Students will learn the impact of heavy rain in cyanide heap-leach mining operations

It is useful to use the same materials and set up a demonstration of the experiment. The groups can either set their experiment along with the teacher or they can watch first and set up after.

Experiment set up

1. Hand each group all the required material to heap-leach inside the plastic bag
    a. 1 cup of gravel
    b. 4 cups labelled
        i. cup 1= heap cup (bottomless cup) * if you have access use plastic funnels resting directly on the ‘catch cup’
        ii. cup 2= leaching solution cup (pouring cup)
        iii. cup 3= pregnant solution cup (catch cup)
        iv. cup 4= gold cup (to keep the wet flour)
    c. 2 tbsp flour
    d. Scissors
    e. Spoon
    f. Marker
2. Spread a tarp on your working surface (needs to be slightly high off the ground – like the edge of a desk or steps of a stair)
3. Use the scissors to remove the bottom of the heap cup (cup 1)

4. Use the scissors to cut the plastic bag open
5. Place the open plastic bag on the edge of the stairs' step
6. Place the bottomless cup on the open plastic bag and use it to cover the bottom of the cup.
7. Fill the bottomless cup with gravel
8. Sprinkle the 2 tablespoons of flour onto the gravel
9. Fill cup 2 (leaching solution cup) with water and add 5 drops of food colouring

Experiment

1. Pour the cup of coloured water on the gravel and with cup 3 (pregnant solution cup) catch the water that will come through the bottom of the plastic bag
2. Wait for the flour to settle and transfer the coloured water back to cup 2 (leaching solution cup)
3. Spoon the wet flour off cup 3 (pregnant solution cup) and store it in cup 4 (gold cup)
    a. The wet flour is your gold (warn students that it's going to be very little)
4. Pour the coloured water you transferred to cup 2 again on the gravel
5. Repeat the process until the rocks are clean (these rocks are now the tailings)
6. Each time you do transfer wet flour to your gold cup check to see if any water was spilled and make note of it. (if you have it available, use a cheese cloth to dry the flour)
7. The teacher will choose a few groups to have heavy rainfall - these groups will be caught by surprise and the teacher will simply pour a bunch of water (using the watering can) on their mining apparatus. The group will have to try their best to prevent spilling on the tarp.

Closure

Tally and discuss the results with the class (you may use a tally table similar to the one below)

	Normal Rain	Heavy Rainfall
# of groups		
# of spills		

1. What should we do with the left over rocks?
2. What should we do with the left over water?
3. What happened to those mines that experienced heavy rainfall?
4. How dangerous do you think cyanide heap-leaching is to food chains?
5. What can we do to prevent it?

Ask students to draw/ write about the experiment in their science Journal (if they have one, if not use the worksheet attached at the end of this lesson)

References

1. Intrusive and Porphyry-related Gold. BC Ministry if Energy, Mines and Petroleum Resources. <http://www.empr.gov.bc.ca/Mining/Geoscience/MetallicMinerals/NewModelsCordillera/Pages/IntrusiveandPorphyryrelatedGold.aspx> Accessed Feb04th 2009.

2. Dirty Gold: The toxic legacy of cyanide leach mining. Mining Australia 2004. <http://studentwork.hss.uts.edu.au/oj1/oj1_s2004/DirtyGold/index.htm> Accessed Feb04th 2009.

3. Heap leaching BioMineWiki. Heap leaching. Created Sept08th 2008. < http://wiki.biomine.skelleftea.se/wiki/index.php/Heap_leaching> Accessed Feb04th 2009.

4. Smith, Kenneth E.(1997) Cold-Weather Gold Heap-Leaching Operational Methods. JOM, 49 (4): 20-23.

5. Atlas of Canada - Precious Metal Mines, 2004. Natural Resources Canada. < http://atlas.nrcan.gc.ca/site/english/maps/economic/mining/metal_mines/metal_mines_2004/prec_metal_2004/1> Accessed Feb04th 2009.

Extension of Lesson Plan

1. Research sustainable mining techniques

Name:_____ **Date:**_____

The Process of Heap-Leaching Gold with Cyanide

In our Cyanide Heap-leaching model what do the following items represent in a real gold mine?

Rocks:_____

Flour:_____

Food colouring:_____

Water:_____

Draw the experiment setup:

What kind of rainfall did your group have?_____

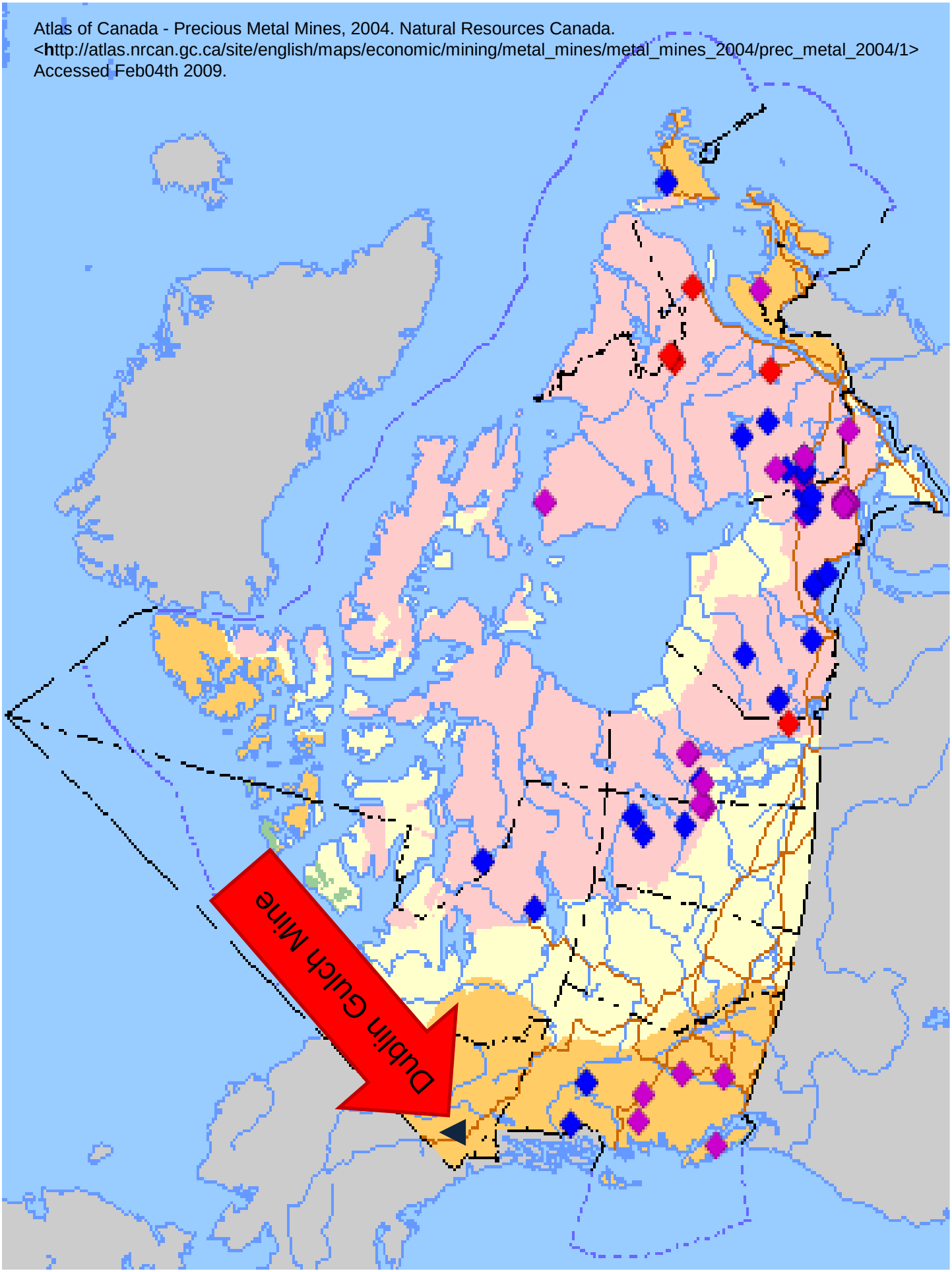
Did you have any spills?_____

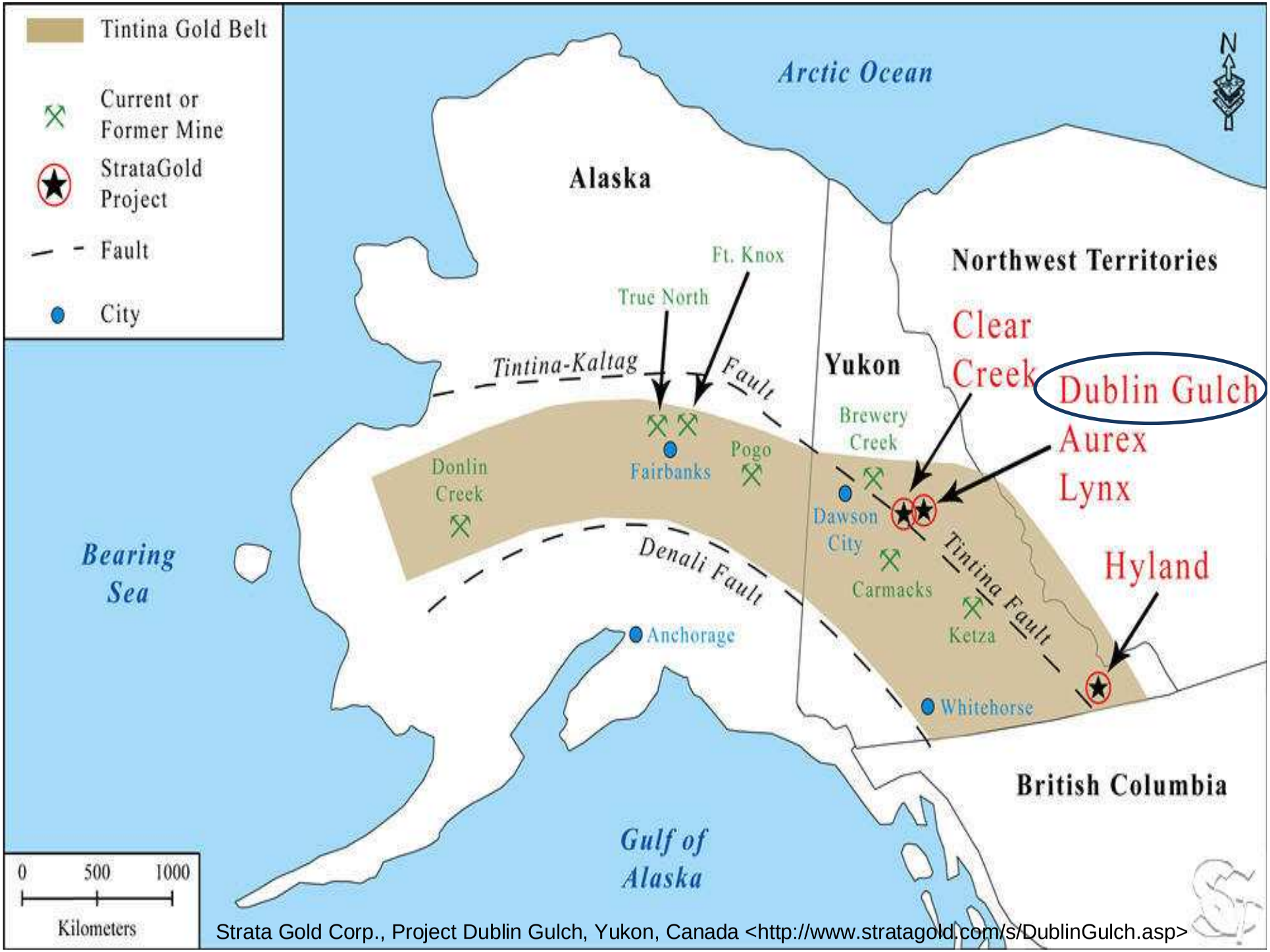
What do you think is the effect of gold extraction on the different biomes?

_____

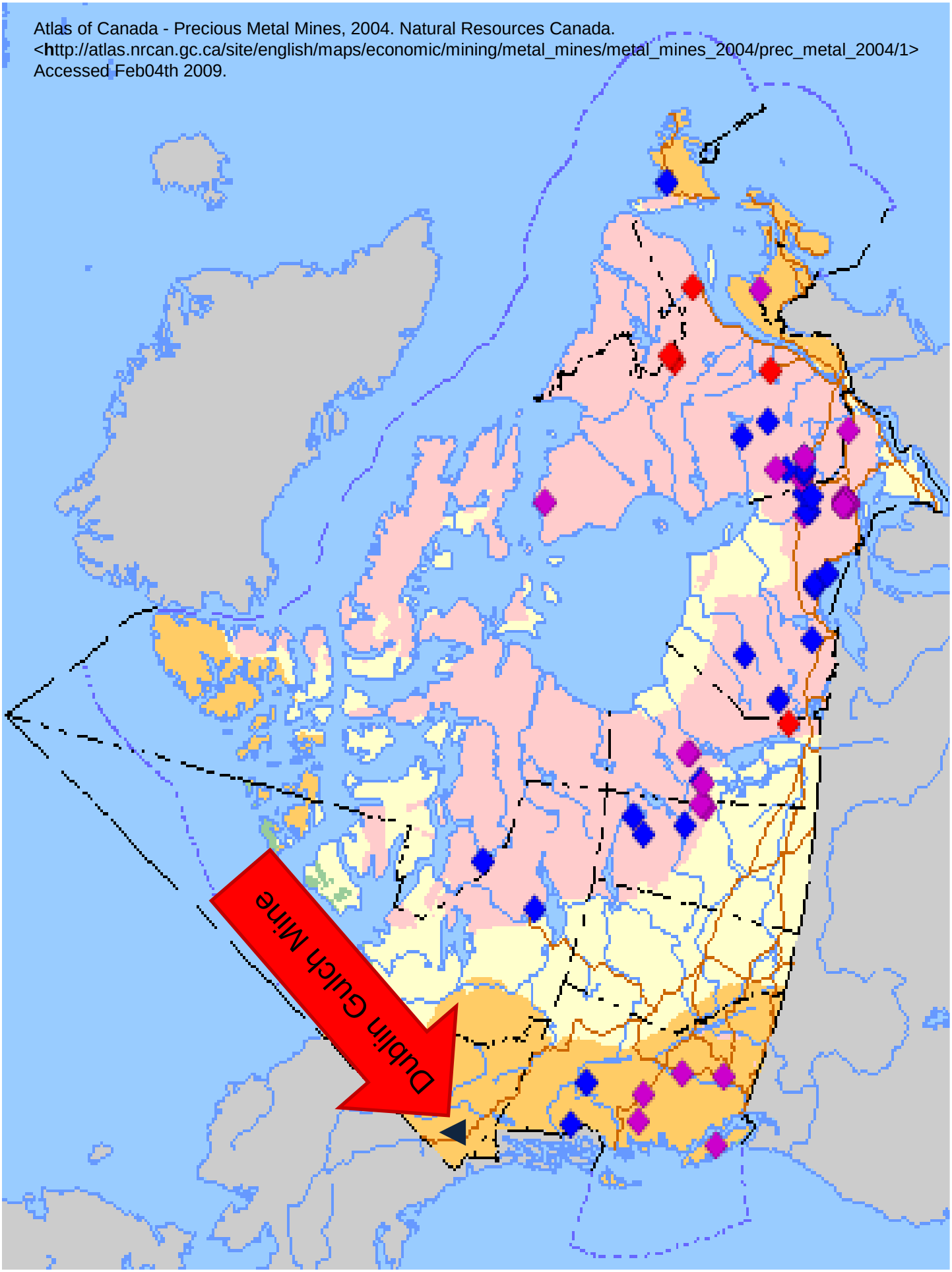
_____

_____


Atlas of Canada - Precious Metal Mines, 2004. Natural Resources Canada.
<http://atlas.nrcan.gc.ca/site/english/maps/economic/mining/metal_mines/metal_mines_2004/prec_metal_2004/1>
Accessed Feb04th 2009.
Dublin Gulch Mine



Strata Gold Corp., Project Dublin Gulch, Yukon, Canada <http://www.stratagold.com/s/DublinGulch.asp>


Atlas of Canada - Precious Metal Mines, 2004. Natural Resources Canada.
<http://atlas.nrcan.gc.ca/site/english/maps/economic/mining/metal_mines/metal_mines_2004/prec_metal_2004/1>
Accessed Feb04th 2009.
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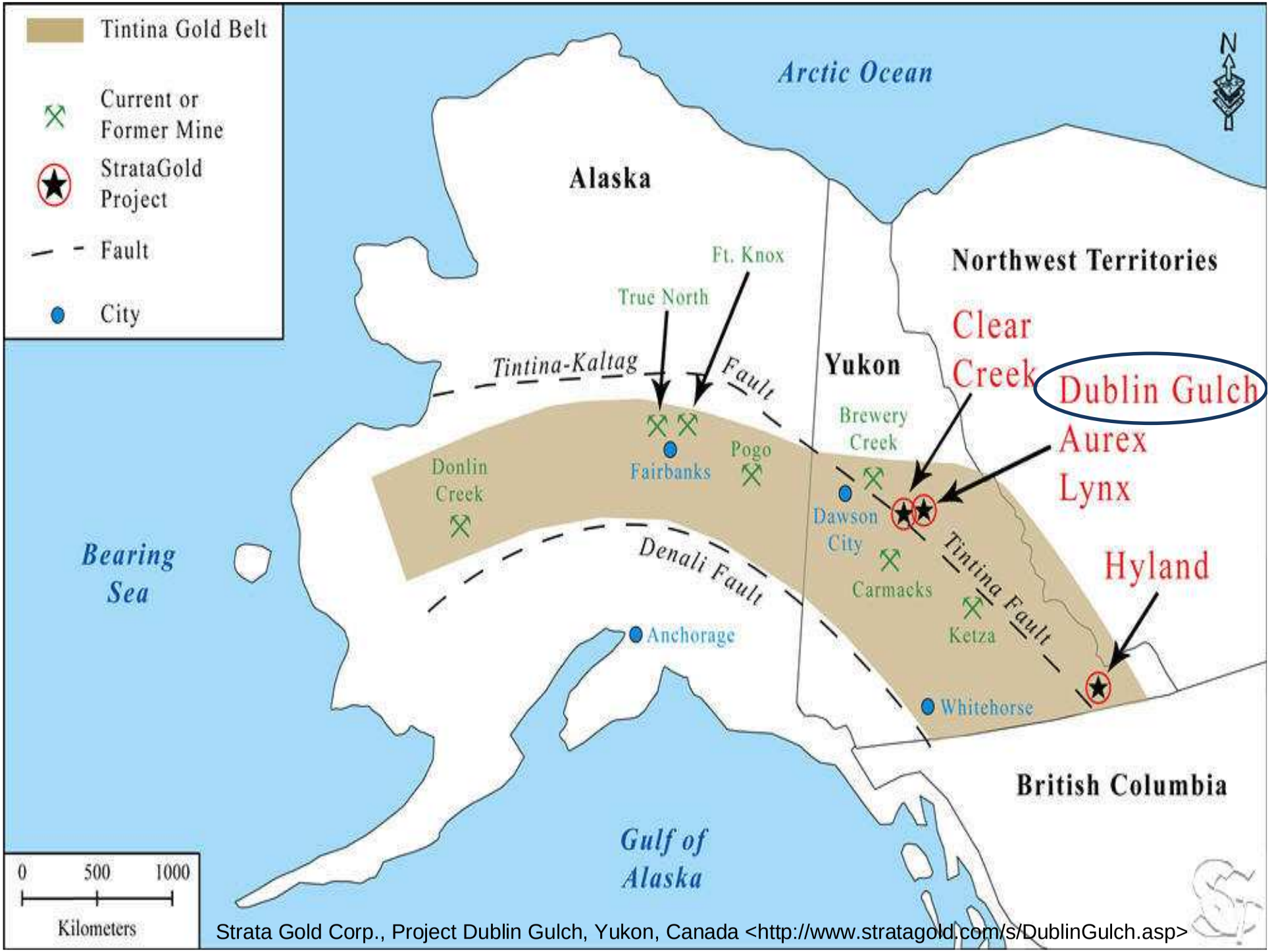
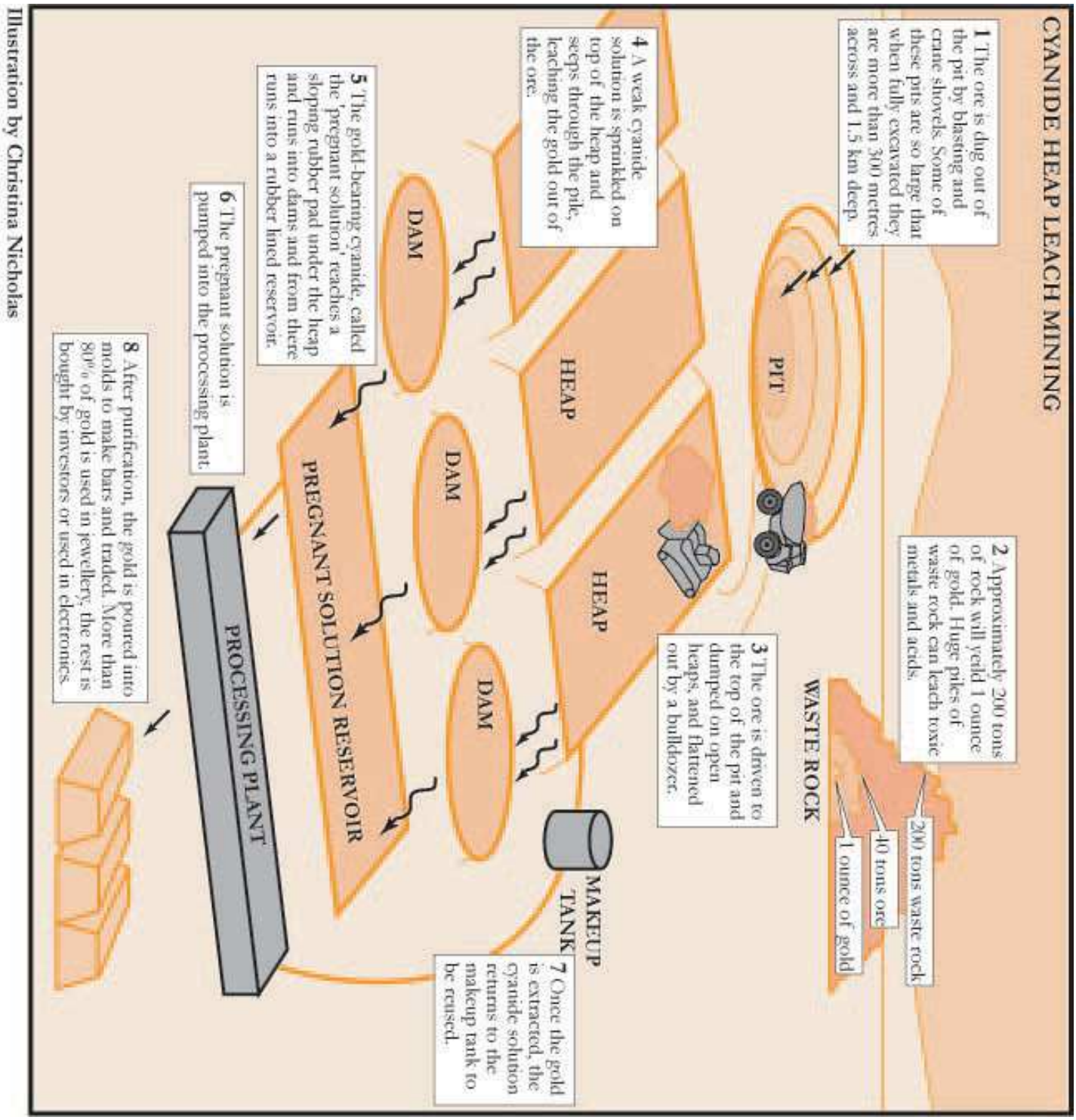
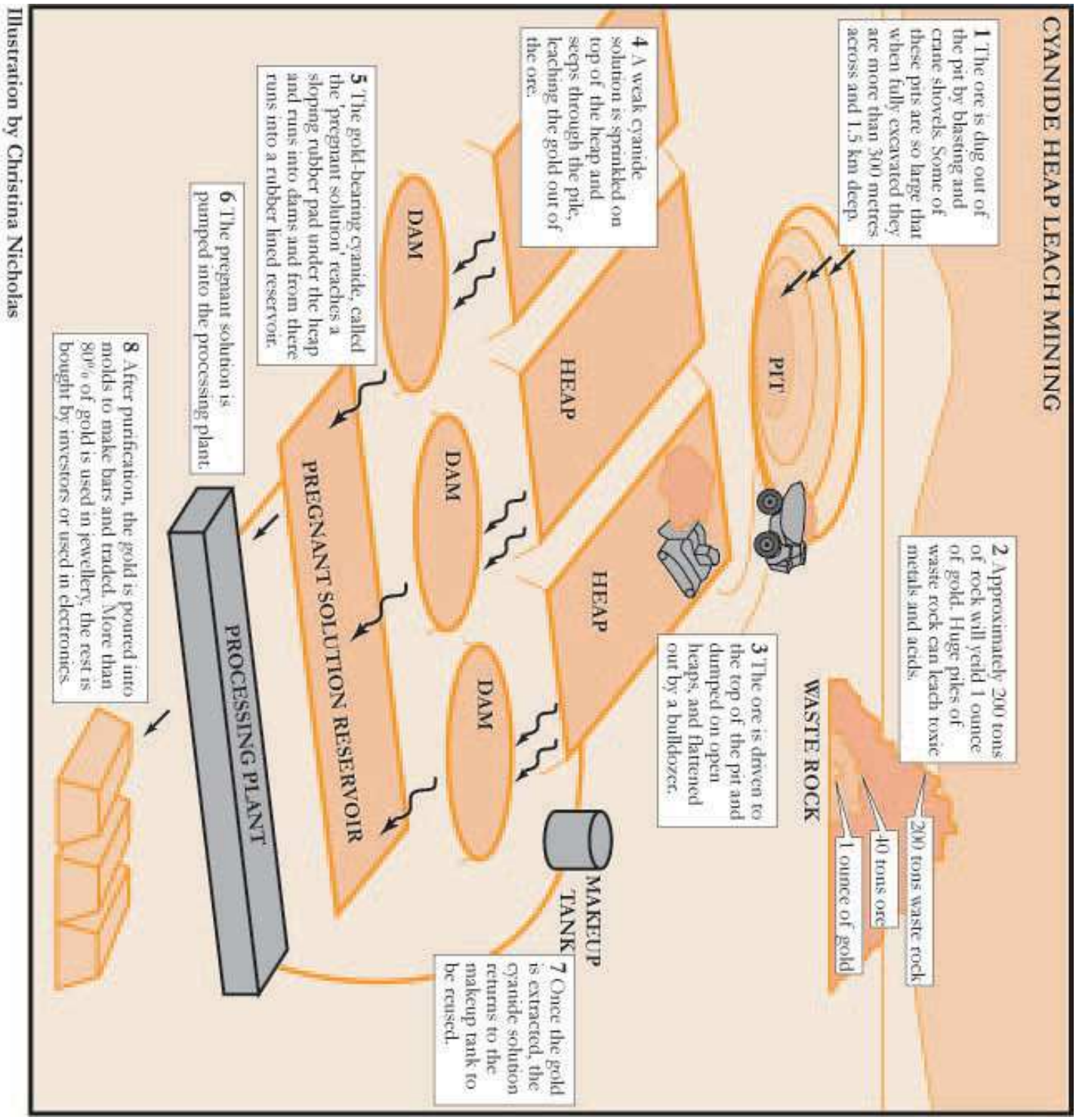


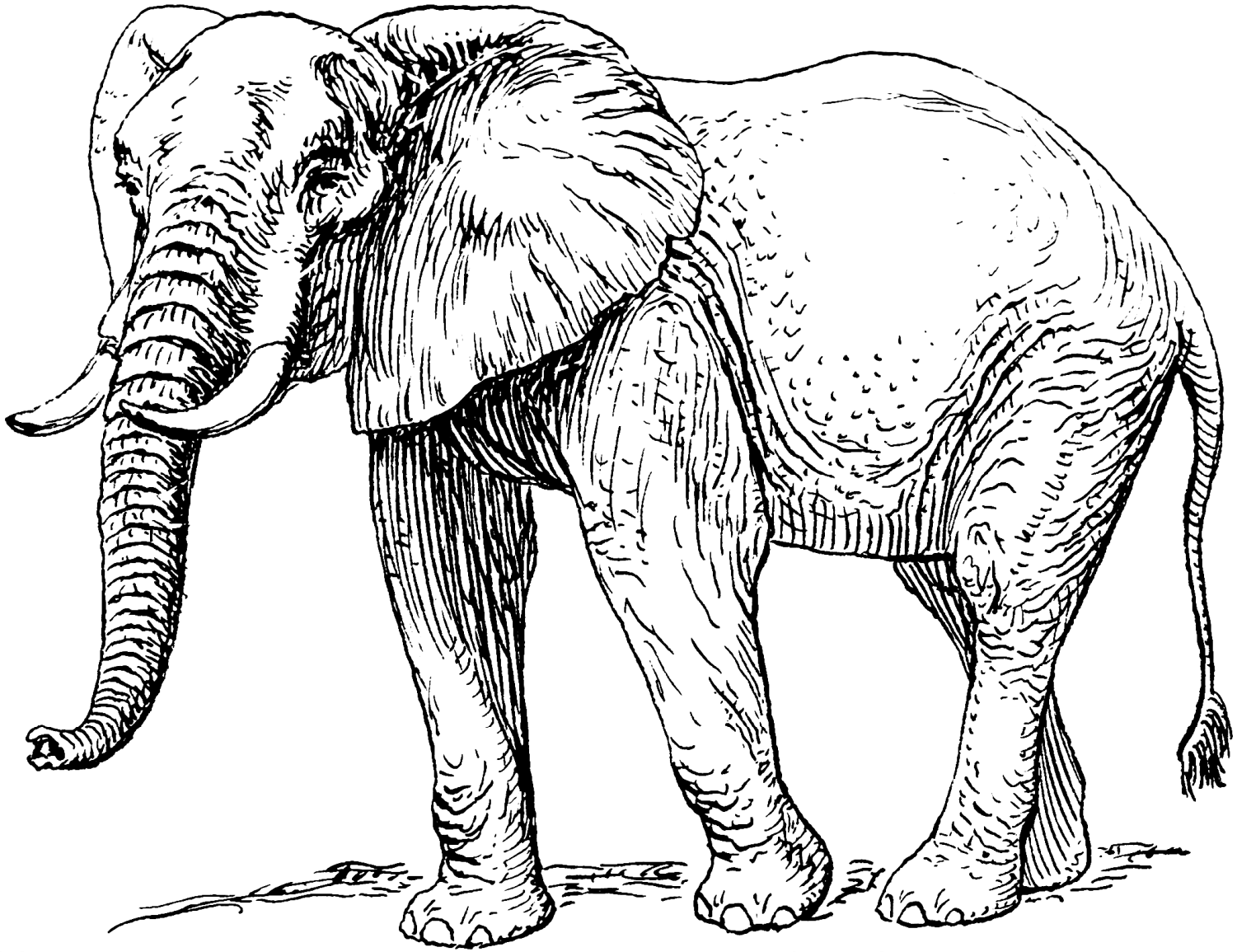
Strata Gold Corp., Project Dublin Gulch, Yukon, Canada <http://www.stratagold.com/s/DublinGulch.asp>

Nicholas, Christina. Dirty Gold: The toxic legacy of cyanide heap-leach mining. Mining Australia 2004. http://studentwork.hss.uts.edu.au/oj1/oj1_s2004/DirtyGold/index.htm Last modified on Nov 29th 2004. Access on June 1st 2009.



Nicholas, Christina. Dirty Gold: The toxic legacy of cyanide heap-leach mining. Mining Australia 2004. http://studentwork.hss.uts.edu.au/oj1/oj1_s2004/DirtyGold/index.htm Last modified on Nov 29th 2004. Access on June 1st 2009.





1 ounce of gold

=

1 pen

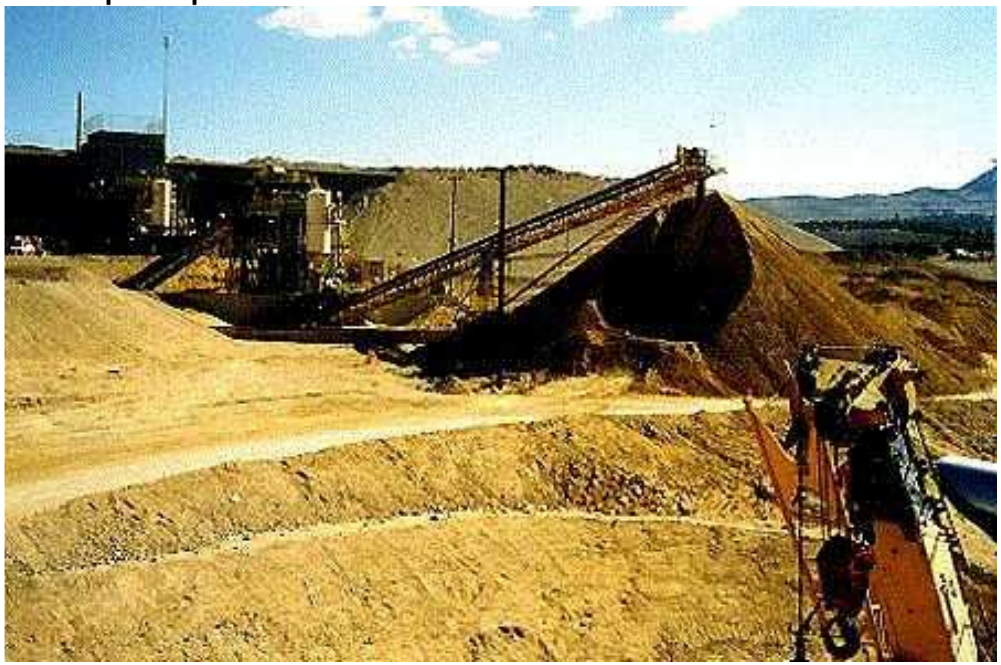
200 tons of Rock

=

1 African Elephant

Open pit - excavation

Ruby Hill Project is an open pit gold mine and ore processing facility 1.6 km northwest of Eureka and 386 km east of Reno, Nevada. Wholly owned by Homestake Mining, it produced 123,800 oz of gold in 1999 at an average cash cost of US$104/oz. The workforce is around 100 people.



Crushing - Making the heap

Leaching – black lines are hoses that will deliver the cyanide to the heap

Myers, Gene. Envr 202 Environmental Studies: A social Science approach. Course Home Page. Western Washington University.

Mineral Resources Forum. http://www.mineralresourcesforum.org/incidents/BaiaMare/maps.htm. Accessed on February 10th 2009.

Nicholas, Christina. Dirty Gold: The toxic legacy of cyanide heap-leach mining. Mining Australia 2004. http://studentwork.hss.uts.edu.au/oj1/oj1_s2004/DirtyGold/index.htm Last modified on Nov 29th 2004. Access on June 1st 2009.