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THE ENVIRONMENTAL IMPACT OF THE OIL SANDS:
A RESEARCH PROJECT FOR SECONDARY SCHOOL SCIENCE STUDENTS

Teacher Introduction

This resource is designed to address the learning outcomes of the “**Life sciences: Sustainability of Ecosystems**” component of the British Columbia **Science 10 Integrated Resource Package**. It can be used specifically for the learning outcomes B2, “assess the potential impacts of bioaccumulation” and B3, “explain the various ways in which natural populations are altered or kept in equilibrium”.

The resource focuses on the effects of bitumen extraction in Alberta (also known as oil sands or tar sands) and the concerns of resident First Nations regarding the environmental effects of the development of this resource. As described in the student material this has become a major issue and could have significant impact on the plans for oil sands development.

The First Nations of the area are applying to the Supreme Court of Canada for a ruling on their right to be consulted. Their primary concern is the environmental impact of the mining and processing of the bitumen.

Resource format:

The resource uses a critical inquiry approach. Students are asked to research and report on the real or potential environmental impact of oils sands development. Their report is to address First Nations concerns, using scientific evidence and science based-hypotheses on environmental impacts. Students must make a judgment on the “weight” of the various concerns and structure their report so that the most serious concerns are given prominence.

This resource contains five student information sheets on the environmental issues most specific to the oil sands. The student activity is best done in partner groups or groups of three. Web sites are provided for each of the issues. Students can use these to find more information if time permits. The resource is structured so students can obtain what they need from the information sheets.

The information sheets cover the following topics;

- Carbon intensity or air quality
- Water use and water quality
- Effects of waste treatment and tailings
- Effects on wildlife and wildlife habitat
- Effects on human health

*Teachers should note that the information sheets have been prepared using information from an article by Kevin Timoney and Peter Lee, “**Does the Alberta Tar Sands Industry Pollute: The Scientific Evidence.**” This article appeared in the Open Conservation Biology Journal 2009/3.*

Background for Students

April 9, 2010 - **Peace River Alberta**

Two more Alberta First Nations are seeking the assistance of the Supreme Court of Canada in defending their Aboriginal and Treaty rights in the face of mounting oil sands development in Alberta. The Supreme Court of Canada has granted intervenor status to Duncan's First Nation (DFN) and Horse Lake First Nation (HLFN), in a case that may have major legal implications for the development of oil sands, pipelines, oil sands infrastructure projects and other major projects.

(note: "intervenor status" means that the Court has given this group permission to appear before the court and present a case on their own behalf)

The problem:

The development of deposits of bitumen (also known as oil sands or tar sands) is one of the most important petroleum resource development projects in Canada and possibly the world. The Alberta and Saskatchewan bitumen deposits are considered to be among the last remaining major sources for oil in the world.

The problem with bitumen however is that it must be mined either with enormous open pit excavations much like some coal mining or forced out of the ground under pressure by injecting steam into the bitumen and forcing it to the ground in a more liquid form. Either one of these methods has significant impact on the environment. In fact these impacts are considered so significant that some people are calling for the development of bitumen deposits to be slowed down until we are more certain of the environmental effects.

One of the groups most concerned are First Nations people living in the area. They are taking their concern to the Supreme Court of Canada and asking the court to act in giving First Nations some say in how the oil sands will be developed.

This is how one of the First Nation's leaders explained their case, **"Our traditional territory is being overrun and cut to pieces by oil sands, major pipelines, gas fields and major power projects. Companies such as Royal Dutch Shell, Trans Canada Pipelines and Bruce Power are proposing massive projects that will fuel unsustainable oil sands growth. Development on this scale is making our Treaty Rights meaningless and threatens our traditional way of life".** Chief Testawich added, **"The governments of Alberta and Canada sit back and refuse to address our concerns. We are intervening before the Supreme Court because it is abundantly clear that neither the environment nor First Nations can expect to receive a fair hearing within Alberta, where oil sands revenues are at stake. We need help now and help fast".**

(Chief Don Testawich, Grand Chief, Western Cree Tribal Council)

Background for Students (con't)

The Research Project

In order for the First Nations to have a case for the Supreme Court they must have some evidence that the environment is being significantly and negatively affected by the development that has taken place so far. Your task is to find out if such evidence exists, what it is and the degree to which it is significant. In other words you are to research the question: What are the proven and possible effects of oil sands development on the environment of affected areas?

Procedure:

The environmental issues regarding oil sands development focus on six different, but connected, topics of concern related to pollution:

- Carbon intensity or air quality
- Water use and water quality
- Effects of waste treatment and tailings
- Effects on wildlife and wildlife habitat
- Effects on human health

In doing your research you will discover that there is disagreement over the impact of the development of the tar sands on the environment. Generally the companies that are doing the work claim the impact is not severe and the measures they are taking to protect and restore the environment address the problems. Environmental groups and First Nations on the other hand say the impacts are serious and whatever efforts the companies are making at limiting environmental impacts are inadequate.

In this assignment your task is quite specific. You are not trying to resolve the controversy over the environmental effects of tar sands development. Rather you are researching the overall effects that tar sands development can have on the environment. Since you are providing information for a Supreme Court hearing you are as concerned with what is happening to the environment as you are with what could happen if development is not controlled. So, for this exercise, it is acceptable if you use words like “could” or “possible”.

To get you started there are short background information sheets on each of the topics of concern. Use these sheets to guide your research. With each sheet are web sites that provide additional information. As you work through the information sheets use the research guide to organize the information.

Background for Students (con't)

Public Domain
Wikipedia image
showing extent of oil
sands resources in
Alberta, BC



Athabasca Oil
Sands NASA Earth
Observatory image

Carbon intensity and air quality

- Releases into the air of five criteria air contaminants (PM2.5, PM10, total particulates, sulphur dioxide, and volatile organic compounds (VOCs), such as benzene, xylene, ammonia, and formaldehyde) and hydrogen sulphide in 2006 indicate that tar sands facilities are major polluters
- A major concern in determining air quality is the amount of particulate matter in the air. This refers to the presence of substances such as sulphur dioxide and volatile organic compounds such as benzene, ammonia and formaldehyde. In the oil sands region of northern Alberta the presence of particulate matter in the air has been identified as a concern.
- Evidence of significant air contamination or pollution has been found in the analysis of ground lichens which grow naturally in the area. It has been found that lichens in oil sands area have significant levels of morphological damage, growth impairment and levels of pollutants in tissue
- Snow melt in the month of April shows how pollutants have accumulated in snow and then released into the soil during the spring.
- The tailings ponds release methane into the atmosphere. Methane is a major green house gas.
- Rapid increases in air emissions are predicted for the Alberta tar sands industry. By 2010, PM2.5 emissions are predicted to reach 11,200 tonnes / year (87% above 2005 levels), while emissions of oxides of sulphur increase 38% (from 118,000 to 163,000 tonnes/year), VOCs increase 119% (from 130,000 to 285,000 tonnes / year), and nitrous oxides increase 78% (from 90,000 to 160,000 tonnes / year)
- In March 2006, southerly winds carried a mass of polluted air at least 200 km north from the tar sands facilities. Air trajectory analyses by Environment Canada tracked the air to a source in the industrial tar sands area north of Ft. McMurray.

http://www.globalforestwatch.ca/climateandforests/TarsandsPollute/Timoney_and_Lee_TOConBJ.pdf

http://www.rsc.ca/documents/expert/RSC_ExP_ExecutiveSummary_ENG_Dec14_10_FINAL_v5.pdf

Wildlife and Habitat

- The harmful alteration, destruction or disruption (“HADD”) of 1.28 million m² of fish habitat within the Muskeg River and its tributaries Imperial Oil has been approved by the federal Dept. of Fisheries and Oceans (HADD permit ED-03-2806).
- Wildlife impacts independent of habitat conversion can result from landscape fragmentation, increased access, and industrial noise. Areas near noiseless energy facilities in Alberta can have a total passerine bird density 1.5 times higher than that in areas near noise-producing energy sites; the abundance of one-third of the species was reduced by noise.
- Spring migration in northeastern Alberta poses a serious threat to birds. The area is located along a convergence zone of migratory bird flyways en route to the Peace-Athabasca Delta, the most important waterfowl staging area in Canada.
- Warm effluent in tailings ponds creates open water attractive to waterfowl and shorebirds while natural water bodies remain frozen. At least 16,000 birds were observed visually flying over one tailings pond during spring migration and single-day counts at (natural) McClelland and Kearl Lakes have reached 1,154 and 2,700 ducks. Relative to a non-terrort control, the odds of landing at a tailings pond protected by industry-standard bird deterrents are unacceptably high (38% for ducks and 69% for shorebirds).
- To date, birds representing 43 species and 51 taxa have died due to tailings pond exposures in the area. Although waterfowl and shorebirds have been the most-affected, dead birds of prey, gulls, passerines, and other groups have been observed.
- In April 2008, an anonymous tip alerted authorities to the death of migratory waterfowl at the Syncrude Aurora North tailings pond. At that time, Syncrude admitted to the death of about 500 ducks. By July 2008, Syncrude and government were aware that 1,606 ducks had died but it was not until March 2009 that the public was informed; no information has been released to date on mortalities of other birds.
- Cree hunters in Ft. Chipewyan suspect that tailings ponds may be causing changes in waterfowl migration patterns.

<http://www.borealbirds.org/resources/factsheet-ibcc-tarsands.pdf>

<http://www.borealbirds.org/resources/background-report-birdstarsands.pdf>

Water Use and Quality

Polycyclic aromatic hydrocarbons (PAHs), also known as **poly-aromatic hydrocarbons** or **polynuclear aromatic hydrocarbons**, are potent atmospheric pollutants that consist of fused aromatic rings and do not contain heteroatoms or carry substituents. Naphthalene is the simplest example of a PAH. PAHs occur in oil, coal, and tar deposits, and are produced as byproducts of fuel burning (whether fossil fuel or biomass). As a pollutant, they are of concern because some compounds have been identified as carcinogenic, mutagenic, and teratogenic. PAHs are also found in cooked foods. Studies have shown that high levels of PAHs are found, for example, in meat cooked at high temperatures such as grilling or barbecuing, and in smoked fish.

- Of the 28 species of PAHs for which differences in upstream and downstream concentrations could be calculated, 26 increased in concentration downstream from oil sands development.
- The largest increases in concentration ratios were observed for C2 and C3 dibenzothiophenes, C2 and C3 fluorenes, and C2 phenanthrenes/anthracenes, in which downstream concentrations were 9-15 times higher than upstream concentrations.
- Over the period 1999-2007, concentrations of alkylated PAHs increased in Athabasca River Delta sediment. (alkyl-PAHs) constitute more than 90% of the total PAHs in crude oil and are the main constituents toxic to fish).
- Mean mercury concentrations in lower Athabasca River fish (walleye) increased over the period 1976 to 2005. Lower Athabasca River walleye (*Stizostedion vitreum*) and lake whitefish (*Coregonus clupeaformis*) sampled in September 2005 posed a human health risk. Virtually all walleye longer than 40 cm or weighing more than 500 g contained more than 0.20 mg/kg of mercury, the Health Canada subsistence fisher guideline.
- In terms of water quality guidelines, analytes of primary concern were ammonia, arsenic, iron, and zinc. Nine analytes increased three- or more-fold downstream of the pond; none decreased three- or more-fold. Analytes that increased at least three-fold were ammonia, aluminum, antimony, arsenic, copper, lead, strontium, uranium, and zinc.

<http://www.ramp-alberta.org/resources/development/upgrading.aspx>

Waste treatment and tailings

- The waste material from extracting bitumen and turning it into oil is usually treated in what are known as tailings ponds. A tar sand tailings pond consists of process water, sand, fines (silts and clays), residual bitumen (1-5%), and associated chemicals.
- Tar Island Pond One seepage affects the concentrations of a host of dissolved analytes in the sediment porewater of the Athabasca River by a factor of 2-4-fold
- At an Athabasca River surface water site adjacent to Site 6 (PD1-93-13-SW), six dissolved analytes have been found to exceed either water quality guidelines or maximum ambient concentrations (beryllium, chromium, manganese, strontium, vanadium, and naphthenic acids).
- As part of an assessment of the ecological risk posed by Tar Island Pond One, Komex identified chemicals of potential ecological concern as arsenic, ammonia, barium, chromium, bismuth, iron, lithium, manganese, naphthenic acids, selenium, strontium, tin, vanadium, zinc, methylnaphthalene and C2 naphthalene.
- On the Suncor lease, the pond known as “Natural Wetland” contains elevated levels of hydrocarbons, naphthenic acids, and salinity due to seepage of tailings water through the adjacent containment dyke.
- Seepage from the Syncrude Mildred Lake site is implied in the high concentration of naphthenic acids found in Beaver Creek and in high and increasing levels of naphthenic acids downstream of the “lower seepage dam” (*Naphthenic acids are one of the main pollutants responsible for the toxicity of tarsands tailings to aquatic organisms, and have been shown to harm liver, heart and brain function in mammals,” wrote Matt Price, the policy director at Environmental Defence, an independent research organization based in Toronto. “Naphthenic acids are also very long-lived, taking decades to break down.”*)
- A current estimated escaped seepage rate of 11 million L /day and a projected peak seepage rate of 26 million L /day in the year 2012. Leakage of toxins from tailings ponds may be a concern for decades if not for centuries.

<http://www.capp.ca/environmentCommunity/land/Pages/TailingsPonds.aspx#NvVHGfKwtipO>

Effects on human health

- Both the quantity and the chemical constituents of the particulates in the air pose health concerns, as they contain not only organic contaminants such as PAHs but also a suite of metals such as vanadium, arsenic, and mercury. Occupational exposure to tar sands employees may be significant.
- Elevated levels of mercury and arsenic in the local fishes are a concern. Health Canada recommended that consumption of large predatory fish should not exceed one meal per week for adults. Pregnant women, women of childbearing age, and children should consume no more than one fish meal per month. Due to the nutritional value of fish, and the traditional-cultural and economic importance of fish to Ft. Chipewyan residents, fish mercury levels pose a serious dilemma.
- Arsenic is a known carcinogen linked with human bile duct, liver, urinary tract, and skin cancers, vascular diseases, and Type II diabetes. The aquatic biota and the people who depend upon aquatic life for food are exposed to both arsenic and PAHs. Co-exposure to arsenic and the PAH benzo(a)pyrene can increase rates of genotoxicity 8-18 times above rates observed after exposure to either carcinogen in isolation.
- Incidences of type II diabetes, lupus, renal failure, and hypertension are elevated in Fort Chipewyan. Based on a 12-year dataset (1995-2006), Chen [93] concluded that the number of cancer cases overall was 30% higher than expected ($p = 0.035$), as were bile duct cancers ($p = 0.030$), cancers of the blood and lymphatic system (overall $p = 0.022$, and of leukemia, $p = 0.034$), and soft tissue sarcomas.

<http://h2oildoc.com/home/health-and-human-impacts>

Organizing your research for the Supreme Court presentation

Your goal is to provide information that will help the Duncan's First Nation make an effective presentation to the Supreme Court of Canada. Your teacher will direct you to work with a partner or in a group of three.

You need to raise the most important issues regarding the oil sands development. From your reading of the information sheets and what you may have found on web sites your task is to narrow down or focus on the issues you feel are of most concern.

To do this you are to use the following presentation outline. This outline requires that you decide on seven of the most important or significant environmental impacts of the oil sands development. Use the following example to help you get started:

Environmental element of concern: Air quality

Specific issue: Increases of air emissions

Evidence: Presence of particulates, eg, sulphur dioxide

Possible consequences: Effects on global warming, human health.

Add the scores for a total:

Environmental Issue of concern	Specific concern	Evidence	Proven effects	Possible effects
Example; Air quality	Increase of air emissions	Presence of particulates, sulphur dioxide, benzene, ammonia	Respiratory problems in humans. Air pollutants in soil.	Climate change, habitat destruction

Ranking the issues:

Finally you are to rank the issues you have selected to help you decide which should be the most emphasized in a presentation to the Supreme Court.

Example:

Rating scale

- 4 - very significant
- 3 - significant
- 2 - Somewhat significant
- 1 - Less significant

Particulate matter:

Possible effect on human health: 3 (significant)

Possible effect on surrounding habitat : 2 (somewhat significant)

Possible lasting or permanent effects: 4 (very significant)

Issue	Effect on human health	Possible effect on surrounding habitat	Lasting permanent effect	Total (sum of three effects)
Particulate matter	Ranking of “1” means less significance. “4” very significant	1 to 4	1 to 4	Up to 12 possible

Written report:

Organize your written report by using your presentation outline and ranking scale. You should write on each issue, using your research, in the order you ranked them beginning with “most significant”. For each issue focus on describing what the specific issue is and how it affects the environment, present the evidence and describe both the possible and proven consequences to the environment including human health.