the PEMBINA institute

Pipeline

Construction & Operation

Environment & Energy in the North

A PRIMER

About the Pembina Institute

The Pembina Institute is an independent non-profit research, education and advocacy organization. It promotes environmental, social and economic sustainability through the development of practical solutions for businesses, governments, individuals and communities. The Pembina Institute provides policy research leadership on climate change, energy policy, green economics, renewable energy, and environmental governance, as well as extensive formal and public education programs. More information about the **Pembina Institute** is available at **www.pembina.org** or by contacting

The Pembina Institute
Box 7558
Drayton Valley, AB
T7A 1S7
Tel: 780-542-6272
Fax: 780-542-6464
E-mail: piad@pembina.org

About the Author / Chris Severson-Baker

Chris Severson-Baker is Director of the Pembina Institute's Energy Watch Program. He graduated from the University of Alberta with a BSc in Environmental and Conservation Science in 1996, joining the Pembina Institute that same year. He has worked to reduce the impacts of the oil and gas industry on the environment — providing recommendations to government on opportunities to strengthen environmental regulation, and encouraging industry to adopt better practices. Chris has represented the Pembina Institute on numerous provincial and federal multi-stakeholder committees focussed on developing environmental management policy for the oil and gas sector.

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Contents

About the Primers

The Pembina Institute's Energy Watch program has developed a series of eight primers to help northern communities understand the potential environmental and, where applicable, human health impacts of oil and gas development. The primers also aim to help these communities effectively take part in managing these risks, ensuring that governments and oil and gas developers are using the best environmental practices available.

Each of the first six primers focuses on a different phase of oil and gas development.

There are four parts to each of these primers:

1. A basic description of the activities of that phase
2. The potential environmental and human health risks of that phase
3. The best practices available to reduce those risks
4. Opportunities for citizens to get involved in deciding how developers carry out the activity.

The following are the six phases of oil and gas development addressed by the primers:

Seismic Exploration — industry activities to create a picture or map of the geology below the Earth's surface to find oil and gas reserves.

Land Disposition — the actions companies need to take to get the rights to explore for and produce oil and gas reserves.

Exploration and Production Drilling — the activities companies perform to first locate oil and gas, then to find out the size and usability of an oil and gas reservoir, and finally to reach the oil and gas using intensive production drilling.

Well Site Operation — industry practices to remove oil and gas from underground reservoirs and transport them to the surface.

Oil and Gas Processing — actions companies take to process oil and gas to prepare it for sale.

Pipeline Construction and Operation — industry activity to set up pipelines that carry oil and gas from the place it comes out of the ground to the places where consumers will use it.

The last two primers focus specifically on citizens' rights around oil and gas development projects:

Citizens' Rights and Oil and Gas Development: Northwest Territories explains the rights that citizens have related to oil and gas development in the Northwest Territories.

Citizens' Rights and Oil and Gas Development: Yukon Territory explains the rights that citizens have related to oil and gas development in the Yukon Territory.

To produce these primers, the authors reviewed the limited oil and gas development already under way in Canada's North. They also researched the current issues and practices in Alberta, northeast British Columbia, and the Alaskan North Slope, where intensive oil and gas development is already occurring.

Introduction

Just as they were about twenty years ago, companies are once again actively exploring for oil and gas reserves in the frontier regions of the Northwest Territories and the Yukon Territory. If developers decide to develop these resources, they will have to build a large capacity (or large diameter) pipeline to export the oil and gas from the far North to other regions. Once developers make a final decision to build one or more pipelines, and once regulators approve the plans, oil and gas exploration and production activity in the North will quickly increase.

Developing the oil and gas resources of the North would offer the people living there many opportunities for economic development. But it is important that companies developing oil and gas reserves, and governments and other regulators overseeing the work, make sure they do not damage the cold, slow-growing and sensitive northern ecosystems. While there will be unavoidable environmental impacts because of oil and gas exploration, developers and regulators can reduce impacts with careful planning and by using the best available technologies and practices.

Since it is the people of the North who will experience the most direct impacts, it is important that they play a strong role in setting the terms and conditions of such development. When deciding on the actions they will take, industry and various levels of government need to be respectful of and consider the needs and wishes of Northern communities.

During the past few decades, the oil and gas industry has become more aware of the environmental impacts associated with its work. Technologies and practices have become much less environmentally damaging than they were in the past. And most, though not all, companies have responded to social and environmental concerns. Despite these improvements, there are still negative environmental impacts associated with oil and gas development and production. This is especially true in areas where the activity is intensive.

When the public shares their questions, concerns and expectations about this work — directly to companies, through the media, and through regulators that inspect the work and

enforce regulations — this helps to uphold and improve industry performance. When the public is able to take part in effectively influencing decisions around oil and gas exploration, this pushes companies to higher levels of performance. When the public gives their input they tend to examine all companies equally; their participation ensures that all developers follow the best practices possible.

This primer, ***Pipeline Construction and Operation***, focuses on industry activity to set up pipelines that carry oil and gas from the place it comes out of the ground to the places where consumers will use it.

There are four sections in this primer:

- Part 1 provides a general description of pipeline construction and operation
- Part 2 outlines the potential environmental impacts associated with pipelines
- Part 3 describes technologies and best practices that companies can use to reduce environmental risks
- Part 4 offers information on citizen rights and opportunities to influence decisions on pipeline proposals.

What Is Pipeline Construction and Operation?

Pipelines are used to transport oil and gas to treatment plants (e.g., oil batteries and gas plants), and from treatment plants to market. Pipelines are also used to carry water that is produced by oil or gas wells (produced water) to processing plants so that it can be cleaned and disposed of.

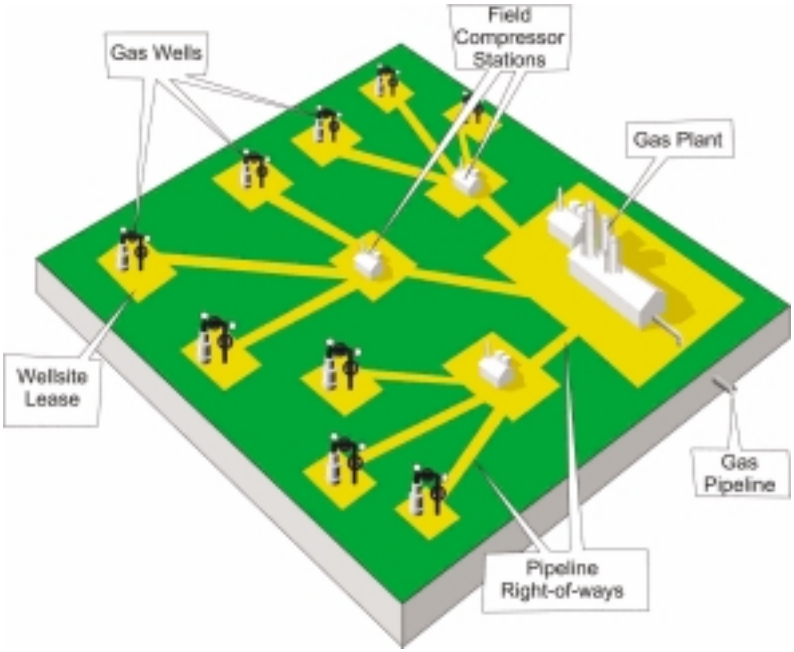
Pipelines come in different sizes and have different pressures, depending on the volume and type of content they contain.

There are two main types of pipelines in the oil and gas industry:

1) **"Gathering system"** pipelines — These pipelines collect raw oil and gas from well sites and carry them to processing facilities, such as a gas plant or an oil battery. Gathering system pipelines tend to have a relatively small diameter and operate at relatively low pressure.
2) **"Transmission system"** pipelines — These pipelines ship the processed oil and gas to market. Transmission system pipelines tend to have a large diameter and operate at high pressure.

Factors that affect pipeline design include pipe wall thickness, type of metal alloy used, type of corrosion-resistant coating used, and spill- or leak-reducing features.

A pipeline must run through land that is clear and free of development. The amount of a "set back" or the amount of clear land needed on



Gathering system pipelines gather gas from wells and transport it to a gas plant.

SOURCE: PEMBINA INSTITUTE CREDIT: DAVE MUSSELL

either side of a pipeline varies considerably and depends mainly on the following: the type of oil, gas, or mixture to be carried; the pipeline pressure; the hydrogen sulphide content of the oil or gas; the risk of corrosion; and the proximity of the pipeline to people and sensitive environments.

Pipelines are normally buried underground, but in some cases pipelines are raised above the ground on supports.

Pipeline Planning

Before pipeline construction begins, an extensive route selection and planning process takes place. Companies investing in the pipeline will want to develop the most profitable project. Therefore, they'll select the ideal pipeline size and route, and they'll consider expanding the project to include more sources of oil or gas along the pipeline route. Planners generally look for a route that uses previously disturbed areas to minimize new environmental damage. Planners may conduct an environmental impact assessment, depending on the size and type of pipeline planned.

Pipeline Construction

There are four basic steps to pipeline construction:

1. building access roads
2. clearing land
3. installing the pipeline
4. building facilities to operate the pipeline

OIL BATTERY

*An **oil battery** is a processing plant where impurities in oil, such as gas, water, and sand, are removed from the oil before it is pumped into a pipeline and shipped to market.*

*A **gas plant** processes raw natural gas to remove impurities, making it high enough quality to be transported in gas transmission pipelines and then burned in a typical home furnace or electrical power plant.*

1) Building Access Roads

Before pipeline construction begins, crews first build temporary roads to allow access during the construction phase. They may also build permanent roads to provide access after the pipeline is in operation.

2) Clearing Land

Crews clear trees and other vegetation along the route of the pipeline, called the "right-of-way." The amount of land to be cleared depends on the size of the pipeline and the size of the trucks and other equipment needed to transport the pipe segments and build the pipeline. In the case of a buried pipeline, this step also includes removing and stockpiling topsoil, and digging trenches that will hold the pipeline.

Pig-launcher.

SOURCE: PEMBINA INSTITUTE

3) Installing the Pipeline

Pipeline segments are welded together, and the pipeline is progressively buried in the trench as construction proceeds. Once a buried pipeline has been covered over and the topsoil has been replaced, the surface is usually seeded with grass or other groundcover plant to prevent erosion from wind and rain.

When the crew comes to install a pipeline at a river or stream that cannot be avoided, it will use one of several water-crossing methods. Most water-crossing methods involve temporarily damming or redirecting water while the crew installs the pipeline under the bed of the river or stream. To avoid potential damage to fish or fish habitat caused by interrupting flows and disturbing the riverbed, crews can also use a special drilling rig to drill a hole from one bank to the other below the riverbed or streambed without disrupting the flow of water.

In the case of an aboveground pipeline, this step also includes building supports upon which to place the pipeline as it is progressively welded together. Crews may need to build bridges to carry the pipeline over water bodies that cannot be avoided.

4) Building Facilities to Operate the Pipeline

Crews must also build all the facilities that are needed to operate a pipeline, including the following:

Compressor stations — These buildings, which are the size of a small house, contain one or more large gas- or electric-powered compressor engines. The compressor engine increases the gas pressure in the pipeline so that gas will flow through it. A compressor engine is one of many different units at gas plants and is used to compress gas leaving the facility by pipeline. Long gas pipelines may need a series of compressor stations along the pipeline to boost pressure.

Pumping stations — These buildings contain large gas- or electric-powered pump engines that apply pressure to oil and water so they will flow through the pipeline. Pumping stations are located at oil batteries and used to push oil through pipelines leaving the facility. Long oil pipelines may need a series of pumping stations along the pipeline to boost pressure.

Workers must excavate buried pipelines to conduct external inspections and to repair segments.

SOURCE: BALLYMAC HOLDINGS LTD.

Aboveground valves — These tools are used to control the flow of contents through the pipeline.

Pipeline tie-in locations — These are the places where other gas or oil pipelines are connected to the main pipeline.

Pig-launchers/Pig-traps — These facilities provide access points where operators can insert devices called "pigs" that can be used to either clean out the pipe or scan the inside of the pipe for cracks or corrosion.

Maintaining the Pipeline

After the pipeline has been constructed, all or a portion of the right-of-way is kept clear of trees and shrubs to let vehicles access, check on, and, if necessary, repair the pipeline. Operators can conduct integrity checks while the system is operating. They check for leaks and stress fractures by monitoring changes in the pipeline's internal pressure. Operators also test for pitting (internal corrosion) using an inspection tool called a "smart pig," and they monitor the pipeline right-of-way from the ground or air. On a regular basis, they clean the inside of the pipeline using "scraper pigs" to clear built-up residue. If a leak is found, the pipeline is shut down, that section of the line is purged of oil, gas, or water, and the pipeline is repaired. Any spilled oil or water that can be collected is removed and the more difficult task of removing or treating the contaminated soil or water begins. If corrosion is detected in the pipeline, operators schedule a time to replace damaged segments with new pieces of pipeline.

Before most types of maintenance work can be done on the segment of a pipeline, that segment must be emptied of gas (this process is called a "blowdown") or drained in the case of oil or water. In the case of gas pipelines, operators close the nearest block valves on either side of the segment to reduce the amount of gas that must be purged. Depending on the pipeline and the location of these valves, several kilometres of pipeline of gas may need to be purged. Operators then open a special blowdown valve to release the gas to the air. Opening the blowdown valve results in a loud roaring sound that can last from 30 minutes to an hour before pressure in

the pipeline drops and the sound is reduced. The entire blowdown can last for up to 3 hours[1]

After the pressure drops, a funnel-shaped air expeller is placed on the blowdown valve to draw out any remaining gas. Operators could use pull down or transfer compressors to transfer a portion of gas into another segment of the pipeline to reduce the need for venting and the amount of noise. When the maintenance is finished, operators pump natural gas into the segment and open the blowdown valve again to get rid of any air that is in the pipeline. When 100% natural gas comes out of the blowdown valve, the valve is shut and the pipeline is ready to go back into operation.

Moving On

When a pipeline is no longer needed — oil and gas in the area has been depleted or the pipeline has reached the end of its useful life — all gases and liquids are removed from it, and the pipeline is plugged. Aboveground pipelines are dismantled and removed. Underground pipelines might be left in place if removing them could potentially create more damage to the land surface than leaving them in the ground. Finally, operators either try to re-establish native plant species on the right-of-way or let them grow back on their own.

Since each area is unique, any oil and gas development will impact each area differently. The nature and extent of environmental impacts will depend upon the regional ecosystem type, local terrain characteristics, the presence or absence of tree cover and permafrost, and the type of soil.

This section identifies potential land disturbances that may result from pipeline construction and operation. Some impacts are common to all areas; others are particular to an area that may be sensitive in some way.

Above ground large volume oil transmission pipeline in Alaska

SOURCE: KEN MADSEN

1 TransCanada Blowdown Notification Fact Sheet, February 2001. http://www.transcanada.com/pdf/social/Blowdown_factsheet_eng.pdf (July 2003).

Environmental Impacts

Canada's north is a diverse landscape. It contains seven distinct ecological areas:

Arctic Cordillera Ecozone	mountains, rock, ice and glaciers, few plants and animals
Northern Arctic Ecozone	barren plains, permafrost, some rock, seabirds and muskox
Southern Arctic Ecozone	shrubs, meadows, lakes, large mammals
Taiga Cordillera Ecozone	mountains, arctic shrubs and flowers, wetlands, valleys, waterfalls, canyons, rivers, wide range of mammals
Taiga Plains Ecozone	low-lying plains, large rivers, rich diversity of plants, birds and mammals
Taiga Shield Ecozone	coniferous forest, bedrock, lakes, wetlands, meeting of the boreal and arctic zones
Boreal Cordillera Ecozone	mountains and valleys separated by wide lowlands

Disturbance of the Land Surface

Developing access roads and associated facilities to support the construction and operation of oil and gas pipelines disturbs the surface of the land. This disturbance starts at the stage of exploration and production drilling *(see Exploration and Production Drilling: A Primer)* and lasts until roads, pipelines, utility corridors, and the well pads that supply oil or gas to the pipeline are fully reclaimed and restored.

When developers create roads, camps, equipment storage areas, oil and gas treatment facilities, pipelines, and other clearings, this leaves breaks or separations in ecosystems. Fragmentation of the landscape disrupts habitat and affects the movement of wildlife. The construction and operation of pipelines can also impact the land if vehicles compact the soil or damage the vegetative mat.

The time it takes for temporary access roads used during the construction of a pipeline to be fully restored to a natural state can vary significantly. Restoration time depends on the time of year roads are built, the surface preparation needed and equipment transport methods used, and the sensitivity of the soil/vegetation. Pipelines and their associated roads and facilities may stay open and active

for decades before they are finally abandoned and the disturbed areas recovered.

Over time, as companies build more and more pipeline and processing infrastructure in an area, production costs become cheaper. This means that previously uneconomic reserves of oil and gas can become economic to produce. This can result in multiple waves of oil and gas exploration and production activity in a given area and lead to cumulative impacts.

Permafrost

In arctic environments, the extent of surface disturbance depends on the type of soil and whether the soil is permafrost (a permanently frozen layer of soil underlying the "active layer" on top that melts and re-freezes each year). Permafrost soils are easily damaged. They are very sensitive to changes in temperature. Human activities, including the operation of large equipment, can result in dramatic reshaping of the land through rutting of roads, "melt-outs" and subsidence (settling of the land). Disturbing, compressing or removing any surface material and vegetation can result in increased soil temperatures in summer months. This can seriously damage the permafrost.

Wildlife

Areas where there are many right of ways, cutlines and access roads damage wildlife and wildlife movement. For example, although woodland caribou often cross cutlines to access adjoining habitat, they will generally avoid being within 250 metres of these lines.[2] In addition, wolves will use cleared pathways to quickly access an area, thus increasing predation on certain animals. Cleared areas have created more habitat for moose. The presence of larger moose populations may decrease habitat available to other animals, attract predators to the area, and thereby upset the ecological balance.[3] Oil and gas pipeline operation and construction may generally affect the size of wildlife populations, the location of herds, and their traditional migratory paths.

Continuous noise from pipeline compression and pumping engines and the sudden roaring noise caused by pipeline blowdowns can also disturb wildlife. Wilderness areas can be damaged by the transportation of both

MORE PIPELINES CAN LEAD TO MORE DRILLING

The lack of a pre-existing gathering system pipeline to transport produced gas or oil is often a major economic barrier to exploration and production drilling in a given area, even if a company is confident that reserves exist. Removing this barrier through construction of a new pipeline often leads to more drilling and more oil and gas production than originally planned in a given area.

2 Dyer, S.J. Summary of master of Science Thesis: Movement and distribution of woodland caribou in response to industrial development in northeastern Alberta (University of Alberta, 1999). http://www.deer.rr.ualberta.ca/caribou. October 5, 2000.

3 Bob Wyne's presentation at the CPAWS Oil and Gas Workshop, Boreal Caribou Research Program, Alberta's Boreal Caribou and Oil and Gas Development, May 26, 2000.

personnel and equipment to and from pipeline operating facilities. Permanent roads and pipeline corridors provide extensive and long-term access to hunters, fishers, and industrial and recreational users, which can have a severe impact on wilderness areas and wildlife populations.

Spills of oil and produced water can damage soil and vegetation and adversely impact water quality. Oil spills can be particularly damaging to aquatic environments and very difficult to clean up.

Arctic fox.

SOURCE: KEN MADSEN

Fish

Pipeline watercourse crossings that involve trenching of the bottom of the stream or river bed can damage fish habitat, either in the immediate area of the crossing, or downstream, by releasing sediment into the watercourse that is deposited further downstream. Fish can be impacted directly if the crossing requires a temporary blockage of the stream flow.[5]

Vegetation

In addition to wildlife, trees and other plants are also affected by land disturbance caused by constructing and operating oil and gas pipelines. When vegetation in arctic regions is damaged or removed, it takes a long time to grow back. This is because the growing season is short, and many areas have permafrost soils and slow-growing plant species. Compared with more southern parts of Canada, northern Canadian vegetation takes more time to recover from surface disturbances like roads and pipeline corridors.

Since oil and gas are non-renewable resources, companies will eventually exhaust supplies. Any surface impacts associated with resource extraction should, in theory, be temporary. However, surface impacts associated with oil and gas development often last far longer than initially expected. This is because oil and gas production typically becomes cheaper as developers build production and transmission infrastructure and as there are advances in technology. This means that previously uneconomic reserves of oil and gas can become economic to produce. In other words, previously constructed pipelines and other facilities can be in production longer and

5 Cott, P.A and J.P. Moore. April 2003. Working Near Water: Considerations for Fish and Fish Habitat, Reference and Workshop Manual. Northwest Territories, Department of Fisheries and Oceans – Western Arctic Area.

companies may drill new wells in areas initially thought to be fully exploited.

If companies do not work cooperatively to coordinate the routes and the sizes of the pipelines, instead of designing pipelines that meet the needs of individual companies only, they will collectively build more pipelines and associated facilities than are really necessary. Unnecessary pipeline infrastructure creates unnecessary additional industrial "footprint" impacts.

ARCTIC CARIBOU

Arctic caribou can be affected by the presence of oil and gas well pads, roads, processing facilities, and pipeline and utility corridors: [4]

Increased Predation

Oil-field development may increase the impact of predators on caribou by forcing them to move into areas that have more predators, by increasing access of predators into areas where the caribou live, and by making caribou more vulnerable to predators by forcing them into the open areas more often where they have less protection.

Changes in Distribution

Studies in Alaska have found that, when they give birth to their calves, caribou will move away from areas where companies are developing. Caribou that have just given birth are sensitive to disturbance and avoid roads and gravel pads with human activity for up to two to three weeks. Conversely, caribou will sometimes stand or lie on gravel pads and roads during times when there are a lot of insects. The lack of vegetation and the cooler air on gravel surfaces means there are fewer insects to trouble the caribou.

Energy Stress

When vehicles and roads disturb an area, caribou react by becoming more active. This means that they spend more time and energy walking and running than do undisturbed caribou. However, caribou that are also being harassed by insects tend to be less sensitive to oil-field disturbances.

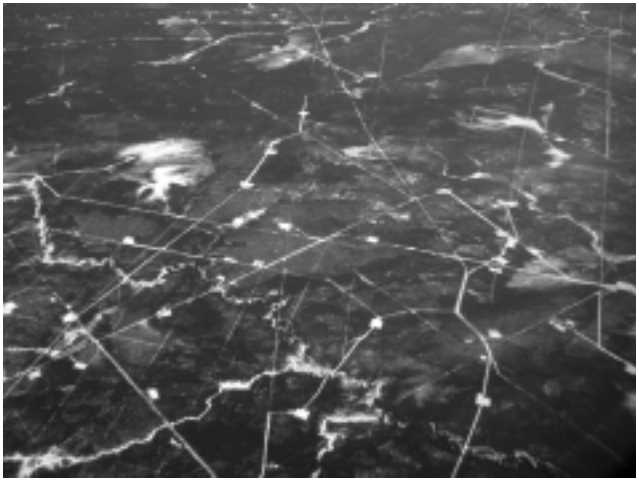
Productivity

The amount of weight that Arctic caribou gain depends on the vegetation they eat during the summer. Caribou that do not gain enough weight during the summer are less likely to become pregnant. The size of caribou herds could become smaller if oil and gas activity were to reduce the quality of and access to the vegetation they eat.

4 Truett, J. and S. Johnson. 2000. The Natural History of an Arctic Oil Field: Development and Biota.

Pipeline Right-of-way, Eastern Slopes Alberta.

SOURCE: VIVIAN PHARIS



Fragmentation in Alberta.

SOURCE: WAYNE SAWCHUK

Damage to Soil and Water

Pipeline construction and operation can cause damage to both soil and water quality, as outlined in detail below.

Soil Erosion

Pipeline construction can damage soil through erosion and compaction (increased density of soil). When crews remove vegetation from the land, or when their equipment damages permafrost, this can lead to soil erosion. Soil that would have been held in place by trees and other vegetation is now steadily worn away from the surface by rain, snow and wind and deposited as sediment into lakes, rivers and streams resulting in siltation (clouding of the water and deposits of fine particles on the bottom).

Spills and Leaks

Spills and leaks from pipelines are a major source of contamination in oil- and gas-producing areas. Pipeline leaks can directly expose vegetation and wildlife to oil and saline produced water, and contribute to overall degradation of soil and surface waters. While much of the spilled hydrocarbon and saline water can be contained and removed quickly, the affected sites can take years or even decades to completely recover.

Slow leaks often cause major soil contamination. Small "pinhole" leaks due to internal corrosion may not be detected for a long time because they have very little impact on pipeline pressure. As a result, slow leaks can release large volumes of oil or produced water into the environment.

Stress Corrosion Cracking (SCC) is one kind of failure that can occur as a result of external corrosion in buried pipelines. SCC refers to small cracks that develop on the outside surface of the buried pipeline. The cracks are not visible to the naked eye. Over a period of years, individual cracks can lengthen and deepen and join with other cracks, becoming large enough to cause the pipeline to fail or leak. While SCC is a factor in only a small percentage of pipeline failures, it is of particular concern because it can contribute to large explosions and fires.

Moose and calf

SOURCE: CPAWS – YUKON CHAPTER

Several serious pipeline failures and growing evidence of more widespread potential for SCC prompted the National Energy Board to initiate a Canada-wide inquiry into SCC in 1995. In spite of new monitoring procedures, SCC failures still occur. On February 7, 1999, an SCC failure of a pipeline owned by a subsidiary of TransCanada Pipelines Limited resulted in a massive explosion and fire at a location 80 km southwest of Drayton Valley, Alberta.[8] In early December 2003 two failures occurred in a single day on TransCanada's Alberta pipeline system.[9] The ruptures were 15 kilometres apart from each other and approximately 100 km south of Grande Prairie.

Damage to Air Quality

Many kinds of air emissions are associated with pipeline operations, including the following:

- carbon dioxide (CO_2) from burning natural gas to power pumps and compressors and flaring, which is a greenhouse gas
- methane (CH_4) from fugitive emissions and purging of gas lines, which is a greenhouse gas
- sulphur dioxide (SO_2) from flaring, which is an acidifying emission
- nitrogen oxides (NOx) from burning natural gas to power pumps and compressors and flaring, which are acidifying emissions

8 "Preliminary Assessment Indicates SCC Caused NGTL Line Break," TransCanada Pipelines Limited Press Release, February 19, 1999.
9 "Western Alberta System Pipeline Incidents," TransCanada Pipelines Limited Press Release, December 2, 2003.

- polycyclic aromatic hydrocarbons (PAHs) and volatile organic carbon compounds (VOCs), both from flaring, which include toxic compounds and fine particulate matter that affect human health
- if the oil or gas is sour, hydrogen sulphide (H_2S) from flaring, an acutely toxic air pollutant.

The largest source of air emissions from pipeline operations is from burning natural gas to drive large gas compressors and oil pump engines. Burning natural gas results in the emission of nitrogen oxides and carbon dioxide.

Other large sources of air emissions include flaring of gas for safety reasons when there is a problem with the pipeline and part of the pipeline needs to be shut down; pipeline blowdowns, which involves flaring and venting gas to empty a section of the pipeline for maintenance; leaks from pipe connections and valves; and pipeline leaks and spills. These sources can release methane, a powerful greenhouse gas, and a number of noxious or potentially harmful gases, including VOCs and hydrogen sulphide.

If monitored, pipeline failures can be detected by pressure changes or flow imbalances. Some small and low-pressure gathering system pipelines and produced water pipelines may not be continuously monitored. Some pinhole leaks are too small to be located by pressure changes or flow imbalances and may only be detected by actual observations at the surface of the pipeline. Landowners are often the first to spot many of the pipeline failures that occur in more populated areas of Canada. After a leak or spill has been detected, the volume of additional gas or liquid released depends on how long it takes to depressurize the pipeline. The shorter the time to depressurize the pipeline, the less leakage occurs. In the case of

FREQUENCY OF PIPELINE FAILURES

Between 1980 and 1997, the oil and gas industry averaged 674 pipeline failures (leaks and spills) per year in Alberta.[6] During fiscal year 1998/99, 885 pipeline failures occurred.[7] At the end of 1997 there were approximately 266,000 km of energy-related pipeline in Alberta. Most of the failures were due to internal corrosion in pipelines that carry produced water and multiphase pipelines (pipelines that transmit both oil and gas); about two-thirds of the failures were in small-diameter gathering system pipelines. Leaks accounted for 87 percent of the failures, and ruptures for 13 percent. Internal or external corrosion was the cause of two-thirds of all failures. Ninety-five percent of spills were of less than 100 m3 of liquid or 100,000 m^3 of gas.

6 Report 98-G, Pipeline Performance in Alberta 1980–1997. Alberta Energy and Utilities Board, December 1998.
7 Statistical Series 57 — Field Surveillance April 1998/March 1999 — Provincial Summaries Alberta Energy and Utilities Board.

a sudden rupture, the volume of gas or liquid released depends on the length of pipeline between control valves and whether control valves are operated remotely by computer or by mobile field operators. Control valves operated remotely by computer can be shut off more quickly than those operated by workers who physically need to go out into the field.

Spills caused by leaks from oil pipelines can release a large volume of VOC emissions. A fraction of the spilled oil evaporates a short time after it spills onto the surface. Burning off spills by deliberately igniting them releases a large volume of pollutants into the air.

Cumulative Impacts

A single oil and gas project, including for example a well, a pipeline and a road, may by itself have only a small impact on the environment. However, in combination with other projects that occur over time, the impacts can become bigger and bigger. Since many wells, roads and pipelines will be needed over time to exploit the large oil or gas reserves in the North, such cumulative impacts will likely be significant.

Flaring at a compressor station

SOURCE: PEMBINA INSTITUTE

OIL & GAS DEVELOPMENT

Oil and gas development in Alaska started in 1960 with one producing oil field. By 2001 oil development consisted of 19 producing fields, 20 pads with processing facilities, 115 pads with support facilities, 91 exploration sites, 13 off-shore exploration islands, 4 offshore production islands, 16 airstrips, 1,395 culverts, 960 km of roads and permanent trails, 725 km of pipeline corridors, 353 km of transmission lines, and gravel mines affecting 2,600 ha.[10]

10 National Research Council of the National Academies, Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope. March 2003.

THERE IS STILL A LOT WE DON'T KNOW

There may be more environmental impacts associated with oil and gas development than are described in this primer. There are many things we still do not know about the impact of the oil and gas industry on the environment in Arctic Canada.

The Committee on Cumulative Environmental Effects of Alaskan North Slope Oil and Gas Activities has identified several major knowledge gaps in Alaska: [11]

Need for Comprehensive Planning
The government has typically decided who is given a permit to develop on a case-by-case, individual application basis. There is not a comprehensive plan to identify the scope, intensity, direction, or consequences of all industrial activities over time.

Ecosystem-level Research
Most ecological research in the Prudhoe Bay region of Alaska has focused on local studies of the behaviour and population of animal species. Long-term studies are needed to determine the impact of industrial activity on the productivity of tundra ecosystems.

Human Health Effects
There is not much information available on the effect of oil and gas activities on human health. More research is needed in this area.

Zones of Influence
The effects of industrial activities go beyond the industrial sites themselves and even the immediate area. Animals can be affected by gravel roads and well pads to a distance of several kilometres. Industrial structures on the tundra can be seen as far as 100 km away. More research is needed to learn about the impacts of activities and structures, and the distances over which the effects occur.

Air Contamination and its Effects
More research is needed to find out how much local emissions oil and gas facilities produce, and to determine ways that local and regional air masses and their contaminants interact.

Seismic Exploration and Other Off-Road Traffic
Studies are needed to determine the amount of snow cover and the depth of frost penetration into the soil that is required to adequately protect the tundra from the effects of seismic exploration vehicles. We need more information on the effects of trails from off-road vehicles, and how long these impacts last.

Bowhead Whales
Studies are needed to find out whether there is a relationship between noise generated by offshore oil and gas activity and the behaviour of bowhead whales.

Water Withdrawals
In Alaska, developers that wish to extract water from fish bearing lakes in the winter time are required to estimate the minimum water volume of the lake and then take no more than 15% of that volume. This level was arbitrarily set. Researchers need to find out whether this level of water withdrawal actually protects fish and invertebrates.

11 National Research Council of the National Academies, Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope. March 2003.

Using the Best Practices Available

Pipeline construction and operation involves activities that will result in some environmental damage. Regulators and developers can minimize disruption of the environment by using "best practices and technologies" — the most environmentally effective standards, practices, and technologies that have been proven to minimize environmental damage.

Overall, best practices aim to ensure community sustainability. When companies use best practices, they take a "triple bottom line" approach, considering the economic, environmental, and social impacts on the community of any action they take. In each of these areas, regulators and developers design best practices to minimize damage to the community's well-being and to increase its viability.

In oil and gas development, there are three types of best practices:

- those that apply to the principles of how the work is planned and carried out
- those that refer to the practices and standards used in the field
- those that have to do with the equipment that is used.

With pipeline construction and operation, most of the best practices refer to choices that industry should make before construction starts. Companies should select the least environmentally damaging configuration of pipeline facilities and pipeline route. They should use low-impact construction techniques, and equipment and technology at facilities that minimize air emissions, as well as leaks and spills.

At this stage of oil and gas exploration, regulators can also use best practices to prevent the rapid growth of pipelines and associated facilities. They can require industry to maximize the use of existing infrastructure before allowing companies to build new facilities and create additional impacts.

The best practices that are used during pipeline construction and operation are designed to

- minimize land disturbance and habitat fragmentation
- minimize soil compaction and erosion
- prevent damage to riparian areas
- avoid soil and water quality impacts
- minimize direct and indirect wildlife disturbance and mortality
- minimize air emissions
- minimize leaks and spills
- ensure worker and public safety in the event of an accident or upset
- avoid impacts to fish and fish habitat

The particular suite of practices and measures adopted for a specific pipeline project should reflect local circumstances. Not all of the best practices or measures listed below are appropriate in all cases.

Planning

Integrated Land Use Planning

Governments should carry out as much land use planning as possible before the oil and gas development activity occurs. Governments should identify and map the areas that are most important from an ecological and cultural perspective, as well as the important habitat areas and wildlife corridors that are needed to connect protected areas together in a way that preserves the overall ecological integrity of the region.

By designating regions as protected, regulators preserve wildlife habitat, sacred sites, areas of traditional use for travel, hunting and gathering, burial grounds, and other sites of deep cultural significance. More work is needed to establish a network of protected areas that is representative of Canada's natural regions. In 1992, federal, territorial and provincial governments in Canada committed to a plan to establish a national network of terrestrial protected areas by 2000. The goal was not achieved. By 2000 only one-third of Canada's 486 terrestrial natural regions were adequately or moderately represented.[12]

Protected Areas

One way regulators can ensure they protect a region from some of the impacts of oil and gas development is to designate a network of parcels of land as "protected areas." These are areas that are of ecological, historical or cultural importance. Ideally, protected areas should be allowed to continue to function naturally and without any disruption. They should be large enough to preserve existing natural relationships and to allow these relationships to cycle and change according to natural forces, and without the impacts of industrial development.

Protected areas can serve as important regions where regulators and developers can conduct scientific research. They can compare the health of ecosystems in areas where oil and gas development has taken place with the health of ecosystems in protected areas where regulators have not allowed any development to occur. By using protected areas as benchmarks, government and industry can also evaluate the performance of measures that are used to mitigate impacts in areas where oil and gas development is allowed.

Special Management Areas

Besides establishing protected areas, another way governments can protect regions from the impacts of oil and gas development is to set aside lands as "special management areas" — areas where, temporarily, they will not allow any development to occur or where they will only allow certain types of development activity. The Muskwa-Kechika area of North Eastern British Columbia is an example of a special management area.

Special management areas must be large enough to preserve ecological integrity and to

12 World Wildlife Federation pamphlet, A Conservation Vision for the Mackenzie Valley natural gas pipeline: Balancing Nature and Industrial Development, July 2002.

THE MUSKWA-KECHIKA MANAGEMENT AREA

Muskwa-Kechika Management Area

SOURCE: GOVERNMENT OF BRITISH COLUMBIA *(http://srmwwwlgov.bc.ca/rmd/rmp/mk/maps/general/mk-over.htm) Feb 2004*

The Muskwa-Kechika Management Area was established in 1997. In 2001 it was enlarged to encompass a total area of 6.4 million hectares. Over one million hectares of the total area are parks and are therefore excluded from industrial development. Resource development including oil and gas is allowed in the rest of the management area in a manner that ensures protection of important wildlife and environmental values in the area.[13]

13 Background on the Northern Rockies/Muskwa-Kechika, Canadian Parks and Wilderness, http://www.cpaws.org/northernrockies/background.html, August 2003.

support biodiversity. They can also act as laboratories for scientific inquiry. Similar to protected areas, special management areas can include areas that serve as "ecological benchmarks" against which industry can measure the success of its reclamation efforts in the parts of the region open to development.

Many migratory bird species spend part of their life cycle in Canada's North.

SOURCE: KEN MADSEN.

To preserve a healthy ecosystem, special management areas cannot exist by themselves. They must connect with other surrounding areas that are also excluded from development, including undisturbed corridors that allow for wildlife to move and wander, and wetland migratory birds.

Special management areas may have restrictions on the total amount of industrial activity that occurs at one time. Once developers have finished their oil and gas work in an area, they may do work to reclaim those areas, restoring as much as possible the original ecological integrity and biodiversity. When regulators deem the reclamation work to be successful, developers can then begin to develop areas originally set aside as reserves. This approach ensures that a certain percentage of the land at any given time is non-developed and functioning as a natural ecosystem.

LAND USE PLANNING IN THE GWICH'IN COMMUNITY

In the Northwest Territories, residents of the Gwich'in First Nation Settlement Area developed a land use planning strategy. Out of this, the Gwich'in Land Use Planning Board issued a land use plan in 1999 entitled Nanh' Geenjit Gwitr'it T'Igwaa'in (Working for the Land). Under this plan, the government divided the entire Gwich'in Settlement Area into three zones: protected areas, special management areas, and general use areas.

Protected Areas

Of the whole settlement region, the Gwich'in have set aside about 10% of the land as protected areas. In Gwich'in Settlement Areas, the traditional knowledge and experience on the land of residents and communities were a key factor in the land use planning process. The Land Use Planning Board has identified four types of Gwich'in Protected Areas in the land use plan:

- *core areas communities would like to see protected based on a variety of values ranging from current and historical use, heritage resources, wildlife, fish, forests, vegetation and water resources;*
- *core areas the scientific community would like to see protected based on critical wildlife habitat and populations, outstanding heritage sites, unique land features and ecological processes;*

SOURCE: NORTH YUKON RENEWABLE RESOURCE COUNCIL

SOURCE: NORTH YUKON RENEWABLE RESOURCE COUNCIL

- *five out of the six ecoregions of the Gwich'in Settlement Area; and*
- *areas that do not unreasonably limit the ability of resource development to occur in the Gwich'in Settlement Area.*

CONTINUED

LAND USE PLANNING IN THE GWICH'IN COMMUNITY

As well as these four types of areas, there are also another 13 smaller Gwich'in Heritage Areas. These are areas of outstanding historical or cultural significance in the Gwich'in Settlement Area. These areas have the same status as Gwich'in Conservation Areas. The Gwich'in identified these areas through community consultation and with the help of the Gwich'in Social and Cultural Institute.

Special Management Areas

Of the whole settlement region, the Gwich'in have set aside about 33% of the land as special management areas. These are areas of special value to residents and communities of the Gwich'in Settlement Area where multiple uses may take place, provided potential developers meet the land use planning conditions of the particular Gwich'in Special Management Area.

General Use Area

Of the whole settlement region, the Gwich'in have set aside about 57% of the land as general use areas. These are areas that communities and other groups decided did not contain any specific resources needing special protection beyond what is available through the normal regulatory system.

Within the Gwich'in Settlement Area, all groups, including the Gwich'in, federal government, territorial government, co-management boards and business groups, must conform to the regulations Land Use Plan once it is approved. Regulators, like the Gwich'in Land and Water Board, cannot issue a licence, permit or authorization until developers show that their proposed activities conform to the Land Use Plan.

A variety of best practices can help reduce the overall impact of pipelines at the design and construction stages:

- Design pipelines as close as possible to the anticipated capacity needed for full development of oil and gas reserves in an area. The numberof pipelines constructed in an area can often increase quickly due to competition and insufficient design capacity for future development.
- Design pipelines so they can be expanded with minimal impact. Examples include placing a second pipeline (called looping) under river crossings to facilitate future expansion without having to conduct another river crossing, and designing future capacity into a gathering system pipeline by installing more compression at an existing site.
- Work cooperatively with other companies to coordinate the routes and the sizes of the pipelines that are developed in an area instead of designing pipelines that meet the needs of individual companies only.
- Use existing rights-of-way (e.g., pipelines, roads) or other cleared areas (e.g., seismic lines, cutlines, cut-blocks), where possible.

- Reduce the width of rights-of-way and working space during construction.
- Route pipeline rights-of-way to avoid sensitive or protected areas.
- Construct when the ground is frozen to minimize vegetation damage.
- Bore under sensitive river and stream crossings, and consider boring underneath sensitive ecosystems.
- Introduce slight "bends" in the rights-of-way to interrupt long line-of-sight impacts for both below-ground and aboveground pipelines (e.g., 5–10 degree bends every 500–700 m).
- Schedule construction to avoid sensitive periods of wildlife activity (such as mating season for sensitive species).
- Be prepared to handle archaeological finds.
- Provide environmental training for all on-site construction staff and contractors.
- Maintain vegetation on stream banks where subsequent grading and ditching is not required.
- Avoid felling cleared trees into adjacent forested areas or water bodies. Felled trees can be lain down on the ground to stabilize soil and prevent erosion in sloped areas.
- Bore below steep slopes to avoid erosion.
- Schedule blasting to minimize impacts on wildlife.
- Clean up all construction debris and

LAND USE PLANNING IN THE DEH CHO COMMUNITY

In April 2003 the Deh Cho First Nations and the Government of Canada announced that, for a five-year period as part of a longer-term land use planning process, it had formally withdrawn from development land totalling 10.1 million hectares[14] of northern boreal forest and wetland habitat in the Mackenzie Valley.[15] The temporary set aside of land in advance of proposed construction of a major natural gas pipeline along the Mackenzie Valley will allow the community to complete a Deh Cho land use plan. The plan will define how land will be managed in the Deh Cho territory.[16]

No development at all will be allowed on some of the lands withdrawn. In other cases only sub-surface development, such as oil and gas extraction, is excluded.

The land withdrawals process included consultations with Deh Cho community members, as well as third parties who have interests in the region like mining companies, oil and gas companies, and environmental groups. The decision to withdraw portions of the Deh Cho lands took account of the following criteria:

- *Lands harvested for food and medicinal purposes*
- *Culturally and spiritually significant lands*
- *Lands that are ecologically sensitive*
- *Watershed protection.*

14 The Deh Cho region of the Northwest Territories encompasses 20.8 million hectares.
15 Gift to the Earth #84, World Wildlife Fund, 17 April, 2003.
16 Backgrounder. Deh Cho Process – Interim Land Withdrawals, www.ainc-inac.gc.ca/nr/prs/j-a2003/02287bbk_e.html, April 17, 2003.

temporary structures (e.g., gates, bridges), and dispose of the debris properly. The goal is to leave the area as close to its pre-development condition as is possible.

- Block off access points by replanting trees, or constructing rollback windrows, earthen berms, slash piles, or fences.

Low-Impact Access Techniques

Temporary Road Access

Pipeline construction crews need vehicle access to the pipeline right-of-way during the site-clearing stage. They also need access to the locations along the right-of-way where segments of pipe are being welded together and buried (in the case of buried pipelines) or mounted on platforms (in the case of aboveground pipelines). Companies should use low-impact access techniques to reduce the land disturbance associated with roads. Forexample, crews can create temporary winter access roads only, and, whenever possible, use existing rights-of-way, cutlines, and so on. Temporary compacted snow or ice roads minimize surface impacts and are especially important in areas of the North where there are sensitive vegetation and permafrost soils. As well, using previously disturbed areas, such as rights-of-way and cutlines, will prevent further damage to these areas.

Grizzly Bear.

SOURCE: CPAWS YUKON CHAPTER

Permanent Road Access

Companies should use remote computer systems, such as Supervisory Control and Data Acquisition (SCADA) systems, to operate valves, and compressor and pumping stations along pipelines to reduce the need for year-round surface access to pipelines. Such computer systems also reduce the need to build numerous permanent roads to a pipeline. Companies can also avoid building permanent roads by using high-tech leak detection and leak monitoring systems, and small all-terrain vehicles and helicopters to do visual inspections and on-site maintenance. Fewer permanent roads also means less need for extracting and transporting gravel to build the roads. In turn, there is less need to spray pesticides at road approaches.

Operation Technology

Production sites (pipeline valve stations, compressors, pumping stations, wells, etc.) can be operated remotely using cellular, radio, or satellite SCADA technology. Remote operation technology minimizes the need for personnel to visit sites and reduces stress on wildlife. SCADA systems allow operators located at central facilities (e.g., gas plants) to control by computer the wells and pipelines that are connected to the facility. If major maintenance is required on a particular part of a pipeline, it can be done using low-impact vehicles or helicopters, or it can be planned for the winter months when access roads along the right-of-way can be constructed with minimal surface impact.

Low-impact Water Crossings

Trenchless water-crossing techniques (horizontal directional drilling, punch/ram, boring) are preferable to in-stream work. Improved technology and experience in directional drilling of pipelines underneath watercourses has reduced the risk and cost associated with this activity. Crews should leave a buffer of riverbank and natural vegetation between the drilling location and the stream or river to prevent erosion, wildlife reduction, and visual impacts associated with trenchless techniques. Crews can minimize the release of mud into the river from drilling below the riverbed by carefully monitoring the pressure and volume of drilling mud in the well bore (the hole that is created by drilling) and by observing the river for siltation.

Many companies now drill water crossings below the riverbed to avoid delays caused by the timing of fish spawning/over-wintering and the time required to obtain regulatory approval for in-stream work.

ARCO Alaska Inc.'s Alpine field designed a 1.2 kilometre-wide pipeline crossing the Colville River to use a horizontal directionally drilled tunnel 30 metres below the riverbed so as to not disturb river ecology.[17] The Alliance Pipeline, which carries gas from Northeast British Columbia to the city of Chicago, US, has used this technology to cross several major river systems (Peace, South Saskatchewan, Battle, Mississippi, and Des Plaines rivers).

SOURCE: CANADIAN PARKS AND WILDERNESS SOCIETY – YUKON CHAPTER

17 U.S. Department of Energy Comments to the Bureau of Land Management, U.S. Department of the Interior on the Northeast National Petroleum Reserve — Alaska Draft Integrated Activity Plan/Environmental Impact Statement, March 12, 1998.

The Canadian Pipeline Water Crossing Committee, a committee of government, industry, and environmental stakeholders, released a report entitled "Water Crossings" (Second Edition). Chapter 7 of the report deals with reducing the environmental impacts associated with pipeline water crossings. Examples of best practices, which apply to more than just water crossings, include the following: [18,19]

General

- schedule construction during periods of lowest sensitivity
- prepare spill, erosion, and flooding contingency plans
- keep fuels and waste well back from water body to prevent spills or contamination
- prevent introduction of noxious weeds
- implement erosion control measures in advance of activity

Surveying

- avoid environmentally or culturally significant areas
- ensure sufficient workspace on approach slopes
- minimize staging area needed
- mark or flag sensitive areas within disturbance area

Clearing

- postpone and minimize clearing to prevent erosion
- use uncleared buffer zones
- use tracked vehicles on slopes to prevent damage
- retain timber for riprap, log-fill crossings, and temporary bridges if needed
- estrict grubbing in wetlands to avoid creation of bog holes

Topsoil Handling

- strip topsoil under dry conditions from all areas to be graded or used for soil storage
- postpone stripping of approach slopes, floodplains, and banks
- stockpile topsoil above the high water mark and stabilize with vegetation if piles are to be left for more than one season

Grading

- grade snow to prevent erosion and runoff of dirty water into water courses
- minimize grading on steep slopes
- avoid blocking channels
- minimize total area graded

Welding and Weighting

- assemble pipeline and complete welding, coating, testing, and weighting of the pipe in an upland area before trenching begins to minimize stream impacts

18 Watercourse Crossings, 2nd Edition, Canadian Pipeline Water Crossing Committee, November 1999.
19 Cott, P.A and J.P. Moore. April 2003. Working Near Water: Considerations for Fish and Fish Habitat, Reference and Workshop Manual. Northwest Territories, Department of Fisheries and Oceans – Western Arctic Area.

In-stream Blasting

- use controlled and less destructive means of removing bedrock, such as ripping or breaking
- avoid the use of ammonium nitrate-based explosives

Pipe Installation

- stop trenching activity short of watercourse and leave trench plugs in place during watercourse crossing to prevent silty trench water from entering the watercourse
- contain runoff and trench de-watering fluids in a storage pond to prevent them from entering the watercourse
- minimize in-stream activity
- install spare pipelines to prevent the need for future in-stream pipeline construction activity
- stop activities if excess sedimentation occurs

In-stream Sediment Control

- use in-stream sediment filtering techniques
- minimize the disturbance of stream bed material and banks
- ensure that no deleterious materials (i.e., sediment) are released into the watercourse

Backfilling

- backfill from the centre to the sides
- ensure backfill is well compacted

Surface Erosion and Sediment Control

- ensure that ditches do not drain directly into a watercourse
- install temporary silt fences near the base of slopes
- re-vegetate disturbed areas as soon as possible, and transplant native shrubs and small trees

Clean-up and Reclamation

- clean up immediately following backfill
- remove crossing structures prior to freeze up if possible
- re-grade to pre-construction profile

Aquatic Habitat Restoration and Enhancement

- avoid important habitat areas
- use non-instream crossing methods
- time activity to minimize aquatic impacts
- restore habitat as quickly as possible
- maintain fish passage during instream construction activities
- monitor site to ensure successful restoration

Bank and Riparian Habitat Restoration and Enhancement

- select work locations that minimize bank impacts
- set activity back from watercourse edge
- leave buffers in place
- minimize space used in bank areas
- restore habitat as quickly as possible using native plant species
- monitor site to ensure successful restoration

Preventing, Detecting, and Handling Spills and Leaks

Spill Prevention

Corrosion Control — Corrosion (internal and external) is the greatest source of pipeline leaks. Companies can minimize, control, and monitor corrosion in pipelines by properly selecting pipe material and putting in place a corrosion control program that uses corrosion inhibitors, cathodic protection, and "smart pigging." Companies can also design and operate pipelines so that corrosive liquids do not build up in low spots along the line and pipeline velocities are not so great as to cause erosion. Companies should review the effectiveness of their corrosion control program each year.

Stress Corrosion Cracking (SCC) — The 1996 recommendations from the SCC Inquiry Panel to the National Energy Board included industry-wide implementation of SCC management programs, development of an industry SCC database, and mandatory monitoring of pipelines that are atrisk of SCC. The panel also called for improved pipeline design standards. Specifically, it recommended that all new pipelines should be designed to allow the passage of in-line inspection tools, and that there should be better information sharing, more research into best practices, and better emergency response planning.[20]

A definitive method of preventing SCC has not been found.

Emergency Shutdown (ESD) Valves — ESD valves are installed along a pipeline and are activated in the event of a leak. The distance between the valves and the speed at which they are closed control the amount of content leaked, especially in the event of a rupture.

Proper Signage and First Call Program — In Alberta, eight percent of pipeline leaks are due to mechanical damage by equipment (e.g., backhoe, trencher) used by non-pipeline workers. Many of these leaks could have been avoided if the equipment operator had known about the pipeline (i.e., if there had been clear signage with an emergency contact number at all road crossings, river crossings, and other pipeline crossings and facilities). A "First Call" or

Workers examine the integrity of a pipeline at a gas plant.

SOURCE: BALLYMAC HOLDINGS LTD.

20 Stress Corrosion Cracking on Canadian Oil and Gas Pipelines, National Energy Board, December 1996, www.neb.gc.ca/safety/scc.htm.

"Call Before You Dig" program run by the government or a third party is an excellent way of ensuring pipelines are not mechanically damaged.

Overpressure Protection — Between 1980 and 1997, 353 pipeline failures in Alberta were attributed to excessive pressures inside thepipeline.[21] Gathering system pipelines can be designed to ensure that the oil or gas wells that feed into them don't create an overpressure situation. As well, transmission system pipelines can be designed to withstand the maximum operating pressure of the pipeline compressors.

Spill Detection and Response

Leaks from pipelines can cause considerable environmental damage, especially if a spill occurs in a watercourse.

Pipeline balancing can detect pipeline failures and most leaks. Pipeline balancing involves measuring and comparing the pressure and volume of gas or oil where it flows into a pipeline with the pressure of gas or oil where it flows out of the pipeline. If there is a difference between the inflow and the outflow, it may mean that there is a leak; in this case, an alarm goes off and the pipeline is shut down. Pipeline balancing could also be used on gathering system pipelines, especially for large pipelines that carry sour gas (oil or gas containing hydrogen sulphide) and pipelines in sensitive areas. Pipeline balancing is regularly used on oil and gas transmission system pipelines.

Not all leaks can be detected by pipeline pressure changes or volume losses. Therefore, operators carry out routine pipeline rights-of-way inspections by air and on the ground.

Operators use portable spill response kits to respond quickly to incidents of pipeline leaks. Most companies have complete spill response teams and equipment in the event of a major spill. In areas with many pipeline developments, companies commonly form spill cooperatives and design plans to share resources in case of a spill. Having spill response equipment in place at strategic locations on pipeline routes before spills happen (especially at river crossings) can minimize the time needed to respond to a pipeline leak and reduce the impact on the land and on water bodies.

THE MACKENZIE DELTA SPILL RESPONSE CORPORATION

EnCana, Anadarko, Devon, BP, Chevron, Petro-Canada, and Shell joined together in 2001 to form the Mackenzie Delta Spill Response Corporation. The group's mission is "to provide a safe, rapid, and effective response to oil spills in the Mackenzie Delta. The goal is to provide for worker safety and environmental protection in the advent of a spill or release."[22]

21 Pipeline Performance in Alberta 1980–1997, Alberta Energy and Utilities Board, December 1998.
22 http://www.deltaspillresponse.org/Site/home.asp (July 2003).

In 1997, a Government/Industry North Slope Response Project Team was established in Alaska to evaluate spill response planning and preparedness for oil spills under every possible combination of environmental conditions for onshore and offshore development. The scenarios were used to identify additional equipment needed for the Alaska Clean Seas program inventory and to develop a technical spill response plan manual.[23]

Double-Walled Pipelines

Double-walled pipelines consist of a pipeline within a larger pipe. The outside pipe captures any fluid that escapes from the inside pipeline. Double-walled pipelines are used when the consequences of a leak, including a non-detected pinhole leak, would be very serious. Examples of double-walled pipelines include the following:

- *Acid Gas Disposal Pipeline* — This pipeline connects a sweetening facility (where hydrogen sulphide and carbon dioxide are extracted from sour gas to create a highly concentrated "acid gas") and a disposal well (where the acid gas is deep-well injected). Hydrogen sulphide gas is extremely toxic. A double-walled pipeline can monitor pressure and hydrogen sulphide, detect leaks very quickly, and direct leaked gas in the outside pipe to a flare that will burn it off.
- *Oil/Liquid River Crossing Pipeline* — An aboveground or buried pipeline that crosses a stream or river represents a contamination risk. If pipeline contents spill or leak into the water, they can kill fish and vegetation, and create long-term damage to the environment. A double-walled pipeline can contain and direct spilled fluids away from the water-crossing area, preventing substances from entering the water.

Pipeline Abandonment

Pipelines that are no longer useful can be depressurized, purged, cleaned, and possibly filled with inert gas to prevent corrosion and leaks.

Minimizing Air Emissions

Maintenance Venting and Flaring

All pipelines need to be depressurized at some point so that operators can maintain or repair them. When operators depressurize pipelines that carry liquids, they should pump the lines as dry as possible and direct any remaining liquid into tanks rather than pits to reduce environmental impacts. When operators depressurize pipelines that carry gas, they should decompress the lines (using field compressors, plant compressors, or portable "pull down or transfer" compressors) and direct any remaining gas into an incinerator or a flare rather than vent it into the air.

The need to blowdown pipelines can be reduced by using new techniques that allow industry to cut holes into a pipeline to connect new branch lines and to conduct repairs while the pipeline is in operation. These new

23 BP Exploration (Alaska) Inc., Environmental Performance on Alaska's North Slope, February 1998.

techniques are called "buttering" and "hot tapping." The key to the procedure is to ensure that no oxygen is allowed to enter into the cutting area so that the natural gas in the pipeline cannot ignite.[24]

Coordination of Pipeline Outages

Outages, or shut-downs of segments of pipelines, are needed to allow for activities such as cleaning, testing, repairing, and tying in new pipelines. To perform an outage, a section of pipeline is isolated and purged of gas. Minimizing outages by coordinating multiple activities into a single outage reduces cost and emissions associated with purging the line. TransCanada uses an Outage Decision Model to reduce the occurrence of outages and the quantity of gas vented to the air.[25]

Remote Shutdown Capability of Gas Gathering Systems and Operating Wells

When a gas pipeline is unexpectedly shut down, the gas from processing facilities and wells must be shut off or directed to a flare to avoid explosion hazards or the release of sour gas in the case of pipelines containing sour gas. The volume of gas released and the duration of flaring can be reduced by using SCADA or a comparable centralized control system, which allows an operator to remotely shut down individual wells and facilities or the entire producing field.

Reducing Emissions from Operating Equipment

Operators can reduce noise, and emissions of nitrogen oxides and greenhouse gases by using electric-powered variable frequency drives (VFDs) to cool fans for compressor engines, amine regenerators, and other equipment. VFDs can turn down cooling fans when ambient air temperature conditions are low (i.e., at night time and during the winter) rather than have them run at a constant rate. VFDs can also be installed on mainline pumping units.

Reducing Emissions by Improving Efficiency

Companies can minimize greenhouse gas emissions by using the most energy efficient engines for compressors and pumps that are available today. Companies can reduce greenhouse gas emissions by retiring older, less

Close up of a flare

SOURCE: PEMBINA INSTITUTE

24 TransCanada's 2002 Submission to the Climate Change Voluntary Challenge and Registry.
25 TransCanada's 2002 Submission to the Climate Change Voluntary Challenge and Registry.

efficient engines and replacing them with modern engines.

Leak Detection and Repair

All pipe connections and processing plant components leak to some degree. Companies can minimize fugitive emissions (emissions that escape) by designing facilities with the fewest possible components and connections, and avoiding components known to cause significant fugitive emissions.

Leak detection and repair (LDR) program operators perform routine preventative maintenance on equipment that is known to leak, and physically check equipment for methane emissions and repairs. An effective leak detection program requires regular and ongoing inspection by operators. To detect gas in the air, operators can use hand-held devices. One of the simplest methods to pin-point a leak in a pipeline is to apply a soap and water solution to fittings and valves where leaks usually occur and watch for bubbles. Operators can also use the latest hand-held devices, such as high-flow samplers, to quantify sweet gas fugitive emissions.

By measuring their fugitive air emissions, companies can design the most effective leak repair program for their facilities and provide realistic estimates of their greenhouse gas emissions to the government. The best LDR programs use low-methane measurement thresholds to determine when a repair is needed and to ensure leaks are repaired quickly. Plant turnarounds, scheduled facility shut-downs for major upgrading or plant-wide maintenance, are a key opportunity to schedule such repairs.

Some of the technologies available to reduce fugitive emissions from wells and facilities are described in the 1993 report entitled "Options for Reducing Methane and VOC Emissions from Upstream Oil and Gas Operations" by the Canadian Association of Petroleum Producers.

Industry Best Practice Commitment to Reduce Greenhouse Gas Emissions

The Kyoto Protocol, ratified by Canada in December 2002, requires a reduction in Canada's greenhouse gas emissions to 6% below the 1990 level during 2008–2012. In 2001, industrial facilities, including electricity generation, accounted for 53% of Canada's greenhouse gas emissions.[26]

Oil and gas companies and jurisdictions within Canada should develop and carry out greenhouse gas management plans to minimize the cost of complying with Kyoto and with subsequent emission reduction requirements. Such plans should include ways to reduce emissions through internal energy efficiency, investments in offsets and "green power," and a commitment to limiting absolute volumes of emissions. One company, BP, has set a goal to maintain its greenhouse gases emissions at 10 percent below its 1990 baseline level until the year 2012.[27]

26 Environment Canada, Greenhouse Gas Emission Summary, http://www.ec.gc.ca/pdb/ghg/canada_2001_e.cfm (July 2003)
27 BP - www.bp.com/environ_social/environment/clim_change/position.asp (July 2003)

Area of Concern	Best Practice
Comprehensive land use planning after subsurface rights are granted to industry	• Exclude oil and gas activity in areas that are of special ecological, historical or cultural importance. • Create special management area rules to govern oil and gas activity in ecologically important areas.
Rapid growth of pipelines	• Design pipelines for the capacity needed for full development of oil and gas reserves in an area.
Land disturbances	• Use existing rights-of-way (e.g., pipelines, roads) or other cleared areas (e.g., seismic lines, cutlines, cut-blocks) where possible. • Introduce slight "bends" in the corridor to interrupt long line-of-sight impacts (e.g., 5–10 degree bends every 500–700 m).
Construction-related impacts	• Reduce the width of rights-of-way and working space during construction. Route pipeline corridors to avoid sensitive or protected areas. • Construct in frozen-ground conditions to minimize damage to vegetation. • Bore under all sensitive river and stream crossings and consider boring underneath sensitive ecosystems. • *Schedule construction to avoid sensitive periods of wildlife activities (such as rutting season).* • Clean up all construction debris and temporary structures (e.g., gates, bridges), and dispose of debris properly. • Use pre-development conditions as a basis for post-development conditions.
Increased access	• Limit road access to the pipeline right-of-way. • Avoid new roads or access points as much as possible. • Construct low-impact temporary roads that can be rapidly reclaimed by the land.
Permanent road access	• Improve leak detection and use low-impact maintenance techniques, such as quads and helicopters, to avoid the need for permanent access roads and cleared rights-of-way.

Area of Concern	Best Practice
Water-crossing impacts to riverbanks and riverbeds	• Use trenchless water crossing techniques (i.e., horizontal directional drilling, punch/ram, boring) to avoid impact on riverbanks and riverbeds. • Leave a buffer of riverbank and natural vegetation between the locan and the stream or river to prevent erosion and reduce wildlife and visual impacts associated with trenchless methods. • Use impact mitigation measures when drilling under the watercourse is not possible.
Wildlife disruption	• Operate production sites (pipeline valve stations, compressors, pump stations, wells, etc.) remotely using cellular, radio, or satellite Supervisory Control and Data Acquisition (SCADA) systems to minimize the need for personnel to visit sites, thereby reducing stress on wildlife.
Pipeline maintenance impacts	• If major maintenance is required on a particular part of a pipeline, use low-impact vehicles or heli-support, or plan it for the winter months when low-impact snow or ice access roads along the right-of-way can be constructed.
Spills and leaks	• Implement any of the following to avoid spills: - Corrosion control - Stress Corrosion Cracking (SCC) - Emergency shutdown valves (ESV) • Overpressure protection • Proper signage and first call system • Inspect pipeline rights-of-way regularly using a combination of inspections by air and ground. These inspections might be as often as once a week for high-risk operations. • Balance pipelines. • Reduce impacts caused by spills by implementing spill response planning, and multi-company spill cooperatives.

Area of Concern	Best Practice
Maintenance venting and flaring	• Liquid pipelines — Depressurize and drain residual liquids into tanks rather than into open pits. • Gas pipelines — Decompress to as low a pressure as possible using field compressors, plant compressors, or even portable "transfer" compressors. After the pressure has been reduced, direct residual gas to an incinerator or a flare rather than venting it into the air.
Coordination of pipeline outages	• Coordinate maintenance and construction work within the overall pipeline system to help reduce unnecessary emissions associated with purging the line. For example, tie-ins of new gas pipelines, cleaning, and testing could all be scheduled and take place in the same area during the same time period. • Centralize control of gas fields using a Supervisory Control and Data Acquisition (SCADA) or comparable system that allows an operator to respond quickly to an unplanned pipeline disruption by shutting down facilities and wells, and thus minimize the duration of flaring incidents
Leaks in sensitive areas	• Use double-walled pipelines in areas where the consequences of a leak, including a non-detected pinhole leak, can be very serious (e.g., Acid Gas Disposal pipelines and Oil/Liquid River Crossing pipelines).
Greenhouse gas emissions	• Use electric-powered variable frequency drives (VFDs) to cool fans for compressor engines, amine regenerators, and other equipment to reduce greenhouse gas emissions.
Pipeline abandonment	• To avoid potential corrosion and leaks, depressurize, purge, clean, and possibly fill with an inert gas those pipelines that are no longer useful.
Leak detection and repair	• Use handheld devices to detect and quantify leaks. • Repair leaks in a timely manner.

Citizens' Rights

If you are concerned about a pipeline construction and operation project and think that you may want to take part in the regulatory approval process, this section gives you information and advice on how to go about it.

It explains how you can get information and summarizes the key issues associated with a pipeline project. It also gives advice on how to have a say in the government's decision-making process when approving such a project.

To construct and operate pipelines and related facilities, companies have to get a permit or licence from the government that will allow them to do the work. The way companies get these rights and permits and licences varies between the NWT and the Yukon, and from region to region within each territory. The rules about public consultation and public intervention opportunities can also vary. You can find more details about the laws and procedures for each region of the Yukon and NWT in Citizens' Rights and Oil and Gas Development: Northwest Territories and Citizens' Rights and Oil and Gas Development Yukon Territory respectively.

If you have concerns about a pipeline project that is in production and has been granted permits and licences to operate, you should direct your questions, comments or concerns to the company and/or appropriate regulatory agency directly – in person, by phone or in writing. Most companies will be interested in addressing public concerns even if the project has already received government approvals.

Here are some steps to follow if you wish to review and comment on a pipeline project that requires a government approval or licence, or if you are concerned about a pipeline project that already has the necessary government approvals:

Find out about Proposed Projects

The first thing you need to do is make sure you know what proposals there are for companies to construct and operate pipelines and related facilities.

Companies send copies of pipeline proposals and licence applications to government agencies, First Nations, and interested parties. Companies may also arrange for copies to be available for public viewing at libraries and government offices.

You can register yourself as an "interested party" by contacting the primary government agency responsible for oil and gas development in your region. You will receive notice of new pipeline construction and operation proposals and information about timelines for public comment on the regulatory approvals process.

Another way to get information about a proposed pipeline and related facilities is to contact the company directly and ask for a

copy of detailed proposals or licence applications, as well as information about future development plans.

A company planning to conduct oil or gas processing (the proponent) must give public notice of their plans before they receive regulatory approval. Notice requirements vary from region to region. Sometimes companies will post notices in local newspapers or other media to announce proposed projects; other times you may have to be more active to ensure you are aware of new proposals.

Learn about Public Consultation Rules

Next, you need to find out the rules for public consultation in your area.

Contact the primary government agency responsible for oil and gas development in your region and get answers to the following questions:

- What does the company have to do to give notice of their proposed project? Who do they have to consult? What form does the consultation have to take (meetings, open houses, etc.)?
- What does the company have to do with the public comments they receive?
- What is the deadline for public comments?
- To what government agency approving bodies does the company have to send public comments?
- What do government agencies do with public comments and concerns they receive?
- What happens if the public objects to or wants conditions attached to the approval, licence or permit?
- What is the process for deciding whether and how the project will proceed?
- Is it possible to call for a public hearing, if needed?
- How can the public find out whether the government has granted a drilling approval, licence or permit?
- How can the public get a copy of approvals, licences or permits?
- Can the public appeal an approval, licence or permit? If so, how?

Review the Pipeline Construction and Operation Application

Once you've received a copy of a company's proposal for a pipeline project, and have learned about the rules for public consultation, you'll next want to review the project application.

When you review the application you may find that you are satisfied with the information presented or you may have questions or concerns about the project.

If you have questions or concerns, make of list of these and call a meeting with the company and/or proper government agency to discuss them *(see box next page: How to negotiate with companies)*.

If you can't resolve your concerns about the project directly with the company or government agency you may wish to call for a public hearing *(see section on page 45: Participate in Decision Making)* if such a legal avenue is available.

Key questions to ask when reviewing a pipeline project operation permit or licence application (note that this is a general list and only a subset will be applicable to specific licence and permit applications):

HOW TO NEGOTIATE WITH COMPANIES

Most companies have experience dealing directly with members of the public who have questions and concerns about oil and gas projects. They usually welcome opportunities to meet with interested parties, to provide information and to try to resolve issues outside of formal regulatory decision-making forums.

When involved in discussions with a company, make sure you

- ❑ *Get everything in writing. If you have an oral agreement or telephone conversation with a company representative, ask him or her to confirm it in writing and to send copies to the proper government agencies.*
- ❑ *Ask the company to explain anything you do not understand. If some of the written information the company has provided is ambiguous, ask for clarification in writing.*
- ❑ *Tell the company any concerns you have about the project. Suggest ways they could change the project to address your concerns. Be persistent if the company does not adequately resolve your concerns right away.*
- ❑ *Don't make a deal with the company wherein they only agree to deal with your issues of concern if you agree to not take part in a hearing. Sometimes it is not possible for you and the company to resolve all of the issues. But, if a public hearing is held, it will be shorter and more focused if you have resolved as many of the issues as possible. A shorter, more focused hearing is to the benefit of all parties involved.*
- ❑ *Recognize that some "give and take" may be necessary. For successful negotiation, both parties must be able to reach their final objectives and be willing to agree with the other.*
- ❑ *Negotiations can take a long time. Often members need a lot of time to both review and write documents. Therefore, it is important to research opportunities for intervener funding. It may be reasonable to ask the company for funding to make sure that members of the public can be more effectively engaged in the consultation.*

- ❑ How long is the pipeline the developer is proposing? How big is the diameter?
- ❑ What type of oil or gas will the pipeline carry?
- ❑ Does the developer have an Emergency Response Plan? How big is the evacuation zone?
- ❑ How wide is the right-of-way? How much vegetation must crews clear to create the right-of-way?
- ❑ How much road access will crews have to create and how will they create it? Will the access they create be temporary or permanent?
- ❑ How will crews manage and reclaim access routes?
- ❑ Has they company assessed sensitive ecosystems within the project area?
- ❑ Will the company erect a camp for the project? For what time frame? Where will they locate it? How big will it be?
- ❑ In what season will construction of the project occur?
- ❑ Will crews use temporary snow and ice roads to transport heavy equipment and materials?
- ❑ How will they protect the soil and vegetative mat?
- ❑ What erosion mitigation measures will they use?
- ❑ What permafrost protection measures will they use?
- ❑ What reclamation practices will they use and will they monitor reclamation success over time?
- ❑ Will crews have to cross water bodies? How will they do this? Where will they locate the water crossings?
- ❑ How will crews manage and dispose of waste?
- ❑ How often will crews visually check the line for leaks?
- ❑ Will the company use a centralized control system to control the pipeline and any wells that are connected to the pipeline?
- ❑ How many pumping and compression facilities are needed, where will they be located and what are the air emissions?
- ❑ Will the company have a wildlife monitor?
- ❑ Has the company clearly outlined measures to avoid disturbing wildlife? Does the company have policies to ensure workers know how to minimize impacts on wildlife?
- ❑ Has the developer assessed socio-economic benefits (e.g., employment of local residents) and impacts associated with the proposed project?
- ❑ Has the company identified ways they will mitigate possible effects on other land uses such as trap lines, as well as on areas of cultural significance?

WORKING WITH THE MEDIA

Using the media to raise public awareness about an issue is not always appropriate. Under some circumstances, however, it can be an important tool:

- ❑ *It can make other members of the public aware of the proposed project and your concerns. This can help build support for your activities and increase your chances of success in negotiating with the company.*
- ❑ *It can encourage a company to negotiate. Many companies worry about their public image and would like to avoid negative publicity. Real or potential media attention on an issue may be an incentive for a company to try to resolve issues.*
- ❑ *It may ensure the government agencies are aware of and involved in your issue.*

Media include:

- ❑ *local, regional and national newspapers*
- ❑ *local and regional radio stations*
- ❑ *community and regional television stations*

If you have a message to get out, sending out a news release can be helpful. It does not have to be long, but you need to consider the following:

- ❑ *Decide on your main message and state this clearly in the first sentence.*
- ❑ *Include a brief outline of your key concerns and the outcome you want.*
- ❑ *Include one or more contact names and numbers.*
- ❑ *Put a short title at the top of the release — something eye-catching. Put the date at the top as well.*
- ❑ *Keep the release short — less than a page. You may want to include quotes and position statements.*
- ❑ *Consider including a separate "backgrounder piece." A backgrounder gives only factual information on the subject, rather than opinions.*
- ❑ *Make sure you are aware of the deadline for making submissions to the media.*
- ❑ *When your news release is ready, you should fax or deliver it to your local and regional newspapers, radio and television stations. Follow up with phone calls to select media contacts.*
- ❑ *Send a copy of your news release to both the company and the proper government agency. This will allow them to be better prepared to respond to the media if they know in advance what you are saying.*

Participate in Decision Making

If you meet with the company and government agencies directly and find you can't resolve your concerns about the project, you may wish to call for a public hearing.

Public hearings are meetings held to get comments from the general public, businesses, special interest groups, and local officials about proposed regulations, permits, or other changes that could affect the public.

You'll need to find out the rules for holding public hearings in your region, whether such a legal avenue is available for commenting on pipeline projects and what the terms are. You can find more details about public participation in regulatory decision making in Citizens' Rights and Oil and Gas Development: Northwest Territories and Citizens' Rights and Oil and Gas Development: Yukon Territory. These guides include government agency contacts that you can call to get more information about how governments conduct hearings and the specific rules for members of the public to call for and participate in hearings.

You'll want to find out:

- ❑ When are the deadlines for letters calling for hearings and for written and oral submissions?
- ❑ Who has intervener status—that is, the legal right to call for a hearing?
- ❑ Is there funding available for interveners to hire experts, including lawyers?
- ❑ What are the hearing procedures?
- ❑ Are there any appeal mechanisms?

For More Information

For information on government agencies, industry associations, and further reading on this issue, please consult the companion publication entitled: **Resources and Contacts**.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