UPGRADER Alley

OIL SANDS FEVER STRIKES EDMONTON

MARY GRIFFITHS

SIMON DYER

June 2008

Oil SANDS Fever SERIES

the PEMBINA institute

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Sustainable Energy Solutions

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About the Pembina Institute

The Pembina Institute creates sustainable energy solutions through research, education, consulting and advocacy. It promotes environmental, social and economic sustainability in the public interest by developing practical solutions for communities, individuals, governments and businesses. The Pembina Institute provides policy research leadership and education on climate change, energy issues, green economics, energy efficiency and conservation, renewable energy and environmental governance. More information about the Pembina Institute is available at http://www.pembina.org or by contacting info@pembina.org.

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Oil Sands Fever Strikes Edmonton

Ten-fold growth in bitumen upgrading will have major impacts on air, land and water

Oil sands production in northern Alberta could triple by 2020, to four million barrels a day. As a result of this increasing oil sands production, a major industrial expansion of bitumen upgraders is underway northeast of Edmonton. This so called “Upgrader Alley” is expected to handle nearly half the oil sands production, right on Edmonton’s doorstep.

Upgraders are large scale industrial complexes similar to oil refineries. They take the tar-like bitumen from the oil sands and “upgrade” it to synthetic crude oil. The upgrading process uses intense heat and pressures, requires large amounts of energy and water, and increases air pollution.

In 2007 there was one upgrader northeast of Edmonton converting bitumen to synthetic crude oil. That upgrader is being expanded, and plans are in progress for another eight. Companies are attracted to the Edmonton area by the availability of labour, land and infrastructure. Some of the synthetic crude oil will be piped elsewhere, but refining and petrochemical industries will also be attracted to the region to use both the oil and various byproducts.

All this development will transform the Edmonton area. The local municipalities have already rezoned agricultural land and natural areas to create a 530-square-kilometre region called Alberta’s Industrial Heartland, which is where Upgrader Alley will be located. The Industrial Heartland is three-quarters the size of the City of Edmonton.

The Athabasca Oil Sands Project (Shell Canada) upgrader northeast of Edmonton is already being expanded to process more bitumen.

Photo: David Dodge, The Pembina Institute

The Heavy Footprint of Oil Sands Upgraders

Nine upgraders are expected to be operating in Upgrader Alley between 2015 and 2020. When all phases are complete, each year the upgraders will

- consume about 10 times as much water as the City of Edmonton
- require twice as much natural gas as all the households in Edmonton
- use more electricity than is produced by the entire EPCOR Genesee coal-fired power facility, equivalent to the electricity needed to power all the homes in Alberta
- produce about 45 megatonnes of greenhouse gases, as much as would be produced by 10 million vehicles

Some companies will gasify coke to provide heat and power. This process reduces their need for natural gas and electricity, but it produces even more greenhouse gases.

Upgraders will also considerably increase air emissions of sulphur dioxide and nitrogen oxides, as well as hydrogen sulphide and other air pollutants.

> "Overall growth pressures in the Industrial Heartland are creating competition for land resources, resulting in known and potential impacts to wetlands, groundwater, soils, habitats and landscapes in general."
> —Alberta Environment

Transforming the Landscape

- Each upgrader will require hundreds of hectares of land. Good agricultural land and natural areas have already been rezoned.
- A new transmission line will be needed to bring in electricity from coal-fired power plants west of Edmonton.
- New railway lines and a new bridge across the North Saskatchewan River will bring trains to the heart of Upgrader Alley.
- Pipelines will carry in bitumen and natural gas and connect the upgraders to external markets.
- If greenhouse gases are captured to reduce emissions to the atmosphere, additional pipelines will be needed to take the greenhouse gases to an injection site.
- About 1 tonne of sulphur is produced for every 100 barrels of bitumen upgraded. Upgrader Alley will produce several million tonnes of sulphur each year when all the upgraders are in operation. If there is no market for it, this sulphur will have to be stored.

Upgrading bitumen, degrading the environment

The upgraders, associated industries and increased traffic are expected to reduce air quality. Alberta Environment is proposing limits on the emissions of sulphur dioxide and nitrogen oxides from current and new industrial plants in the Industrial Heartland, but their plan will still allow the concentration of sulphur dioxide and nitrogen oxides in the region's air to increase by 30–40% above current levels. These new measures will help limit the creation of fine particulate matter and ground level ozone, which can affect human health, but there are no specific plans to reduce emissions of hydrogen sulphide or volatile organic compounds.

Bitumen upgrading capacity for planned projects in Upgrader Alley

Company/Upgrader	Scheduled start-up	Bitumen (barrels/day)
Athabasca Oil Sands (Shell) – Scotford #1 and expansion	2003–10	290,000
BA Energy/Value Creation – Heartland	2008–13	163,000
North American Oilsands Corp/StatoilHydro – Strathcona	2016–20	243,000
North West Upgrading	2010–16	150,000
Petro-Canada/Fort Hills – Sturgeon	2011–15	340,000
Shell – Scotford #2	2013–22	400,000
Synenco – Northern Lights	on hold	115,000
Total E & P Upgrader	2013–19	245,000
Total for eight upgraders		***1,946,000***
Suncor (land holdings for upgrader, no details available)	?	?

Local residents worry they could face air emissions and sulphur storage problems similar to those at this Syncrude plant north of Fort McMurray

Photo: David Dodge, The Pembina Institute

It's Time to Get It Right

The Alberta government has selected Alberta's Industrial Heartland, which includes Upgrader Alley, as a pilot area for its Cumulative Effects Management Framework. Its approach will limit somewhat the increases in air pollution and withdrawals from the North Saskatchewan River, but it will not prevent the loss of good quality agricultural land. Provincial plans to address greenhouse gas emissions impose intensity limits, but they will allow an absolute growth in emissions from upgraders. The Capital Region Integrated Growth Management Plan will not be complete until 2010.

Impacts on land, air and water can be considerably reduced by integrating several industrial activities. But that requires careful planning. Given the fact that projects are likely to be approved before detailed plans and infrastructure are in place, some of the problems associated with rapid and uncontrolled growth in the Fort McMurray region could reoccur in Upgrader Alley.

> "The question is … how much can be removed or consumed out of the river and still maintain a good balance and a healthy aquatic ecosystem?"
>
> — Gord Thompson, North Saskatchewan Watershed Alliance

The North Saskatchewan River will supply the water for the upgraders. Alberta's new Water Management Framework for the North Saskatchewan River will limit withdrawals when water levels are low, but it will not stop them, even during critically low flow conditions.

Photo: David Dodge, The Pembina Institute

Summary of Recommendations

The Pembina Institute is asking for a pause on new approvals for oil sands production and upgrading. There will still be substantial growth — projects already approved will continue — but a pause would give time to plan new projects to reduce the cumulative effects.

Address Cumulative Impacts: The Capital Regional Integrated Growth Management Plan should be completed to ensure that infrastructure is in place before further projects proceed. The Cumulative Effects Management Framework should be strengthened to further limit impacts on air, land and water.

Limit Environmental Impacts to Protect Human Health and the Environment:

- Require all upgrader projects to be carbon neutral by preventing or offsetting their greenhouse gas emissions.
- Ensure flows in the North Saskatchewan River are adequate to protect aquatic life.
- Set protective limits for air pollutants, not adequately addressed in current plans.
- Compensate for the amount of land used for industrial development by protecting appropriate, additional lands elsewhere.

Focus on Quality of Life: The rate of growth must be managed to protect the quality of life, to maximize the benefits to those living in the region and to ensure that social services and infrastructure can keep pace.

Upgrader Alley

Oil Sands Fever Strikes Edmonton

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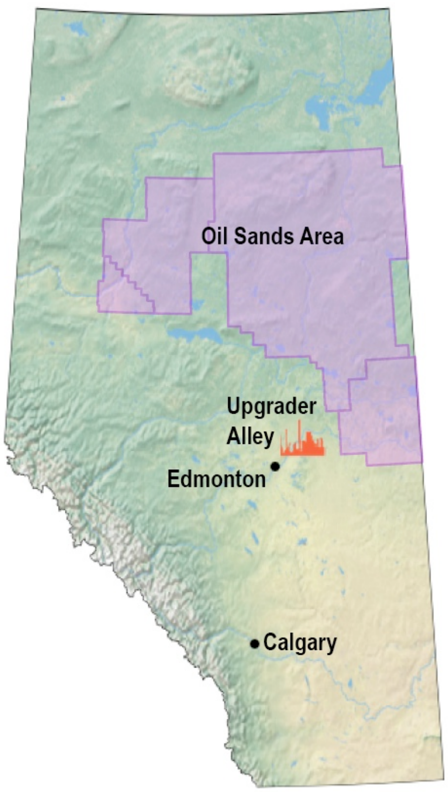
1. Oil Sands Fever Strikes Edmonton



The congestion and environmental impacts of the oil sands industry that is all too familiar in the Fort McMurray region is coming to Edmonton. Upgraders are large-scale industrial complexes similar to oil refineries, and several of them are planned for the area just northeast of Edmonton, known as Upgrader Alley. A staggering $46 billion for upgraders and associated projects are lined up for the Edmonton Capital Region.[1]

Upgrader Alley is centred in the area branded by government and industry as Alberta's Industrial Heartland (see Figures 1 and 2). If all the planned projects proceed, within a decade there will be at least nine upgraders in Upgrader Alley. With the capacity to upgrade almost two million barrels of bitumen into synthetic crude oil a day, over 40% of Alberta's upgrading capacity will be right on Edmonton's doorstep.[2] Upgraders will attract other industry, and the cumulative effects of development will have major impacts on the region, its people and the natural environment.

Figure 1: Location of Upgrader Alley within Alberta

Map: Roland Lines, The Pembina Institute

This transformation will be very rapid and on a huge scale. At present one upgrader is operating in Upgrader Alley and two are under construction. Applications have been submitted for five more, but these have yet to be approved. Land has been acquired for a ninth upgrader, but it has not yet been announced. All these upgraders will require extensive areas of land, which is permanently lost to agriculture. They consume vast amounts of water and contribute to air pollution. In addition, many new petrochemical industries are likely to establish in the region, to make use of some of the products that result from upgrading, leading to yet more growth.

Those living in the area are already concerned about the loss of agricultural lands, traffic congestion, noise, local air quality and emergency services, which all affect their quality of life. During construction of an upgrader, there may be between 1,000 and 2,000 workers on site. Once built, an upgrader needs several hundred people to operate it. The exact number depends on its size. Many more people will move to the region to work, not only at the upgraders but in other associated industries that will expand in the region.

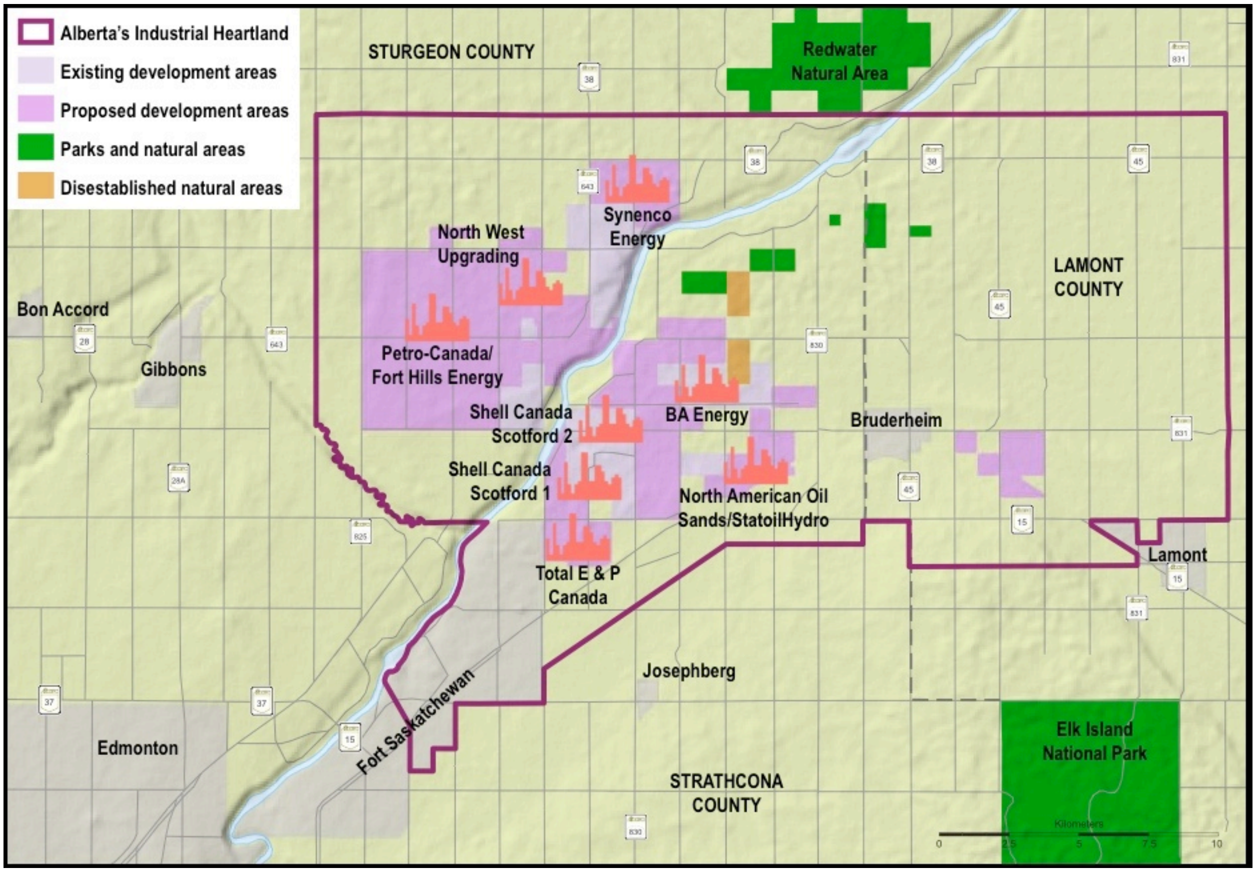


Figure 2: Upgrader Alley will form the core of Alberta's Industrial Heartland in the counties of Strathcona, Sturgeon and Lamont.

Map: Roland Lines, The Pembina Institute
Sources: Alberta Employment, Immigration and Industry, *Alberta's Industrial Heartland: Existing and Proposed Major Pipelines and Facilities*, 2007 & 2008, www.environment.alberta.ca/documents/CEM_Industrial_Heartland_map.pdf. Alberta Tourism Parks and Recreation, Land Reference Manual ArcView Shapefiles, www.tpr.alberta.ca/parks/landreferencemanual/arcviewshapefiles.aspx. Alberta's Industrial Heartland Association, 2008, *Alberta's Industrial Heartland: Existing and Proposed Land Holdings*.

Such an enormous amount of development needs careful planning, but, as in the Fort McMurray area, the projects are being approved before an integrated plan is in place. The Capital Region Integrated Growth Management Board, which was set up early in 2008, will take until 2010 to develop the long-range plan on regional land use and infrastructure.[3] In recognition of the cumulative impacts of so much activity in the region, in October 2007 the Government of Alberta selected Alberta's Industrial Heartland as a pilot for its new Cumulative Effects Management Framework.[4] This framework, however, does not get to the root of the problem.

- It does not slow the pace of development and ensure that it proceeds in an orderly manner; nor does it allow time for development of infrastructure that could help reduce environmental impacts.
- There is nothing to stop thousands of hectares of rich agricultural lands being buried by development across the Industrial Heartland, an area which is three-quarters the size of the City of Edmonton.
- The caps set on air emissions address only two pollutants and will allow those pollutants, nitrogen oxides and sulphur dioxide, to increase by 30–40% above current levels.

Emissions from industrial operations and vehicles already affect air quality and future increases will further affect those living in the region and the natural environment.

- Upgraders consume large volumes of water. They are likely to increase the volume of water permanently removed from the river downstream of Edmonton by more than 60%. Even though a proposed integrated wastewater and recycling system could limit the volume of water withdrawn directly from the North Saskatchewan River, the flows within the river will still be reduced. If all the planned projects proceed, it could mean that 6% of the mean annual flow in the North Saskatchewan River is permanently removed in Alberta.[5]
- Upgraders need large amounts of electricity, which will drive demand for power generation and additional pollution elsewhere in the Edmonton region, as well as require the construction of a new transmission line.

Instead of learning from the problems in Fort McMurray, the stage seems set for them to be repeated in Edmonton's backyard. Why all the rush? Do we want to add to the congestion and expenses associated with a boom economy? Wouldn't it be better to develop an integrated plan and build step by step in line with the construction of the necessary infrastructure?

In a 2007 public opinion survey, 71% of Albertans surveyed indicated that they believe that the Government of Alberta should suspend new oil sands approvals until infrastructure and environmental management issues have been addressed in areas affected by oil sands development.[6] Now a spike of oil sands development is coming to Upgrader Alley, and we need to take the same approach here.

The Pembina Institute believes that it's time to pause and take stock. The Cumulative Effects Management Framework is a first step to addressing the problems in Upgrader Alley, but the Government of Alberta is allowing development to continue before proper planning is complete. At the time of writing this report, there is no plan to slow the rate at which new approvals are issued.

New projects should only proceed when there is a truly effective process in place to limit the cumulative impacts and when we know how to manage the growth, instead of letting it manage us. We are not advocating that bitumen should be sent to the U.S. for upgrading, but we believe that government and industry must work together to better limit the impacts of growth.

This report examines what the development of Upgrader Alley will do to the region and what can and must be done to maintain the quality of life and minimize damage to the natural environment in the region.

2. Upgrader Alley Overview

2.1 What Is Driving Development?

In the past most upgrading was conducted in the Fort McMurray area as an integrated component of the extensive open pit mining of oil sands. Some companies are now choosing to locate new upgraders in the Edmonton region to avoid competition for workers and the high cost of doing business in the chronically strained Regional Municipality of Wood Buffalo, which includes Fort McMurray. The area around Upgrader Alley has a skilled workforce, land that has been zoned for heavy industry, the necessary infrastructure (roads, rail, electricity) and proximity to fresh water. Pipelines bring in the bitumen and natural gas and can take out the synthetic crude oil. The area already has some refining and petrochemical industries, which can use the products and byproducts from the upgrading process. Development is being actively promoted and encouraged by Alberta's Industrial Heartland Association, a government-industry partnership covering four municipalities: the City of Fort Saskatchewan and the Counties of Strathcona, Sturgeon and Lamont.

Albertans can benefit from upgrading bitumen within the province, rather than exporting it for upgrading elsewhere, since the upgrading process creates jobs and forms the basis for many value-added products. However, the developments planned for Upgrader Alley will have far-reaching effects on those living in the region. It is essential that all new development is carefully planned and regulated.

The production of bitumen from oil sands is rapidly expanding. By the end of 2007 the total bitumen production capacity in Alberta was over 1.4 million barrels per day.[7] Estimates of growth vary, but by 2020 bitumen production capacity is expected to increase to approximately four million barrels per day.[8] As a result, many more upgraders are needed to handle the increase.

About 60% of the bitumen produced in Alberta is upgraded in the province, to form light, sweet synthetic crude oil. The remainder is transported by pipeline to other regions of Canada and the United States for upgrading.[9]

For oil sands projects that do not include onsite upgraders, the bitumen is transported by pipeline to be upgraded elsewhere. Because the bitumen is very thick, it must be mixed with a diluent, usually light oil, condensates or naphtha, so that it is fluid enough to flow through a pipeline. The relative cost of piping bitumen has declined since the industry started diluting it with synthetic crude oil instead of condensates, which makes it possible to locate upgraders away from the bitumen production areas. Today, more than 40% of Alberta's upgrading capacity is planned for Upgrader Alley.[10]

When bitumen is upgraded, it creates a slightly smaller volume of synthetic crude oil or other end-products. The exact ratio varies with the process used but one barrel of bitumen produces about 0.9 barrels of synthetic crude oil.[11]

Figure 3: Scotford Upgrader 1, Athabasca Oil Sands Project (Shell Canada)
Photo: Courtesy of Shell Canada

The first upgrading facility in the region opened in 2003, when Shell added an upgrader to its refinery at Scotford (Figure 3). That upgrader processes bitumen from the Albian Sands Muskeg River Mine. The Scotford upgrader, which is currently able to upgrade 155,000 barrels of bitumen per day, is being expanded. If all the announced projects are approved, upgrading capacity in the region will probably increase more than 12 times, to nearly two million billion barrels a day by 2020.[12] In addition to the eight upgraders listed in the tables in this report, Suncor has land holdings and also plans to build an upgrader, bringing the total to nine upgraders.[13]

Between 2010 and 2020, it is expected that about half the bitumen for the upgraders will come from the bitumen mining area and half from "in situ" ("in place") operations.[14] In situ operations are found across northern Alberta where the bitumen is too deep to mine. The bitumen is recovered by drilling into the bitumen and heating it (usually with steam) so it can be pumped to the surface. In the past, most of the bitumen from in situ operations was not upgraded before delivery to market, but in the future some will be sent to Upgrader Alley.[15]

One barrel of synthetic crude oil produces enough gasoline to fill three-quarters of a Chevy Avalanche's gas tank, enough to drive it about 490 kilometres.

Sometimes oil production is measured in cubic metres instead of barrels. One cubic metre (1000 litres) is equivalent to about 6.3 barrels. For comparison, a standard bathtub has about the same volume as a barrel (159 litres).

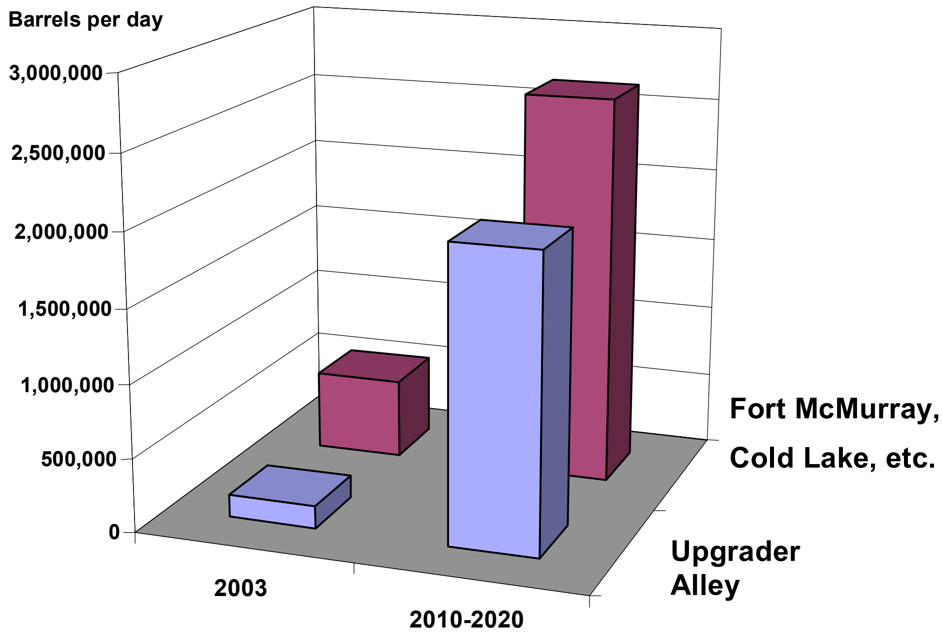


Figure 4: Upgrading capacity in Alberta

Source: 2003 data derived from Government of Alberta[16] and 2010–2020 prediction based on Strategy West Inc.[17]

2.2 What Is Upgrading?

An upgrader is a large facility that processes crude bitumen into synthetic crude oil. When bitumen is removed from oil sands, it is a thick, tar-like substance, so it must be treated or "upgraded." Upgrading is a special type of conversion process used at the front end of refining. It changes the characteristics of the hydrocarbons and creates synthetic crude oil. Heavy oil and bitumen contain little hydrogen, and the upgrading process brings the ratio of hydrogen and carbon closer to the ratio found in conventional crude oil. This involves breaking the long, heavy molecules of bitumen into smaller ones and adding hydrogen. At the same time impurities, including sulphur, nitrogen and carbon, are removed, as is normally done in the refining process. Upgrading is carried out in two stages.

The first stage, which cracks the long, heavy bitumen hydrocarbons, is done using either coking or hydrocracking or both. In the coking process, excess carbon is removed when high temperatures (around 500°C) crack the bitumen molecules by vaporizing them. The excess carbon forms a solid residue called coke. The coke is often stockpiled as a waste by-product, although some companies use it as the basis for producing gas. The alternative method, hydrocracking, involves the addition of hydrogen to bitumen molecules that are cracked using a catalyst, such as platinum.

The second stage of upgrading is called hydrotreating. High pressure and temperatures (300-400°C) are used to remove nitrogen, sulphur and metals, using a catalyst in a hydrogen environment. The nitrogen is removed as ammonia and is normally used as a source of fuel, while the sulphur by-product is converted to elemental sulphur and either transported for use in other industrial processes (e.g., production of fertilizers) or stored in massive sulphur blocks. The liquids produced are then stored separately before being mixed to form synthetic crude oil, which can be refined into gasoline, jet fuel and diesel fuel at modified refineries. Synthetic crude oil also provides the feedstock for petrochemical products, such as aromatics, propylene and styrene, that are the building blocks for pharmaceuticals, synthetic fibres, plastics and resins. We find many of these products in our homes, in aspirin and antibiotics, carpets and clothing, cell phones and CDs.

Figure 5 shows, in a much simplified manner, the main inputs and outputs from upgrading using the coking process. It includes the option of gasifying the coke byproduct.

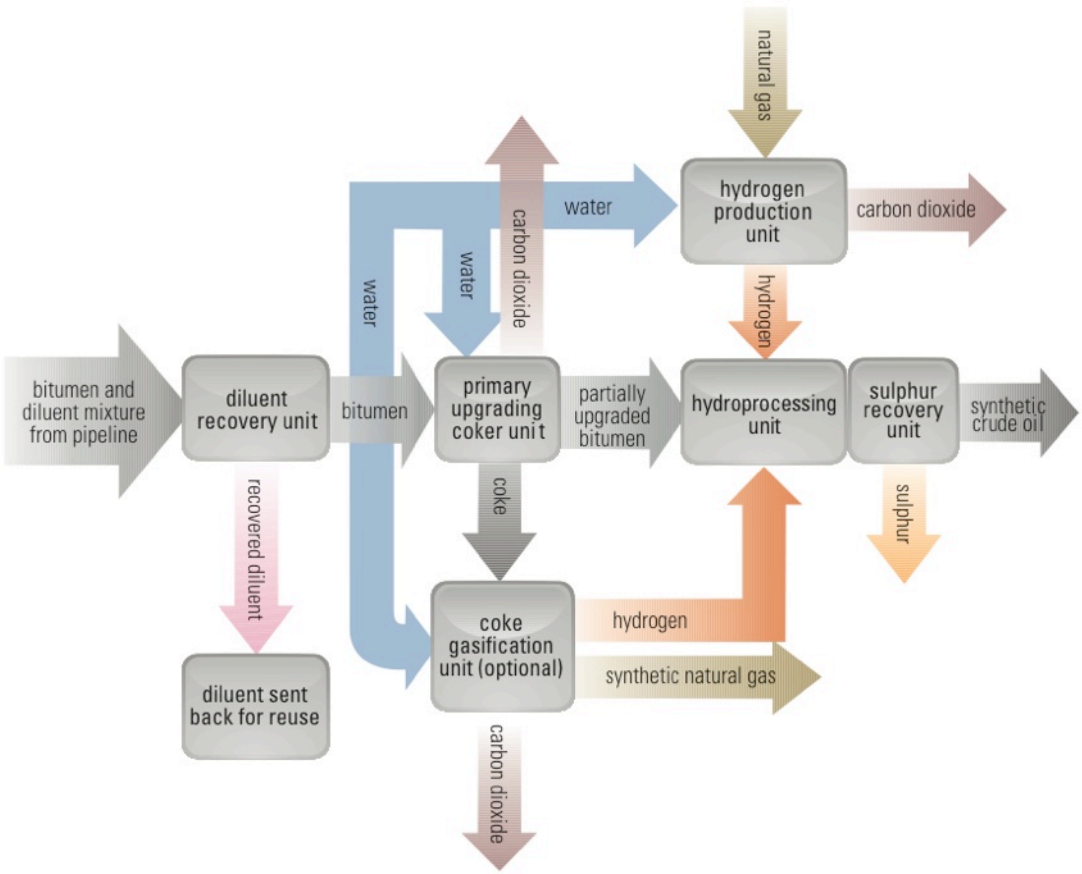


Figure 5: Simplified Overview of an Upgrading Process

Illustration: Rob Weidemann, Uber Communications

Several processes can be used to obtain the hydrogen required to upgrade the bitumen. It is often obtained by steam reforming, using water and natural gas. The gas can also be produced by gasifying the coke or asphaltene by-product from the upgrading process or by gasifiying coal (as planned at Sherritt International’s proposed Dodds-Roundhill facility south-east of Edmonton). The process requires large amounts of water and can create large emissions of carbon dioxide, the main gas that contributes to global climate change. However, the carbon dioxide can be captured and stored or sequestered deep underground, avoiding emissions to the atmosphere, although this is not required under current regulations.

2.3 What Will Upgrader Alley Look Like?

Upgrader Alley is centred in the area known as Alberta's Industrial Heartland. The zones for medium and heavy industrial development have been repeatedly expanded, and this region now covers an area of 530 square kilometres.[18] It starts at the City of Fort Saskatchewan in the southwest and reaches as far as the Town of Lamont, 30 km to the east; it is between 15 km and 20 km wide in a north-south direction, extending almost as far as Redwater, as shown in Figure 6. Large areas, which are still currently rural, will be transformed.

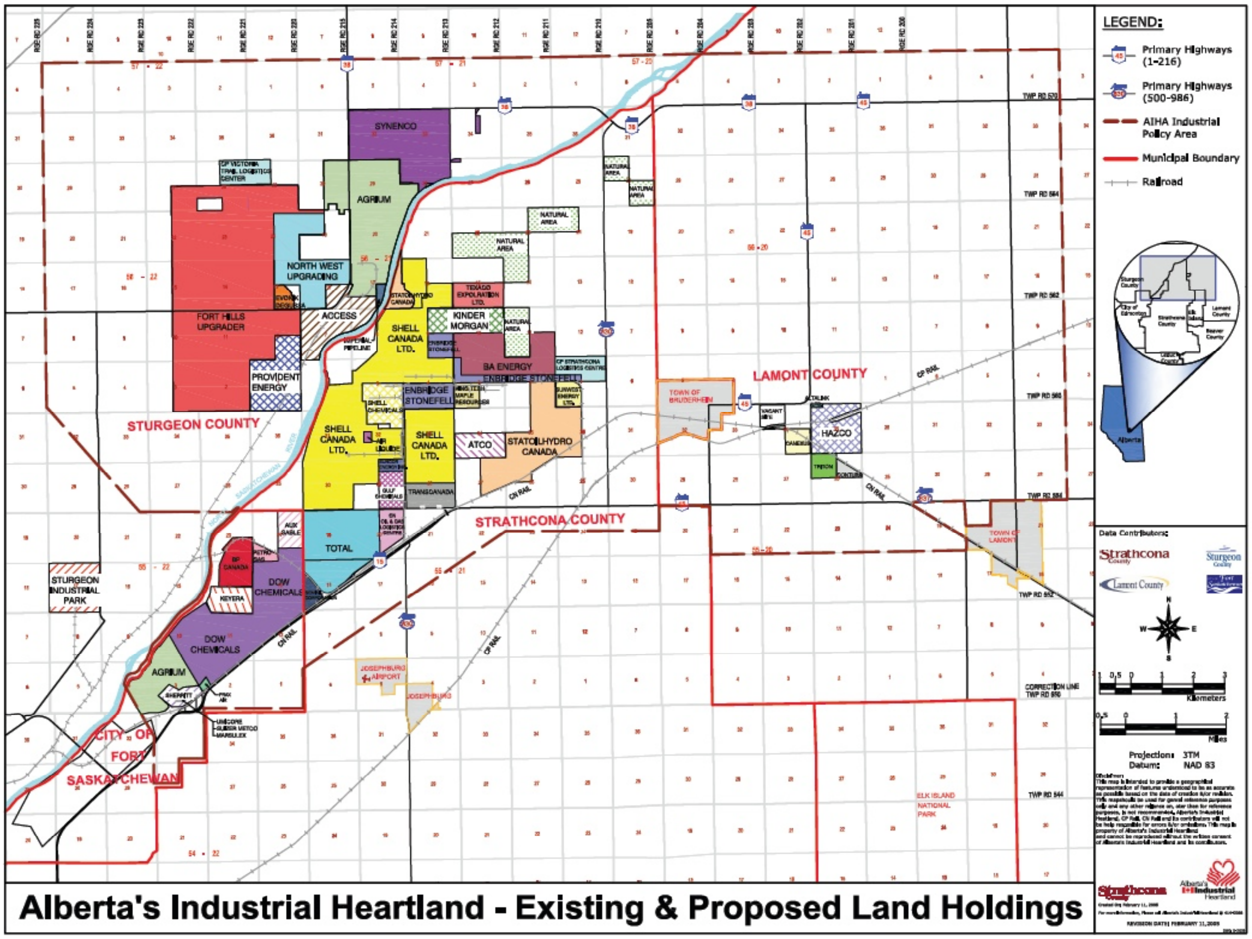


Figure 6: Alberta's Industrial Heartland

Source: Courtesy of Alberta's Industrial Heartland Association.

Already, productive farmland in the area is being rapidly converted into a major industrial region. The construction of the upgraders will exacerbate this process. Figure 6 shows the land holdings for the upgraders and other Industrial Heartland facilities. The site for each upgrader is large and will cover two to more than five square kilometres (one to two sections of land or more). Each upgrader requires roads to bring workers and supplies from within and beyond the region, pipelines to supply bitumen, gas and water and power lines for electricity. The exact requirements for each facility will vary, depending on the process used, but the cumulative impacts of multiple projects all proceeding simultaneously will be enormous. Industry recognizes that meeting the infrastructure needs of upgrader development is one of the major challenges to development.[19] For example, the main 500 kilovolt electricity transmission line needs to be reinforced with new transmission lines to bring in more electricity from west of Edmonton.[20] One proposed route is directly from the power plants near Lake Wabamun, west of Edmonton. A line may also come from the Ellerslie substation in south-east Edmonton. In addition, 250 and 138 kilovolt transmission and distribution lines will need to be expanded to service new sites.[21]

> "New transmission is necessary to support the oilsands upgraders currently planned in the Fort Saskatchewan area."[22]

Improvements are required in the pipeline for incoming bitumen and connections are needed to take the upgraded product to market. To reduce the greenhouse gas pollution from upgraders, additional pipelines will be required to transport carbon dioxide captured from the upgrading process for injection underground (as is explained in Chapter 5).

Additional railway lines will be needed to service the new sites and this, in turn, will require an expansion of the rail yards. Canadian Pacific Railway has announced that it is seeking regulatory approval to build a new line, including a bridge over the North Saskatchewan River.[23] Canadian National Railway also intends to expand in the region.[24] Railways will be used to transport by-products, such as sulphur, petroleum coke, asphaltene and various liquids and gases created from bitumen upgrading, to national and international markets.

Table 1 provides an overview of the status and size of the upgrading facilities. One operating upgrader (at Scotford) is being expanded, two are under construction, five have submitted their applications and another company (Suncor) has a land holding but has not disclosed plans. In addition, the converted PetroCanada refinery will upgrade a small volume of bitumen.[25]

Table 1: Current, approved and announced upgraders in Upgrader Alley

Company	**Project Name/ Phase**	**Status**	**Scheduled**	**Bitumen** barrels/day	**Synthetic crude oil** barrels/day
Athabaca Oil Sands Project (Shell)	Scotford Upgrader Phase 1	Operating	2003	150,000	177,000[a]
	Expansion 1	Approved	2010	140,000	156,000
BA Energy Inc./Value Creation	Heartland Upgrader Phase 1 - 3	Under construction	2008–13	163,000	139,000
North American Oil Sands Corporation/ StatoilHydro	North American Upgrader Phase 1 - 2	Application	2016–20	243,000	217,000
North West Upgrading Inc.	North West Upgrader Phase 1 - 3	Under construction	2010–16	150,000	136,000
Petro-Canada/Fort Hills Energy Corporation	Sturgeon Upgrader Phase 1	Application	2011	165,000	140,000
	Phase 2 - 3	Application	2014–15	175,000	140,000
Shell Canada	Scotford Upgrader # 2	Application	2013–22	400,000	438,000[a]
Synenco Energy Inc.	Northern Lights Phase 1 - 2	Application	On hold	115,000	100,000
Total E&P Canada Ltd.	Total Upgrader Phase 1 - 2	Application	2013–19	245,000[b]	200,000
All eight upgraders				**1,946,000**	**1,841,000**

Source: Data in this table was obtained both from the companies and from Strategy West Inc.[26]
Notes:
a. The production of synthetic crude oil exceeds the bitumen input, since the production includes additional purchased blendstocks. The same applies to the expansion.
b. Total E&P Canada Ltd. plans to increase capacity to 295,000 bpd as a result of debottlenecking after 2019.

The upgraders will use large amounts of natural gas and electricity. The annual natural gas requirement for the eight upgraders for which information is currently available is estimated to be 140 million gigajoules (see box). Some companies, including the Petro-Canada/Fort Hills (Sturgeon upgrader, phases 2 and 3), North American Oil Sands/StatoilHydro, North West Upgrading and Synenco plan to gasify coke or asphaltene (a by-product of the upgrading process), because they recognize that natural gas is an increasingly scarce resource.

> The eight upgraders for which information is available will purchase approximately 127 million gigajoules of natural gas each year. This amount of gas is
>
> - more than twice the volume used by all households in Edmonton in a year[27]
> - more than 70% of the gas produced by the 6,900 coalbed methane wells in Alberta in 2006[28]

The eight upgraders listed in Table 1 expect to purchase about 1,150 megawatts of electricity.[29] This is almost as much as the total output of the three generation units at EPCOR's Genesee power plant, west of Edmonton.[30] The upgraders will actually use more power, but some upgraders will generate some of their own electricity. The Athabasca Oil Sands Project, for example, plans to generate over half the electricity it needs for the Scotford Upgrader Expansion, and North American Oil Sands/StatoilHydro expects to generate about three-quarters of their power. Petro-Canada/Fort Hills intends to generate electricity when it develops phases 2 and 3 of the Sturgeon Upgrader and add some power to the grid. However, the growing demand for power is spurring development of a new transmission line from the coal-burning power plants west of Edmonton to Upgrader Alley.

> "The overall impact on Alberta's power grid will depend on whether or not the companies developing these facilities decide to build generation onsite to meet their power needs or whether they will require power from the grid."[31]

2.4 How Much Water Do the Upgraders Need?

"As many as 10 upgraders are expected to be built in 5–10 years within this region … 10 upgraders could demand as much water every day as the entire City of Edmonton."[32]

All upgraders require a large volume of water. On average, four barrels of water is required for every five barrels of bitumen upgraded. The smallest volume of water an upgrader will use is about five billion litres per year and several require two to four times that amount. Upgraders currently expect to return, on average, only about one quarter of the water they withdraw from the North Saskatchewan River back to the river.[33] The rest is used or "consumed."

> The consumptive use of water here refers to water that is "consumed" in process operations, evaporates to the air or is disposed of (e.g., through deep well injection) and thus does not flow back to the river.[34]

Water is needed to create steam that is used to produce hydrogen for use in hydrocracking and hydrodesulphurization. Because the hydrogen ends up in the upgraded products there is a net loss of water from the site. The amount varies, depending on the type of upgrading process used and the end products, which require different amounts of hydrogen. A lot of water is also used for cooling, and some water evaporates instead of being returned to the river. The net volume of water withdrawn also depends on the extent to which a company recycles the water. One company may treat the water and return some treated water back to the river, while another will recycle all the water, so there are no return flows. A company may have quite different processes and discharges at different stages in its project. As an example, Figure 7 illustrates the main ways in which water is used and the variation in the proportion of water used at different stages in the upgrading process.

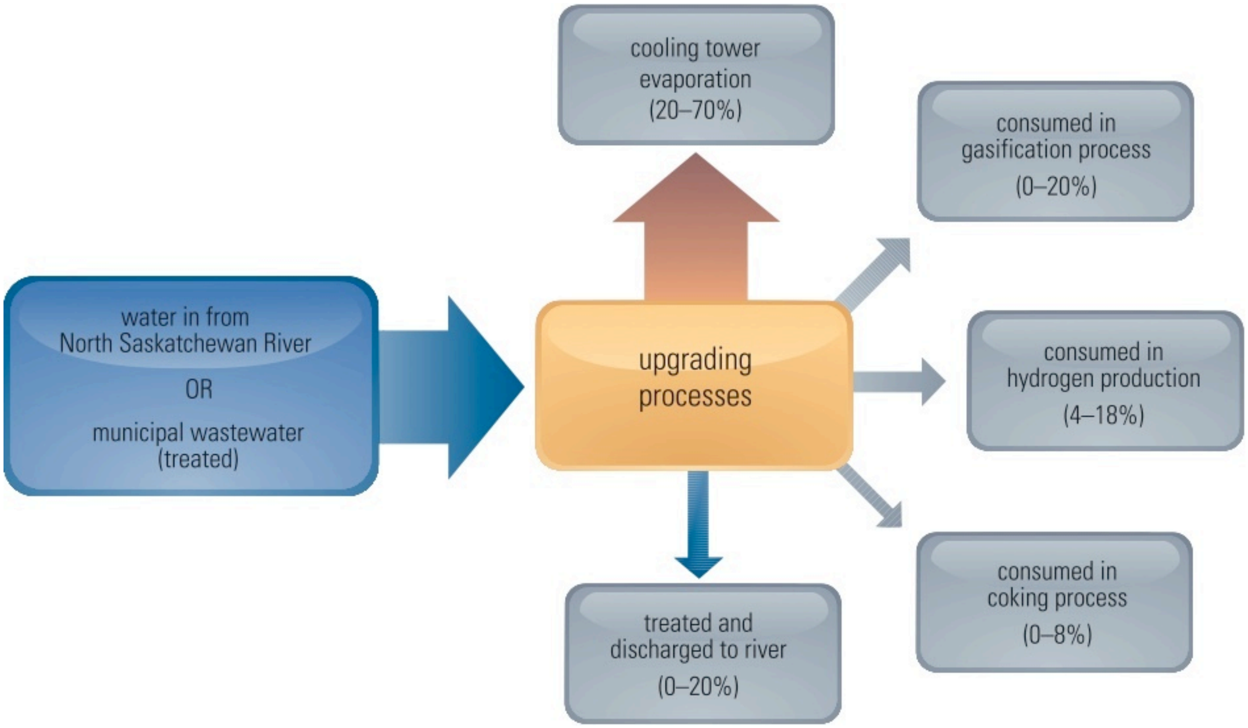


Figure 7: Simplified Overview of Water Use for Upgrading

Illustration: Rob Weidemann, Uber Communications

Note: The sketch shows the variation in the percentage of water used for different purposes.[35]

3. Impacts on the Land

3.1 The Impacts

> "Overall growth pressures in the Industrial Heartland … are creating competition for land resources, resulting in known and potential impacts to wetlands, groundwater, soils, habitats and landscapes in general."[36]

Much of the area now zoned for industrial use in the Industrial Heartland region is agricultural land that continues to be farmed. The most obvious impact of Upgrader Alley is the permanent loss of this good agricultural land. The loss of this land is a loss to the province. While individual farmers may sell out for a profit, they are often very reluctant to leave.

Many people still live close to this new and rapidly expanding industrial area. They report that their property value declines because of the proximity to industry, and they are concerned about the affects on roads in the area and on their quality of life. Two local groups, Northeast Sturgeon County Industrial Landowners (NESCIL) and Citizens for Responsible Development (CFRD), raised these issues at a public hearing in 2007. "NESCIL/CFRD believed that the roads in the area were already too small and could not handle the existing traffic. They were concerned about increased traffic accidents, spills from trucks hauling dangerous chemicals, and the deterioration of the roads from heavy loads."[37] Moreover, there is "growing resident pressure to deal with cumulative impacts that reach beyond individual corporate compliance."[38]

> Wayne Groot, doesn't want to sell his land in the Upgrader Alley because his family has been farming the rich soil northeast of Edmonton for three generations. It pains him to think of smokestacks plopped on some of the finest agricultural fields in the country. "Some people would probably say, 'You're lucky. You can sell your land for a lot of money and live the good life.' I thought I was living the good life already."[39]

Another concern in the region relates to sulphur, which is a by-product from cleaning emissions of sulphur dioxide. Approximately 1 tonne of sulphur is produced from every 100 barrels of bitumen upgraded.[40] By 2015, the upgraders could be producing four million tonnes of sulphur a year, and there could be a proliferation of handling sites throughout the region.[41] The sulphur may be sold for industrial use, but some local residents are concerned that when there is a glut, it will be stored outdoors in huge blocks.[42] They are especially worried that the proposed storage sites are close to Bruderheim and Lamont, because of the danger if the sulphur were to catch fire.

> "With production accelerating and potential sales falling, Alberta has a serious, chronic problem of sulphur oversupply on its hands. … We need a serious long-term strategy to accommodate this sulphur tsunami."[43]

The development of an industrial area also affects natural areas within the region. The Astotin, North Bruderheim, Northwest of Bruderheim and Redwater Natural Areas were located in the area to be surrounded by industrial development. The Astotin Natural Area contained a regionally significant wetland and the Northwest of Bruderheim Natural Area includes upland sand dunes interspersed with lowland wetlands. However, in December 2007, the government removed the natural areas designation from the Astotin area and reduced the size of the Northwest of Bruderheim Natural Area, cutting the remaining land in two. The land is to be used by BP Energy and CP Rail for a rail yard to service Upgrader Alley.[44] A larger area will be protected elsewhere, to compensate for the loss, but that is, inevitably, beyond Upgrader Alley. The entire region will be dissected by new pipelines and electricity transmission lines, as well as new railway lines. The North Saskatchewan River Valley, which is considered a provincially significant area,[45] will be a narrow ribbon through the centre of a major industrial region.

Figure 8 shows the current and potential pipeline, utility and railway corridors that will be needed to bring in the bitumen, gas and electricity and to take away the upgraded products.

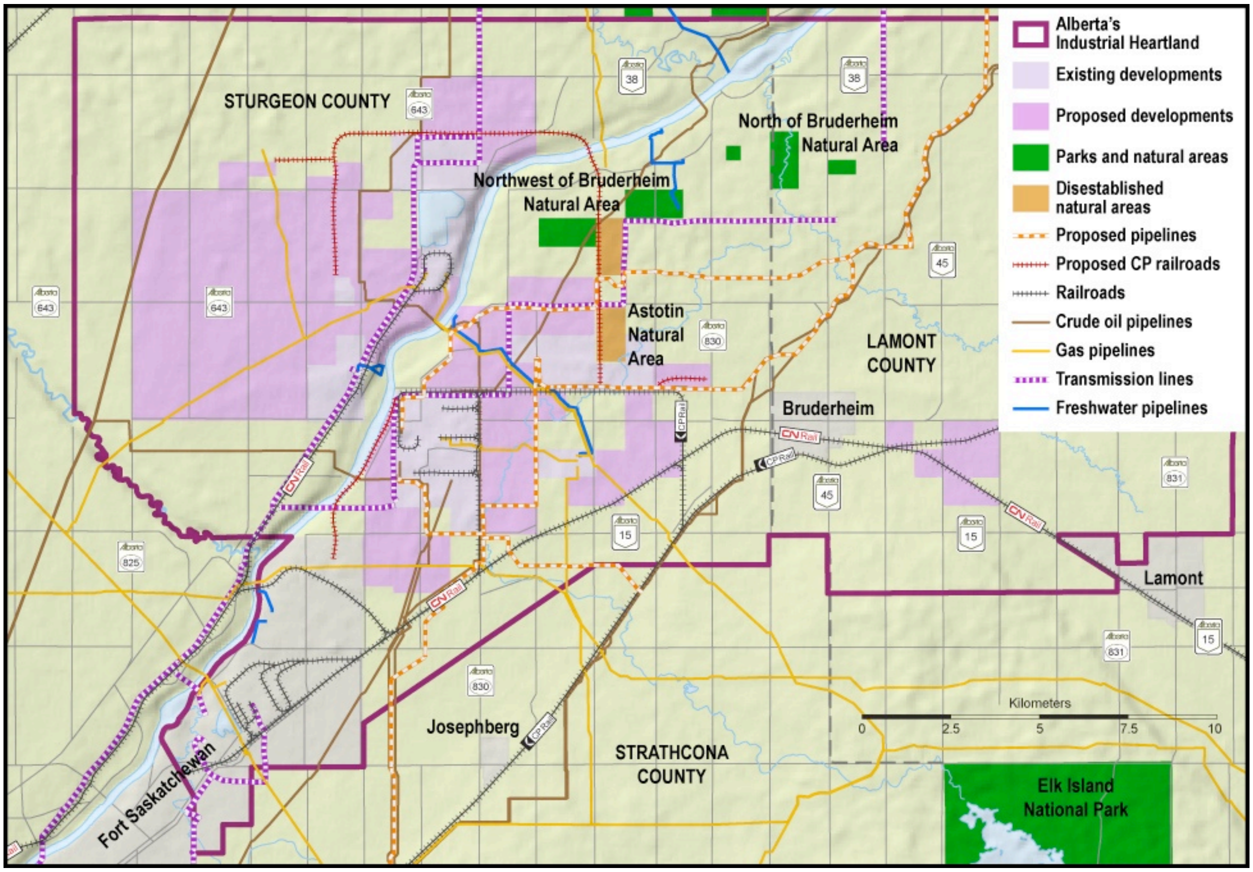


Figure 8: Potential Transportation and Utility Corridors In and Around Upgrader Alley

Map: Roland Lines, The Pembina Institute
Sources: Alberta Employment, Immigration and Industry, *Alberta's Industrial Heartland: Existing and Proposed Major Pipelines and Facilities*, 2007 & 2008, www.environment.alberta.ca/documents/CEM_Industrial_Heartland_map.pdf. Alberta Tourism Parks and Recreation, Land Reference Manual ArcView Shapefiles, www.tpr.alberta.ca/parks/landreferencemanual/arcviewshapefiles.aspx.

3.2 Can the Impacts Be Reduced?

Many people realize that the increasing population and industrial activity in Edmonton and Upgrader Alley will require innovative ways to limit the impacts on land, as well as limit pollution and conserve water. In October 2007, the Alberta government announced its Cumulative Effects Management Framework and selected the Industrial Heartland to serve as a pilot for the new approach.[46] The framework has separate plans to deal with impacts on air, land and water. Here we examine the section that relates to land.

Alberta Environment says it will work with facility operators to reduce the industrial footprint and develop new guidelines, such as establishing minimum setbacks along the North

Saskatchewan River,[47] but with so much new development, most measures will be "around the edges". The Department recognizes that the loss of more wetlands in the region will affect watershed health and groundwater, but the inventory of wetlands (drained and existing) will not be complete until 2009. Although they intend to require companies to compensate for loss of wetlands, this will not necessarily be in the same area and the land may not drain to the same tributary of the North Saskatchewan River.[48]

There are no provisions to minimize the impact of development on agricultural lands. While land required for industry is inevitably lost, it would be possible to require some form of offset, as is done for natural areas and wetlands. This might, for example, take the form of an industry payment for the purchase of development rights, so that those who remain in agriculture around the industrial zone are compensated for keeping their land in agricultural production.[49]

Careful location of pipelines and transmission lines may be able to limit the impact on some residential areas, but there will still be visual impacts and fragmentation by lines, roads and railways. Other measures are needed to reduce the volume of traffic in the region. This includes planning for an efficient transport system, such as the extension of the light rapid transit system from Edmonton to Upgrader Alley, to reduce the need for new roads for commuter traffic.

The Capital Region Integrated Growth Management Board has been set up "to promote an integrated and strategic approach to planning for future growth in the Capital Region" and one of their objectives is to "identify the overall development pattern and key future infrastructure investments…"[50] The board is to develop a long-range plan for regional land use and infrastructure, by 2010.[51] The plan will include Upgrader Alley, which is located within the Capital Region. However, at the time of writing, it is not clear that the required level of environmental planning will be in place prior to issuing upgrader approvals. Given the fact that more projects are likely to be approved before detailed plans and infrastructure are in place to limit environmental impacts, it is likely that some of the problems associated with rapid and uncontrolled growth in the Fort McMurray region will reoccur in Upgrader Alley.

Figure 9: The province disestablished the Astotin Natural Area in December 2007. Canadian Pacific will use the land for a new railway into Upgrader Alley.

Photos: David Dodge, The Pembina Institute

4. Air Quality

4.1 Emissions

Several health and environmental problems can arise from the types of emissions produced by upgraders and other industrial sources in the Upgrader Alley area, so the public is naturally concerned about air quality.[52]

The main emissions of concern from the upgrading process are sulphur dioxide, hydrogen sulphide, nitrogen oxides[53] and particulate matter. Other emissions include volatile organic compounds (such as benzene),[54] polycyclic aromatic hydrocarbons and carbon monoxide. Some of these primary emissions combine to create secondary pollutants. Nitrogen oxides combine with volatile organic compounds in the presence of sunlight to form ground level ozone. This causes photochemical smog in summer which affects human health and plant growth. Both sulphur dioxide and nitrogen oxides contribute to fine particulate matter in the air, which also reduces visibility. Because ozone and fine particulate matter affect human health, Canada Wide Standards have been set for both these substances.

In addition, upgraders are a major source of carbon dioxide, a major greenhouse gas. Greenhouse gas emissions are described in Chapter 5.

Air quality in Upgrader Alley and the surrounding region is measured by the Fort Air Partnership, which has a network of monitoring sites to measure air contaminants.[55] In 2004, the air quality at the Lamont station, to the east of Upgrader Alley, was the worst of the 11 provincial stations where the Air Quality Index is reported and in 2005 and 2006 it came second to worst. Where other Alberta stations report good air quality much of the time (around 96–99% of the time in Edmonton and Calgary), at the Lamont station air was ranked as good only 92% of the time in 2006; the rest of the time it was only fair (and even poor for 0.05% of the time).[56]

Landowners are especially concerned when accidents and incidental releases affect local air quality.[57] There are already examples each year when the monitored values of hydrogen sulphide and sulphur dioxide exceed the air quality objectives at monitoring stations in the region[58] and it seems likely that these exceedances will increase in number when the number of upgraders increases from one to eight or nine.

When the existing and planned upgraders are operating, the emissions within the Industrial Heartland are expected to greatly increase, as shown in Table 2. The base case includes all the main industrial sources in 2007, with only one upgrader. The planned development case includes eight operating, approved and planned upgraders.[59] According to these figures, long term sulphur dioxide emissions are expected to increase to three times their current level; hydrogen sulphide emissions are expected to increase eight fold.[60] The industrial emissions of other substances such as nitrogen oxides, fine particulate matter and volatile organic compounds are expected to increase considerably, with nitrogen oxides and fine particulate emissions more than doubling and volatile organic compounds increasing by 80%, if all planned projects proceed.

Table 2: Expected growth in industrial emissions in the Fort Air Partnership region

	Emission Rate (tonnes/day)						
	Sulphur dioxide (short)*	Sulphur dioxide (long)*	Nitrogen oxides	Carbon monoxide	Fine particulate matter	Volatile organic compounds/ polycyclic aromatic hydrocarbons	Hydrogen sulphide
Base case	46.1	41.7	40.3	23.1	2.9	5.1	0.2
Planned development case	185.4	133.4	93.0	75.0	6.3	9.1	1.6
% increase	**302**	**220**	**131**	**225**	**117**	**80**	**685**

Source: Total E & P Canada Ltd. See endnote 61.

* Two values are given for sulphur dioxide: the short value is used to evaluate 1-hour and 24-hour concentrations; the long value is used to evaluate annual average concentrations and deposition.

Because of the increase in emissions, the ambient levels of these pollutants in the air and the number of occasions when the air quality objectives are exceeded can be expected to increase. For example, in the planned development case there are several areas where the one-hour values are expected to sometimes exceed the one-hour Alberta ambient air quality objective for sulphur dioxide of 450 $\mu g/m^3$.[62] The highest values will usually be close to existing and proposed plants with the sulphur dioxide concentration maxima near the plants predicted to range from 374 $\mu g/m^3$ (Sturgeon) to 676 $\mu g/m^3$ (Scotford).[63] Some of the predicted 24-hour maxima are expected to also exceed the air quality objective.[64] The predicted maxima values in the residential/agricultural communities are below the air quality objective but will still be higher than at present, unless action is taken to limit emissions (see section 4.4).

Noting some exceedances of the air quality objective at the Redwater air monitoring station, the Energy Resources Conservation Board commented that "… the Board believes that recurring exceedances of the AAAQO [air quality objective] can erode public confidence in the regional monitoring network."[65]

The maximum hydrogen sulphide values already exceed the 1 hour and 24 hour air quality objectives in the industrial areas, and exceedances sometimes occur in agricultural/residential areas. Individual maximum values are expected to be several times the air quality objective when all the planned development proceeds.[66] Hydrogen sulphide is characterized by its smell of rotten eggs. There are already times when the maximum odour from hydrogen sulphide exceeds the "odour threshold" in the agricultural and industrial areas, and if all planned development proceeds, maximum odour values are expected to sometimes exceed the threshold in public use areas.[67] Sensitive individuals can perceive odours when they are below the threshold.[68]

Ambient levels of nitrogen oxides in Upgrader Alley are expected to increase considerably and emissions of nitrogen oxides are an emerging regional issue. The increase will come not only from the upgraders but from the overall growth in the region. As in central Edmonton (where emissions of nitrogen oxides are already high), vehicles and heating contribute to the emissions of nitrogen oxides.[69] We can expect the fuel consumed in heating new accommodations and industrial complexes, as well as the amount of driving to these sites, to also increase as people come to the region to take advantage of the employment opportunities.

Of equal concern are the secondary pollutants, fine particulate matter and ozone. The operation of upgraders will increase fine particulate matter and ozone downwind of the developments. Fine particulate levels are already high in Edmonton and Fort Saskatchewan, where the 24-hour values have exceeded the Canada Wide Standard.[70] Ozone levels are expected to increase and to exceed the Canada Wide Standard.[71] At a public hearing in 2007, Environment Canada expressed concern about "the environmental capacity of the region to handle the cumulative impacts of current and planned upgrader developments in the AIH [Alberta Industrial Heartland] with respect to ozone formation."[72]

While attention is here focused on growth in Upgrader Alley, some of the electricity used in Upgrader Alley will come from coal-fired power plants west of Edmonton. Burning coal creates emissions of sulphur dioxide, fine particulate matter and mercury, in addition to nitrogen oxides, so to the extent that upgraders purchase electricity from the coal-fired power plants, they will also contribute to increasing pollutants in the air to the west of Edmonton.

Many substances are monitored on a routine basis, but some special studies have been conducted to learn about those substances that are not. As explained above, volatile organic compounds are a concern because they react in sunlight with other substances and contribute to the formation of ozone. Environment Canada conducted a study of volatile organic compounds in the Fort Saskatchewan area.[73] It found that "ambient monitoring data indicated emissions were higher than calculated values and that routine activities may have bigger impacts than expected."[74] These emissions may come from releases during industrial processes, including fugitive emissions, which are pollutants released to the air from equipment leaks or evaporation. These are of special concern during inversion conditions (that is, when colder air is trapped near the ground by warmer, overlying air) as the releases do not dissipate.

One set of measurements, analyzed by Dr. Blake from the University of California, found high levels of non-methane hydrocarbons such as ethane, butane, pentane, hexane, propane and benzene in Upgrader Alley and some measured values were much higher than in some major cities.[75] Hydrocarbon levels measured in the study were generally found to be higher than the measurements reported by Environment Canada, Alberta Environment or the Fort Air Partnership. The study report stated that it is extremely difficult to accurately measure hydrocarbons but there was "strong evidence that additional, reliable monitoring is required in this region in order to be able to accurately assess the true impact of industry on local air quality."[76] The report recommended more rigorous air sampling, additional sampling sites and the use of reliable analytical techniques.

It is possible to locate the source of hydrocarbon gases, such as those described in Blake's report, using infra red imaging technology and to quantify the leaks with new laser-based DIAL technology.[77] When the technology was used to check emissions from an Alberta refinery it was found that emissions of benzene and methane were significantly higher than had been estimated. It would thus seem advisable to repeat such measurements at regular intervals in Upgrader Alley to identify and quantify fugitive emissions, so that measures can be taken to reduce them.[78]

4.2 Health Risks

Air quality affects human health, as shown in Table 3. In addition to the pollutants listed in that table, there are many other substances released to the air that can affect health, including benzene and hydrogen sulphide.

Table 3: Effects of criteria air contaminant emissions on human health and the environment

Pollutant	Effects on Human Health	Effects on the Environment
Nitrogen oxides ($N0_x$)	• Irritates the lungs and increases susceptibility to respiratory infections[79] • Combines with volatile organic compounds in the presence of sunlight to form ground-level ozone, which can cause damage to human health[80]	• Is a major component of acid rain,[81] which can ○ leach essential nutrients from the soil and thereby negatively affect health and rate of growth of trees ○ reduce capacity of lakes and soil to neutralize acids and potentially change the pH condition of lakes and soil ○ alter lakes and soil that become acidified • Can create a “fertilizer effect,” called eutrophication, which can alter the types of plants and animals that can live in the boreal forest[82] • Can combine with volatile organic compounds in the presence of sunlight to form ground-level ozone[83] • Contributes to the formation of smog and haze
Sulphur dioxide ($S0_2$)	• At high levels can cause premature death, increased respiratory symptoms and disease, decreased lung function, as well as alterations in lung tissue and structure, and in respiratory tract defence mechanisms [84]	• Is a major component of acid rain • Contributes to the formation of smog and haze
Particulate matter ($PM_{2.5}$)	• Can be carried deep into the lungs • Has been linked with heart and lung problems such as asthma, bronchitis and emphysema[85] • Strong links between high levels of airborne sulphate particles and increased hospital admissions for heart and respiratory problems, and higher death rates from these ailments[86]	• Is composed of organic and elemental carbon particles from combustion of fossil fuels as well as sulphur and nitrogen compounds that can contribute to acid deposition • Contributes to the formation of smog and haze
VOCs	• Individual volatile organic compounds can be toxic to humans • Benzene is a volatile organic compound emitted by oil sands operations. It is carcinogenic to humans and a non-threshold toxicant, which means that there is some probability of harm at any level of exposure[87]	• Can combine with nitrogen oxides in the presence of sunlight to form ground-level ozone[88] • Contributes to the formation of smog and haze.

Source: This table was originally published in Oil Sands Fever[89]

It is not often realized that the Alberta objectives are not set specifically to protect health. The AAAQO "are based on an evaluation of scientific, social, technical and economic factors",[90] which probably explains why they are sometimes higher than the purely health-based guidelines recommended by the World Health Organization (WHO). In fact, as can be seen from Table 4, the 24-hour AAAQO for sulphur dioxide is more than seven times higher than the WHO Guideline. The 24-hour sulphur dioxide value throughout Upgrader Alley already exceeds the WHO guideline value.[91]

Table 4: Comparison of Alberta Environment and World Health Organization Air Quality Guidelines

Pollutant	Averaging time	Alberta Environment Ambient Air Quality Objective[92] $\mu g/m^3$ [93]	World Health Organization Air Quality Guidelines[94] $\mu g/m^3$	Comments
Nitrogen dioxide (NO_2)	1 year	60	40	
	24 hour	200	-	
	1 hour	400	200	
Ozone – ground level (O_3)	8 hour, daily maximum	127*	100	* This is the Canada Wide Standard, which has been adopted by Alberta[95]
	1 hour	160	-	
Particulate matter ($PM_{2.5}$)	1 year	-	10	
	24 hour	30[96]	25*	* WHO figure is for 99th percentile
	1 hour	80	-	
Sulphur dioxide (SO_2)	1 year	30	-	
	24 hour	150	20	
	1 hour	450	-	
	10 minute	-	500	
Hydrogen sulphide	24 hour	4*	150**	* Based on odour ** Based on eye irritation
	1 hour	14*	-	* Based on odour
	30 minutes	-	7*	* Based on odour

The AAAQO for some other substances emitted in the Heartland area are higher than health-based limits.[97] For example, the one-hour AAAQO for benzene is 30 $\mu g/m^3$, but benzene is carcinogenic to humans and no safe level can be recommended.[98] Although planned development may lead to a slight increase in benzene levels, it seems that the main contribution comes from indoor air quality.[99]

Alberta Environment's air quality objective for hydrogen sulphide, which is based on odour perception not health, is a one-hour average of 14 $\mu g/m^3$. WHO recommends that concentrations should not exceed 7 μg/m^3 for more than 30 minutes to avoid "substantial" complaints about odour.[100]

It is not possible to indicate exactly what concentration of air contaminants will affect human health — the duration as well as the concentrations is often a factor — but it is important to keep contaminant levels as low as possible, especially since a variety of contaminants is likely to be found in the air at any given time.

4.3 Impact on Ecosystems

Air pollution can affect soils, vegetation and water bodies. Sulphur dioxide and nitrogen oxides in the air eventually settle downwind (often washed out of the air by precipitation), resulting in acid deposition. Air quality is already affecting lichens in the area downwind of the Strathcona Industrial Area.[101]

> Like the canary in the coalmine, lichens are a good measuring stick for air quality because they obtain their nutrients only from air and precipitation, have difficulty warding off impurities, and are quick to show signs of stress.— ecologist Kevin Timoney[102]

Naturally acidic soils are especially sensitive and the threshold above which the deposition will harm the soils and vegetation is called the "critical loading." It has been estimated that as a result of future emissions in the Heartland region, the total area where the critical load exceeds that for sensitive soils could grow from less than nine square kilometres to nearly 160 square kilometers.[103] Some soils are more sensitive than others and the actual area of sensitive soils within the area affected by this critical loading has not yet been determined.[104]

Acid deposition is likely to increase with the expected industrial growth but, as the Energy Resources Conservation Board observed in 2007, "there is no comprehensive regional monitoring program assessing the affects of regional emissions on terrestrial ecosystems and potential soil acidification. The Board notes the level of industrial activity proposed for the area and recommends that AENV [Alberta Environment] consider implementing such programs, possibly through FAP [Fort Air Partnership]."[105] The way in which Alberta Environment plans to address regional air quality issues is described in the next section.

4.4 Cumulative Effects Management Framework for Air

In recognition of the increasing level of air pollution in the area, Alberta Environment has announced a plan for managing emissions in the Industrial Heartland, which includes Upgrader Alley.

> "Under the Industrial Heartland project, all large industrial facilities within the Industrial Heartland will be subject to a cumulative airshed target of 25,000 tonnes per year of NO_X and 28,000 tonnes per year of SO_2."[106]

In what represents a novel approach for the province, Alberta Environment has publicly announced emissions caps on sulphur dioxide and nitrogen oxides for the Industrial Heartland. These caps are set at 28,000 tonnes per year for sulphur dioxide and 25,000 tonnes per year for nitrogen oxides, approximately 30–40% above current emissions.[107] For both pollutants, the caps were based on the expected emission levels if all new facilities were equipped with best available technology economically available (BATEA) and if all existing facilities reduced emissions by

50% using best available retrofit technology (BART). Because the current levels are below the proposed caps, the values were selected to continue to allow industrial development while reducing air quality impacts to some degree. While these caps are much lower than a “business as usual” scenario, air pollution in the region can be expected to increase.

Alberta Environment indicates that it aims to take action before the standards are exceeded. This is important as ground level ozone levels in the region are approaching the “Exceedance Trigger Action Level” set by the Canada Wide Standards.[108]

The detailed plans for the new approach are being developed in a multi-stakeholder process. The Pembina Institute is sitting on the committee to put forth the position that government must ensure that all new facilities are required to use BATEA and that there is an effective process and timeframe for retrofitting existing operations with BART. To protect air quality, new development may need to be delayed until the existing operations have considerably reduced their emissions. It is also important that the caps remain in place as firm, enforceable regulatory limits or backstops.

5. Greenhouse Gases

The large amounts of energy consumed in the upgrading process produce very large volumes of greenhouse gases (GHGs), the most important one being carbon dioxide (CO_2). In fact, with the expansion of upgrading and associated industries, the region could become a significant contributor to Canada's GHG emissions. Figure 10 shows the estimated greenhouse gas production from operations at eight upgraders.[109] Between 2015 and 2020, it is estimated that the upgraders in Upgrader Alley could be producing approximately 45 megatonnes of GHG emissions each year. If no efforts are made to limit or capture those gases, they could contribute about 18% of Alberta's greenhouse gas emissions.[110] Since it is expected that Alberta will produce 35% of Canada's GHGs in 2015,[111] this means that the upgraders in Upgrader Alley could be producing over 6% of Canada's total emissions. If the indirect emissions from the purchase of electricity by the upgraders are included, the greenhouse gas emissions associated with the upgraders is considerably higher.[112] It is not yet known what proportion of the emissions will be captured, rather than released to the atmosphere.

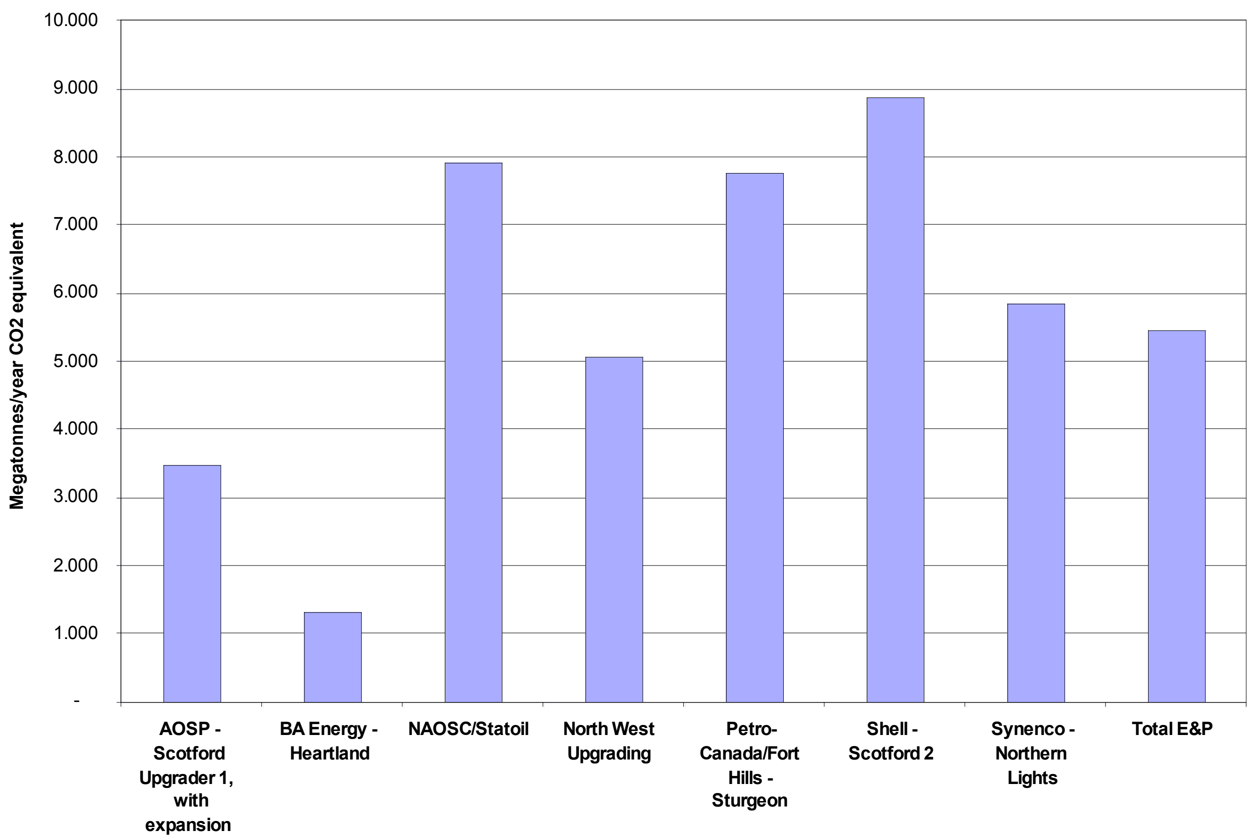


Figure 10: Estimated Greenhouse Gas Production at Upgraders in Upgrader Alley

See text and endnotes for sources and explanation.

Since July 2007, the Alberta government has required companies emitting more than 100,000 tonnes of GHGs a year to reduce their emissions intensity by 12%. Greenhouse gas intensity refers to the emissions of CO_2 and other greenhouse gases per unit of production. If total production increases, the total GHG emissions to the atmosphere can increase even if the GHG intensity decreases. The government does not require an absolute reduction in emissions, so there is not yet any absolute cap on the GHGs that can be emitted from industrial facilities in Upgrader Alley. Some companies are considering ways to reduce their emissions to the atmosphere by capturing CO_2 before it is emitted to the atmosphere and storing it deep underground. This process is called carbon capture and storage. Neither Alberta nor federal regulations currently require carbon capture and storage, but the federal government will require all "upgrader facilities coming onstream in 2012 or later to meet a target that is equivalent in stringency to carbon capture and storage."[113] The target will become effective in 2018.[114]

Carbon capture and storage is possible with upgraders, because some upgrading processes produce a concentrated source of CO_2, which is quite easy to capture. The CO_2 can be compressed, piped to a suitable geological locationand pumped deep underground. The CO_2 may be stored permanently in deep saline aquifers or it may be pumped into oil reservoirs to increase the production of oil (enhanced oil recovery). Although some CO_2 will come back to the surface with the oil, some will remain in the oil-bearing formation. The closest location for carbon storage is in the Redwater area, where an oilfield (the Redwater reef) is underlain by a deep saline aquifer. A preliminary geological assessment of the saline water zone of the Redwater reef indicates that "the potential exists to inject sustainably in excess of 1,000 tonnes of CO_2 per day per well in the aquifer portion of the reef. Preliminary storage capacity estimates for the aquifer are in the order of one gigatonne (i.e. one billion tonnes) of CO_2."[115] A three-stage pilot study seeks to verify that potential. The pipeline between the CO_2 sources and the injection area would be relatively short compared with other potential injection sites, but it is not yet known if or when the plan will proceed. Given the costs of capture and injection, it will not be a cost-effective solution until there is a higher cost on emitting CO_2 to the atmosphere.

Companies that intend to gasify coke or asphaltenes (a by-product of the upgrading process) to provide some of the energy for their operations are especially considering carbon capture and storage. While gasification makes use of a waste product and reduces the consumption of natural gas, it creates more greenhouse gases per barrel of synthetic crude oil than a process using natural gas. North West Upgrading has already announced an agreement to supply CO_2 to Enhance Energy, which will use the gas for enhanced oil recovery.[116]

The Pembina Institute accepts that carbon capture and storage is one way to reduce greenhouse gas emissions associated with oil sands development, provided it is done in a responsible manner and efforts are also made to minimize the use of energy and promote energy efficiency in all aspects of an operation.

6. The Demand for Water

6.1 Total Water Needed by the Upgraders

Upgrading bitumen requires a lot of fresh water. The total licensed allocations and applications for the eight upgrader projects for which information is available, is about 114 million cubic metres (m^3) or 14 billion litres a year (see Table 5). If the upgraders use current technology, they will return about 25% of that water to the river. As shown in Figure 11, they could permanently remove from the river nearly 80 million m^3 of water a year when they are all operating (for example, between 2015 and 2020).[117]

For comparison, the City of Edmonton withdrew and treated almost 132 million m^3 of water in 2006, of which 48% was for household use.[118] The volume of water consumed by the city is estimated at about nine million m^3/year or less.[119] It seems that between 90% and 96% of treated municipal water flows back to the North Saskatchewan River after treatment in the Capital Region sewage system. Major industrial withdrawals from the North Saskatchewan River start upstream of Edmonton, where the power plants are licensed to use very large volumes of water, primarily for cooling. Despite losses from evaporation, much of the water is later discharged back to the river. Downstream of Edmonton, where large water withdrawals for the refinery and petrochemical facilities in the Fort Saskatchewan area occur, the volume of water returned to the river is considerably lower, at around 84%.[120]

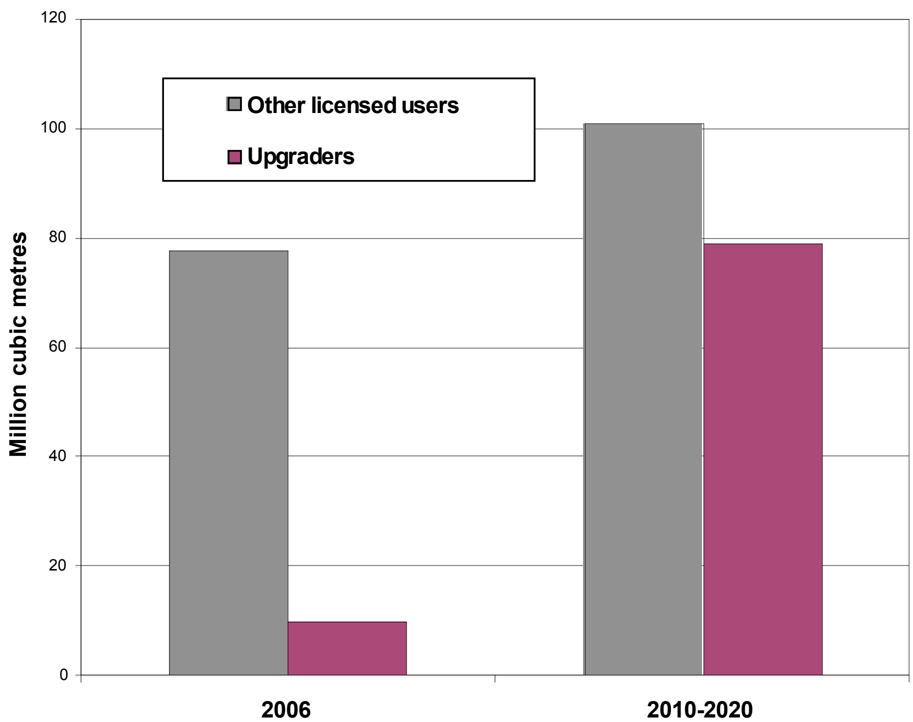


Figure 11: Expected growth in consumptive water use by the eight upgraders and by all other major Alberta licensees along the North Saskatchewan River downstream of Edmonton

Source: see endnote 121.

> "In the face of accelerated energy production and population growth all efforts should be made to advance the research and regulatory activities needed to protect water resources that could be threatened."[122]

In 2006, the total consumptive use of water from the North Saskatchewan River between the Low Level Bridge in Edmonton and the Saskatchewan border was approximately 87 million m^3 per year.[123] If all nine upgraders proceed (the eight listed in Table 5 and the Suncor upgrader yet to be announced), the consumptive water use for that stretch of the river is likely to double. If one includes the stretch of river upstream of Edmonton as far as Devon, the total consumptive use is higher, at 122 million m^3 per year (see Table 6). In this case, the upgraders will increase total consumptive use by about two-thirds.

It is not possible to directly compare the water consumption of different projects in Table 5, because some companies undertake more processing and thus require more water than others. For example, a company that gasifies the coke byproduct to produce its own energy will require more water than one that buys all the natural gas it needs. Some companies are making efforts to reduce their demand for water. For example, as a result of public pressure, North West Upgrading made a commitment to reduce water use.[124] It will reduce its intake from the river through additional recycling, and it will use air coolers to reduce evaporative losses of the water required for cooling. North West Upgrading has the second-lowest projected net use of water per barrel of bitumen processed (see Table 5).

Table 5: Licensed and projected water withdrawals and consumptive use for upgraders in Upgrader Alley

Company	Project Name/Phase	Barrels bitumen per day	Licensed/ projected withdrawals (m^3/year)	Potential consumptive water use (m^3/year)	Net water/ bitumen ratio[a]
Athabasca Oil Sands Project (Shell Canada)	Scotford Upgrader, including expansion 1	290,000	14,936,000	5,571,000	0.59
BA Energy Inc./Value Creation	Heartland Upgrader Phases 1–3	163,000	11,200,000	11,200,000	1.19
North American Oil Sands Corporation/ StatoilHydro	North American Upgrader Phases 1–2	250,000	14,400,000	14,400,000	0.70
North West Upgrading Inc.	North West Upgrader Phases 1–3	150,000	5,571,000	4,888,000	0.56
Petro-Canada/Fort Hills Energy Corporation	Sturgeon Upgrader Phases 1–3	340,000	14,454,000	7,227,000	0.76
Shell Canada	Scotford Upgrader # 2	400,000	30,660,000	19,237,000	0.83
Synenco Energy Inc.	Northern Lights Phases 1–2	115,000	10,300,000	10,300,000	1.55
Total E & P Canada Ltd.	Total Upgrader Phases 1–2	245,000	12,264,000	6,132,000	0.43
All eight upgraders		**1,953,000**	**113,785,000**	**78,955,000**	**0.83**

Source: Company environmental impact assessments and personal communication with companies.
Note: The water to bitumen ratio for each company is not directly comparable, since it depends on the process used, on whether a company gasifies residual coke, etc. Bitumen and water volumes are converted to the same units to calculate the ratio.

6.2 Impacts on the North Saskatchewan River

Most of the water for the upgraders is expected to come from the North Saskatchewan River, either directly or by treating and reusing wastewater from the City of Edmonton and other industries. Because much of the water used by upgraders is consumed in the process, the total volume of water in the river is reduced, whether river water or wastewater is used.

A government report written in 2006 pointed out that *"Alberta Environment has not been able to provide timely advice and direction to industry relative to water use. ... Little work has been done by the department to advise and direct industry (upgraders and other plants) who are planning to locate in the Industrial Heartland, about the availability of groundwater or withdrawals from the North Saskatchewan River."*[125] It recommended that *"Alberta Environment should assign urgent priority to defining the water supply (both surface and groundwater) available for use in the Industrial Heartland area."*[126]

Following this criticism, some information on current and future water use has since been published in a study conducted for the North Saskatchewan Watershed Alliance[127] and in a province-wide report on the basic ecological health of rivers,[128] but more work needs to be done. Alberta Environment's Water Management Framework for the Industrial Heartland is still in its early stages (see section 6.5).

> "The aquatic environment of the North Saskatchewan River may become stressed and ecosystem capacity exceeded if a regional plan to manage water issues and cumulative impacts is not implemented in the near term."[129]

Alberta Environment has indicated that: "Although the Government of Alberta has licensed the use of 29% of the mean annual flow of the NSR, only 5% of the mean annual river flow is permanently lost for consumptive use. Projected development of eight upgraders will increase total consumptive use to 6% (an increase of 1%)."[130] This refers to the entire North Saskatchewan River within Alberta. The figures for a specific stretch of the river may be rather different.[131]

Table 6 shows that if all the listed upgraders proceed and there are no limits on the proposed water requirements, about 3.3% of the mean annual flow in the stretch of the North Saskatchewan River that runs through the Industrial Heartland will be consumed. This number, however, is misleading because flows in the North Saskatchewan River are highly seasonal. During certain times of the year, impacts will be much greater. Low flows are most likely to occur in winter, between November and February. In Table 6, low flows are defined as the lowest stream flow for seven consecutive days that is expected to occur one year in ten (the 7Q10 flow).[132] In the future, during periods when the winter flows are low (the 7Q10 flows), all river users are likely to consume nearly 11% of the river flow. This represents a 65% increase in consumptive use for this stretch of the river.[133] The total licensed withdrawals will be much higher and could be equivalent to over 37% of the low flow during winter and over 11% of mean annual flows.[134] These figures do not include the additional water which will likely be required for other projects related to the growth in Upgrader Alley.

In addition to the planned upgraders, other future facilities, including additional refinery and petrochemical facilities located near the upgraders, will also require water from the river. Sherritt is planning an extensive coal mine and coal gasification plant at Dodds-Roundhill, approximately 80 km southeast of Edmonton, which could provide some of the hydrogen needed in Upgrader Alley. The operation will not only gasify coal, but also generate electricity. The first stage of the Sherritt project is expected to use almost 9.5 million m^3/year of water.[135] Although this operation will use water from the Gold Bar wastewater treatment facility,[136] and not require a new intake, it will reduce the volume of water returning to the North Saskatchewan River from the Gold Bar facility.

Table 6: Actual and predicted water withdrawals from the North Saskatchewan River, Edmonton and the Industrial Heartland

Company	Licensed Withdrawal	Return Flow	Consumptive Use		
Current projects	**m^3/year**	**m^3/year**	**m^3/year**	**% of low flow (7Q10)**	**% of mean annual flow**
EPCOR Power	450.22	427.71	22.51	1.32	0.40
Petro-Canada Products Inc.	5.78	1.44	4.34	0.23	0.07
Celanese Canada Inc.	16.03	8.54	7.49	0.40	0.12
Imperial Oil Resources Ltd.	9.25	3.75	5.50	0.29	0.08
Dow Chemical Canada Inc.	21.49	0.00	21.49	1.15	0.35
Agrium Products Inc.	19.46	2.90	16.56	0.88	0.28
Sherritt International Corp.	5.15	1.80	3.35	0.18	0.05
Provident Energy Ltd.	4.56	0.00	4.56	0.25	0.07
Shell Canada Products	13.30	3.76	9.54	0.51	0.15
Athabasca Oil Sands (Shell Canada) – Scotford Upgrader, including expansion*	14.94	9.37	5.57	0.30	0.09
ATCO Gas and Pipelines Ltd.	3.70	0.00	3.70	0.20	0.06
172 licences under 2.5 m^3/year	22.26	4.56	17.70	0.92	0.28
Total for current projects	**586.14**	**463.83**	**122.31**	**6.63**	**2.00**
Future upgrader projects					
Athabasca Oil Sands – Bitumen Blending	8.76	1.7	7.06	0.38	0.11
BA Energy Inc. – Upgrader	11.20	0.00	11.20	0.60	0.18
North American Oil Sands Corporation/StatoilHydro	14.40	0.00	14.40	0.77	0.23
North West Upgrading Inc.	5.57	0.68	4.89	0.26	0.08
Petro-Canada/Fort Hills	14.45	7.22	7.23	0.39	0.12
Shell Canada – Scotford #2	30.66	11.42	19.24	1.03	0.31
Synenco Energy Inc. Northern Lights	10.30	0.00	10.30	0.55	0.17
Total E & P Canada Ltd.	12.26	6.13	6.13	0.33	0.10
Total for future upgrader projects	**107.60**	**27.15**	**80.45**	**4.31**	**1.29**
Current projects and future upgraders	**693.74**	**490.98**	**202.76**	**10.94**	**3.29**

Source: Modified from Total E & P Canada Ltd., with the addition of data from North American Oil Sands Corp.[137]
* Scotford Upgrader #1 is included with existing projects, but the current water consumption is less than stated, since the expansion is not yet operating.

The overall demand for water in the North Saskatchewan Basin is expected to increase over the forecast period, largely because of the increase in water required for upgraders.[138]

Predictions on future growth in water use in the two sub-basins of the North Saskatchewan River in which the upgraders are located indicate that the consumptive use of water could increase by 250% from 65 million m^3/year in 2005 to 170 million m^3/year by 2025. Much of that increase will be due to the upgraders.[139] These estimates, for a medium growth scenario, are depicted in Figure 12.[140]

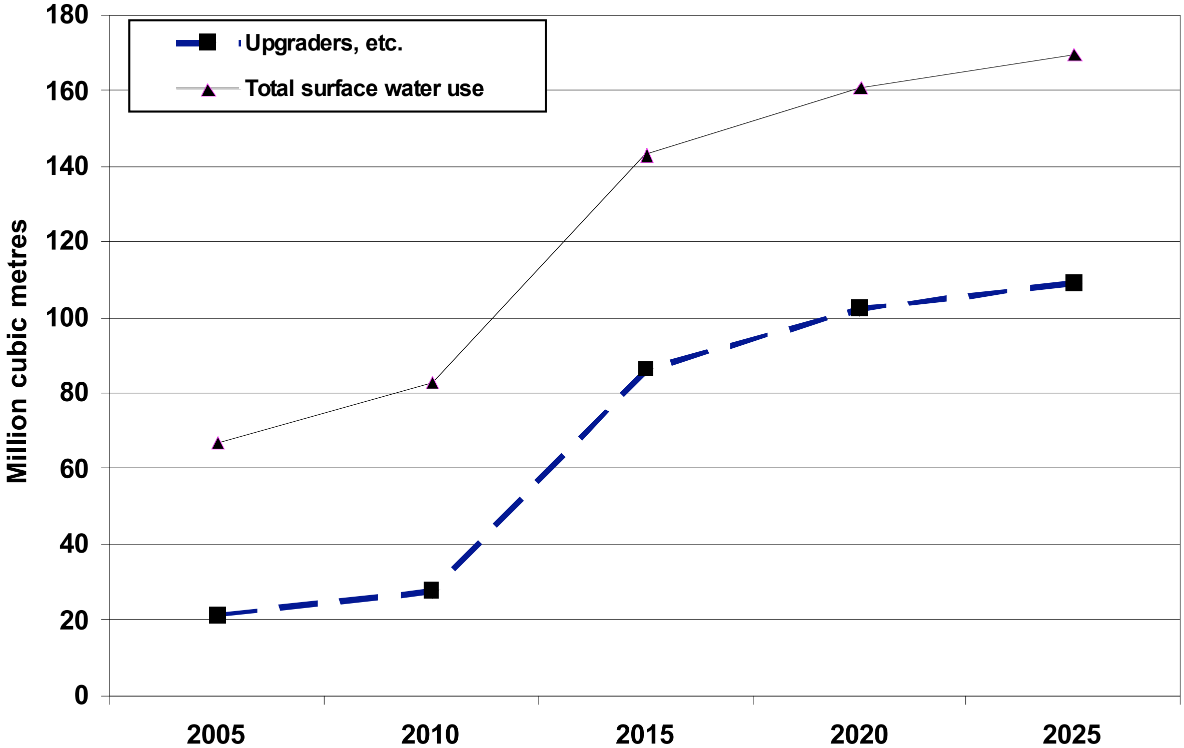


Figure 12: Forecast consumptive water use for two sub-basins of the North Saskatchewan River where upgraders are located and planned, 2005–25, medium-growth scenario

Source: North Saskatchewan Watershed Alliance. 2007. *Current and Future Water Use in the North Saskatchewan River Basin.*[141]

6.3 Is There Enough Water?

The North Saskatchewan River, the main source of water for the upgraders, is generally wide and quite shallow. It is the same size as the South Saskatchewan, but has only about one-third the flow of the Athabasca River and one-seventh the flow of the Peace River.[142]

The Bighorn and Brazeau dams, constructed in 1960 and 1973, respectively, have changed the natural flows of the North Saskatchewan River. The dams, which are also used for hydroelectric power generation, store water in the summer months and release it during low-flow periods in winter. Indeed, one reason for the construction of the dams was to increase the winter river flow to better dilute the discharge from sewage treatment operations. TransAlta, which operates the dams, is required to allow a certain flow-through on the river, which can be adjusted by Alberta Environment if more water is required.[143]

> "The question is how much can be removed or consumed out of the river and still maintain a good balance and a healthy aquatic ecosystem? What is the upper limit? That may vary from week to week. That's the question that needs to be answered."
> —Gord Thompson, North Saskatchewan Watershed Alliance[144]

Figure 13: Alberta's new Water Management Framework for the North Saskatchewan River will limit withdrawals when water levels are low, but it will not stop them, even during critical low flow conditions.

Photo: David Dodge, The Pembina Institute

Despite the dams, monthly flows vary considerably, and the volume of winter flows is still less than half the mean flow during summer months.[145] In the driest month, November, the low flow can be only half of that month's median flow and only one quarter of the median flow for the wettest month, July.[146] The low flows need to be considered when determining how much water can be removed without affecting the health of the river.

A certain level of water flow is needed in the river throughout the year to provide adequate fish habitat, spawning areas and healthy fish populations. White and longnose suckers are the most prevalent fish found in the North Saskatchewan River east of Edmonton. Some walleye, goldeye, whitefish and other species are found, as are the various smaller organisms on which they feed. However, there is insufficient information to determine the extent to which the many industrial developments along the river have affected the fish and other aquatic organisms, or how they will be affected in the future by water flows or water quality.

Some years are drier than others. Moreover, the long-term flows in the North Saskatchewan River have been declining[147] and are likely to continue to decline because of climate change and increasing use. The combination of these effects could mean lower flows during drought periods than have been experienced in the past century. In the future, evaporation is expected to increase and river flows are likely to become more variable. In other words, the resilience of the river and its ecosystem to human-caused changes in flow — such as water withdrawals for upgraders — will be weakened.

"We predict that in the near future climate warming, via its effects on glaciers, snow-packs, and evaporation, will combine with cyclic drought and rapidly increasing human activity in the [Western Prairie Provinces] to cause a crisis in water quantity and quality with far-reaching implications."[148]

6.4 Water Quality Is a Major Concern

When flows in the North Saskatchewan River are low, the concentration of contaminants increases. Despite improvements in wastewater treatment over the past decade, water quality in the North Saskatchewan River is affected by municipal wastewater and industrial discharges, as well as runoff and sewage outfalls. In 2005–06 the water quality at Devon, upstream of Edmonton, was rated good, but at Pakan, downstream of Upgrader Alley, the water quality was rated only fair.[149] Downstream of Edmonton the North Saskatchewan River contains relatively high levels of nutrients (such as ammonia, phosphorus and nitrogen), phenols and some metals.[150] These substances come primarily from the Capital Region and Gold Bar wastewater treatment plants. Historically (1985–2002) the median concentration of phosphorus and aluminum and the maximum concentrations of some other substances (including phenols and metals) exceeded either the Alberta Surface Water Quality Guidelines or the Canadian Water Quality Guidelines for freshwater aquatic life.[151]

The provincial government limits the contaminants that a company is permitted to discharge into a river, but it allows the diluting effect of the river to reduce the concentrations to acceptable levels.[152] During low-flow conditions there is less water to dilute the contaminants and the concentration of effluent will probably not be reduced to 1% of the discharge levels until several kilometers downstream of the discharge point.[153] Although it might be expected that the concentration of contaminants would be higher when there is less water in the river to dilute them, this is not always the case. This is because some contaminants, especially from non-point sources, are mobilized during higher flows.[154]

Under the current regulatory process, new facilities, such as the upgraders, are likely to increase the discharge of some substances. An increase in ammonia from an upgrader, added to ammonia already in the river from the municipal wastewater treatment plants, could cause an exceedance of Canadian guidelines for freshwater aquatic life for more than 500 metres downstream of the discharge pipe.[155] Excessive ammonia concentrations would be most likely to occur along the river bank close to where discharges occur and in summer when water temperatures are high.[156] Fish and other aquatic organisms may be affected by the contaminants or avoid discharge areas, resulting in some loss of their habitat.

Discharge from upgraders is expected to increase the concentration of phenols in the river water (which, as noted above, have already sometimes exceeded guidelines) and some ions (including sodium, chloride and sulphate). Even though individual additions of a substance may be relatively small, the accumulation of these contaminants from numerous sources would lead to a gradual increase in the stress on the river's ecosystem.[157]

6.5 The Water Management Framework

In recognition of the cumulative impacts of development, a government-appointed advisory committee has prepared the Water Management Framework for the Industrial Heartland and Capital Region*,* to address both water quality and quantity issues on the stretch of the North Saskatchewan River between Devon and Pakan.[158]

Is oil getting precedence over protection of the river?

Alberta Environment has set flow volumes below which withdrawals from the North Saskatchewan River will be reduced, but we do not yet know if the flows will be sufficient to protect fish and fish habitat, as the ecological base flows have not yet been established. To be truly protective, the Water Management Framework should prohibit withdrawals if there is a risk that fish habitat will be damaged.

The framework report recognizes that low flows are likely to be an issue and sets targets for water quantity based on the regulated river flows.[159] It points out that current science considers that 85% of instantaneous river flows are needed to support aquatic life, but that more water needs to be left in the river during low-flow conditions. On that basis, Alberta Environment has prepared a table showing target levels for the volume of water that it will allow to be withdrawn during dry periods (identified as “yellow” and “red” conditions).[160] Even when the flow rate is very low during the winter months, the framework allows approximately 5% of flows to be diverted under “red” conditions and 10% of flows during “yellow” conditions. Based on historic records, flows may be in the “red” zone in any month between October and March for a week or longer more than one year in ten.[161] Although it is not yet known how much water must be retained in the North Saskatchewan River to protect aquatic life, Alberta Environment will still allow some water to be withdrawn when flows are low. However, as a result of dams on the river, low flows during the past 35 years have been higher than the natural flows before the river was regulated.[162]

Scientific study of the river is needed to determine its instream flow needs. The North Saskatchewan Watershed Alliance has published a study that shows what work must be conducted to determine the volume of water required to maintain a healthy aquatic ecosystem.[163] The North Saskatchewan Watershed Alliance has also initiated work on a Watershed Management Plan for the entire watershed. One element of this plan is to establish a water conservation objective to ensure that instream flow needs are met.[164]

The instream flow needs of a river are determined relative to its natural flow and natural habitat, that is, the flow and habitat that would have occurred in the river without the intervention of humans. The instream flow needs are based on scientific research that identifies the amount of water necessary to maintain and protect an aquatic ecosystem. This includes fluctuations in flow over time, which mimic natural cycles of high, medium, and low flows and meet the varied needs of the river’s ecosystem.[165]

In recognition of the increasing pressures on the North Saskatchewan River, the new water management framework outlines a plan to both limit the diversion of water and minimize the discharge of nutrients and contaminants to the river, by ensuring that wastewater is treated and reused (or “reclaimed”). It envisages a new regional infrastructure for collecting and treating wastewater, which will be established between 2009 and 2012, followed by a period which “will see the integration of existing facilities into the framework, making an integrated supply network for the Industrial Heartland.”[166] The City of Edmonton and the adjacent counties of Strathcona and Sturgeon had earlier indicated their support for the re-use of municipal and industrial wastewater.[167, 168] The first project to reuse municipal wastewater is Petro-Canada’s converted refinery, which pipes treated wastewater from the Gold Bar sewage treatment plant.[169] The company has an agreement to use treated wastewater for its Fort Hills Sturgeon Upgrader.[170]

When wastewater is reused, water does not flow back to the river. This system has some benefits — it reduces the load of nutrients and other substances that are usually found in discharged water and it limits disturbance on the river caused by the construction of new intakes — but it also reduces river flows, which can be a concern during low-flow conditions.[171]

The first phase of the Water Management Framework is entitled "Enabling Current Developments," so that "… projects currently in the regulatory queue will go ahead."[172] This means that by the time the full infrastructure is in place for a regional water and wastewater system, "new and future planned upgraders will have moved through the regulatory phase."[173]

The success of the framework will depend to a considerable extent on how Alberta Environment responds to new applications for water and whether it requires each new project to join the regional water reuse network as soon as it is built. Although no new intakes are to be permitted during the first phase, Alberta Environment will make decisions about whether to allow additional diversions from the North Saskatchewan River.[174] Alberta Environment intends to write a condition into any water licence issued during phases 1 and 2, which will allow it to be revised whenever the director sees fit.[175]

The Pembina Institute thinks that new approvals should be deferred until the infrastructure for an integrated water and wastewater system in place. If this deferral is not possible, it is very important that all projects seeking approval are required to meet the highest technical standards and to participate in the water management scheme proposed in the framework as soon as the infrastructure is in place. Alberta Environment should write a condition into each new licence requiring the facility to join the regional infrastructure as soon as the infrastructure is complete. Given the large water consumption by upgraders, there must be no "grandfathering" of projects approved. This is especially important since, once approved, upgraders are likely to continue in operation and want to withdraw water for several decades.

> "In the management of Alberta's economy, water should be viewed as being every bit as important as oil. Evolving water policy should be proactive in anticipating the needs and demands of a growing economy rather than simply providing reactive response to resource development and population growth and pressures."[176]

Although the Water Management Framework sets maximum withdrawal rates during low-flow conditions, Alberta Environment should not allow any withdrawals during low-flow conditions until a water conservation objective has been established that recognizes the instream flow needs of the river. We must not repeat the experience in the South Saskatchewan River Basin or the Lower Athabasca River downstream of Fort McMurray, by granting water allocations and potentially over-allocating the river before instream flow needs are protected. Also, river flows are likely to decline or be more variable, because of climate change and the increasing demands of other industries and a growing population in the region. Reduced flows means that the pollutants in discharge water will become more concentrated, which will further affect the river's aquatic ecosystem in addition to upgraders, other industries and a growing population in the region.

6.6 Groundwater Resources

At present, the North Saskatchewan River is the source of water for the upgraders and most other industrial projects. It is possible that limitations on the use of the river could lead to more applications for groundwater, but this is not indicated in future estimates from Alberta Environment.[177] One company, BA Energy, initially proposed using groundwater, but later applied for and received a licence to withdraw river water.

A freshwater aquifer, known as the Beverly Channel, underlies part of the North Saskatchewan River and adjacent land. The sands and gravels in this channel, which was created over an extensive area during earlier glacial periods, are connected with the North Saskatchewan River. The Beverly Channel Aquifer has been contaminated in some places by activities on the surface.[178] The Northeast Capital Industrial Association (an industry group made up of oil refining and petrochemical companies) has, in conjunction with Alberta Environment, led research to learn more about this important aquifer. Monitoring wells and test holes are used to measure the quality of the water and help understand how it moves, but more wells are needed to find out how far contaminants have spread.[179] Modelling is underway to examine possible scenarios that could affect groundwater and these will be used to develop strategies to protect water quality. The government's Cumulative Effects Management Framework includes plans to expand the study of the Beverly Channel aquifer and to map shallow aquifers, to assess their vulnerability to contamination.[180]

To minimize the risk of future spills or leaks reaching shallow aquifers, companies are required to ensure that storage tanks meet certain provincial and federal specifications and to engineer secondary containment systems. However, leaks can still occur, for example, from pipelines.

Surface water and groundwater are part of a single resource and changes in the flow in the North Saskatchewan River will affect adjacent groundwater levels. Likewise, changes in groundwater levels will affect the river. Wetlands play an important role in capturing precipitation so it can recharge groundwater. Under the framework, any loss of wetlands for development is to be compensated by restoring or creating a more extensive wetland area, but they will not necessarily be within the same sub-basins.[181]

7. Cumulative Impacts

The cumulative environmental and socioeconomic impacts of the development planned in Upgrader Alley and the surrounding region will be enormous. They will be driven by a similar surge in bitumen extraction in northern Alberta. Alberta Environment's Cumulative Effects Management Framework attempts to address some of the issues, but it does little to limit the effects on land. It allows air pollution to increase. The discharge of contaminants to the North Saskatchewan River will be reduced, but river flows will also be lower. The framework provides some limits to the environmental impacts of development, but it does not take an active role in planning the way development takes place.

Development in Upgrader Alley will not stop with the building of upgraders. Refineries and various petrochemical operations are likely to grow up or expand to use some of the products from the upgrading process. The Edmonton region is seen as having the potential to become a world class industrial chemical cluster.[182] If this vision is realized, it will mean a lot more development, and ways must be found to limit the harmful impacts of this growth. Area structure plans have focused on economic development for the region,[183] but a recognition of the negative cumulative effects of the growth on the environment is fairly new. Projects are approved one at a time, but a way needs to be found to gain the benefits of an integrated approach.

Experience in other petrochemical centres in the world shows both the economic and environmental benefits of integration.[184] This integration can go far beyond sharing roads and pipelines or the construction of a centralized water management system, as is being proposed as part of the Cumulative Effects Management Framework. A preliminary study, conducted for the government's Hydrocarbon Task Force, shows that integrating upgrading with refining and petrochemicals can considerably reduce the effects of separate facilities.[185] In an integrated complex, the upgraded bitumen may become the basis for a wide variety of petrochemical industries, which not only adds value to the synthetic crude oil,[186] but enables the operations to share resources. In some cases waste or by-products from one operation may supply the raw materials for another.[187] If companies work together they may obtain synergies in the use of energy and by-products — with one company using waste products (including heat) from another. For example, it may be feasible to collect and reuse the waste gases from the upgrading process, instead of burning them off. Some companies plan to use the coke byproduct of the upgrading process to provide power for their operations, but it might be more efficient if this were done in a centralized operation, where any surplus gas could be used for other purposes. Proposals are being developed for capturing and storing CO_2, but it would make sense to have the infrastructure in place, so that projects can immediately tie into the pipeline, rather than develop their own independent plans.

If the region is to expect so much growth, it is important that it is conducted in a way that minimizes the impacts. Various scenarios indicate that the air emissions from stand-alone operations are 1.5 to 5.1 times greater than from an integrated complex; water use is 1.1 to 1.6 times greater; and the surface footprint on the land is 1.4 to 2.2 times greater, as is shown in Figure 14.

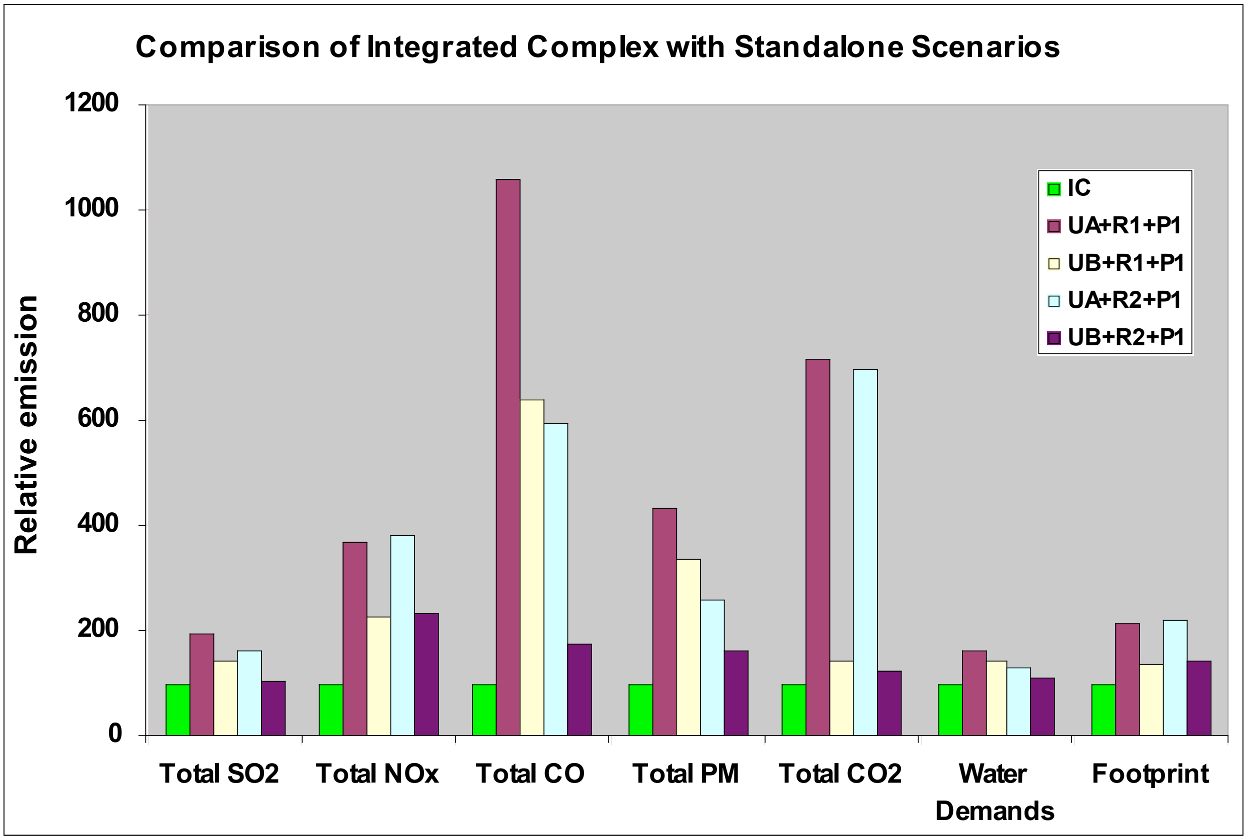


Figure 14: Summary of environmental benefits of an integrated complex (upgrader, refinery and petrochemicals)

Source: AMEC Earth and Environmental, with permission from Hydrocarbon Task Force, Alberta Energy. Explanation: IC = integrated complex. U = upgrader, R = refinery, p = petrochemical plan. Values are shown for two upgrader scenarios, A and B, and two refinery scenarios, 1 and 2.S02 = sulphur dioxide, NOx = nitrogen oxides; CO = carbon monoxide, PM = particulate matter, CO2 = carbon dioxide, the main greenhouse gas.

An integrated approach will require the full cooperation of government and industry. The task force set up to develop an integrated growth management plan for the entire Capital Region noted that “industry can be called upon to participate in projects to address regional water supply, process water supply and regional waste disposal not to mention potential regional solutions to capture and reduce carbon dioxide emissions.”[188]

Integrated development requires careful planning and takes time. As noted above, the long-term integrated growth management plan for the region will not be ready until 2010. In the interim, five companies have applications in progress to build new upgraders. We need to find ways to provide the necessary infrastructure, such as a wastewater treatment network or pipelines to take CO_2 to storage locations, so that they are in place when a company starts its operations.[189] Even though the benefits of an integrated complex of industries are widely recognized, companies may find it easier to proceed with their own independent plans. Thus the right incentives need to be in place to promote an integrated approach. Government must take the lead in setting limits, which will encourage industry to adopt an integrated approach and reduce the total burden on the environment. This will help to manage the pace of growth.

8. Why the Rush?

8.1 Time to Pause and Do Things Better

If all the projects for which applications have been submitted are approved, the rapid pace of growth in Upgrader Alley will mimic that in Fort McMurray. If the rate of development were somewhat slower, there would be more time to develop and implement plans to reduce the impacts.

The air, land and water in Upgrader Alley are already being degraded. The government is trying to limit impacts through its Cumulative Effects Management Framework. This effort is commendable, but while caps on a limited number of air pollutants are proposed to come into place in 2009, they will still allow considerable increases in the level of air pollutants. Measures must also be taken to reduce emissions of hydrogen sulphide and volatile organic compounds, including benzene. Several years will elapse before the full system is in place to optimize the opportunities for water reuse. It may be considerably longer before all facilities are joined in. There seems to be no plan to ensure that the area of productive land converted to industrial use is kept to an absolute minimum.

The Capital Region Integrated Growth Management Plan is to be developed to address the pressures of growth in the entire region. It needs to be in place before further upgrader projects proceed to avoid the problems associated with environmental management in the Fort McMurray region. The Pembina Institute has already called for a pause in new oil sands approvals until the environmental, social and economic impacts of already approved projects have been addressed and to allow time for the implementation of a proactive plan to deal with future impacts. This also applies to the upgraders.

We are not advocating that bitumen should be sent to the U.S. for upgrading, but we believe that Alberta needs time to implement plans to ensure responsible upgrading and refining in the region. Government and industry should work together to find the optimum way to coordinate the various projects to get all the benefits of an integrated complex in Upgrader Alley.

The Pembina Institute is thus calling for a pause in approving new upgrading projects to give time for the implementation of a better planned, integrated approach to new industrial development. The objective is to minimize the cumulative impacts on the environment. This pause would give time to plan and develop the necessary regional infrastructure including housing, roads and social services. It would, for example, enable the construction of wastewater treatment and reuse system for the industrial area and the development of pipelines to take CO_2 that is captured to suitable locations for geologic storage.

Objectives of a healthy pause

- **Catch up** to current upgrader development **by addressing the environmental, social and economic impacts** of already approved projects.
- **Get ahead** of future upgrader developments by **implementing plans to proactively manage** environmental, social and economic impacts.

A pause in the approval of new upgrader projects is needed until government and industry show they can do the following:

Limit Environmental Impacts: This means applying science-based precautionary limits that protect human health and ecosystems. These limits should be achieved by:

- Requiring all upgrader projects to be carbon neutral. This will require measures to prevent or offset all greenhouse gas emissions. It may be achieved through carbon capture and storage or in other ways.
- Setting strict limits to protect flows on the North Saskatchewan River and preventing industrial water withdrawals when the river is below flows needed to protect aquatic life in the river.
- Setting protective limits for air pollutants, not adequately covered in current plans, such as air toxics (e.g. benzene, volatile organic carbon and hydrogen sulphide).
- Finding ways to limit the amount of land used for industrial development. This includes careful planning to ensure land is used as efficiently as possible. Efforts should be made to compensate for all types of land lost to industrial development, not only natural areas and wetlands. This might include the purchase of development rights to protect agricultural land.

Address Cumulative Impacts: The measures set out in the government's Cumulative Effects Management Framework need to be revised to further limit impacts on air, land and water. An effective monitoring and reporting process must be set up, to ensure that the framework is fully implemented and is effective in minimizing impacts. Where necessary, additional measures must be taken to ensure that precautionary limits are not exceeded.

Focus on Quality of Life: The rate of growth must be managed to protect the quality of life, maximize the benefits to those living in the region and ensure that social services and infrastructure can keep pace.

The Government of Alberta and industry need to take the time to get it right.

9. Want More Information?

Visit www.oilsandswatch.org for the Pembina Institute report *Oil Sands Fever* and *Oil Sands Fever — Blueprint for Responsible Oil Sands Development,* photos, videos and other information and reports on oil sands.

Support our work. For more information or to make a donation to the Pembina Institute, please visit www.pembina.org.

Sources of information on Upgrader Alley:

Alberta's Industrial Heartland Association, www.industrialheartland.com.

Government of Alberta. 2006. *Investing in our Future: Responding to the Rapid Growth of Oil Sands Development — Final Report,* www.alberta.ca/home/395.cfm.

Government of Alberta. 2007.

> Government of Alberta Hydrocarbon Upgrading Task Force, www.energy.gov.ab.ca/Petrochemical/844.asp.
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> *Alberta's Environmental Plan to Deal with the Cumulative Effects of Development*, environment.alberta.ca/documents/CEM_Environmental_Plan.pdf.
>
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> *Current and Future Water Use in Alberta,* www.waterforlife.gov.ab.ca/watershed/current-future_water_use.html.
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Northeast Capital Industrial Association, www.ncia.ab.ca.

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The Rosenberg International Forum on Water Policy. 2007. *Report of the Rosenberg International Forum on Water Policy to the Ministry of Environment, Province of Alberta*, rosenberg.ucanr.org/documents/RegRoseAlbertaFinalRpt.pdf.

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Endnotes

[1] Government of Alberta. 2007. *Alberta's Environmental Plan to Deal with the Cumulative Effects of Development,* p. 2, environment.alberta.ca/documents/CEM_Environmental_Plan.pdf.

[2] Strategy West Inc. 2008. *Existing and Proposed Commercial Oil Sands Projects,* February edition, Alberta Upgraders, www.strategywest.com/downloads/StratWest_OSProjects.pdf This document gives total upgrader capacity in Alberta as 4.65 million barrels/day; the expected capacity in Upgrader Alley is 1.95 million barrels/day, or 42% of the total.

[3] Alberta Municipal Affairs. 2008. *Long-range Capital Region Planning, Cooperation Gets Underway,* media release, April 15, www.alberta.ca/acn/200804/2332053872D91-CAEB-D235-A9E31D09CE32A46A.html.

[4] Alberta Environment. 2007. *Alberta's Environmental Plan to Deal with the Cumulative Effects of Development,* environment.alberta.ca/documents/CEM_Environmental_Plan.pdf.

For general background see also the *Cumulative effects management* web page, environment.alberta.ca/1930.html.

[5] Alberta Environment. Personal communication, May 9, 2008.

[6] The Pembina Institute. 2007. *Overwhelming Majority of Albertans Support a Pause on New Oil Sands Approvals,* media release, May 8, www.oilsandswatch.org/media-release/1445.

[7] Strategy West Inc. 2008. *Existing and Proposed Commercial Oil Sands Projects,* February edition, www.strategywest.com/downloads/StratWest_OSProjects.pdf The total bitumen design capacity listed as "Operating" is 1.43 million barrels per day.

[8] Strategy West Inc. 2008. *Existing and Proposed Commercial Oil Sands Projects,* February edition, www.strategywest.com/downloads/StratWest_OSProjects.pdf This document gives a total of 4.65 million barrels/day, but the scheduled start-up date for some projects is still unknown.

[9] Gordon Jaremko, "Alberta wants top value from oil", *Edmonton Journal,* April 27, 2007.

[10] Strategy West Inc. 2008. *Existing and Proposed Commercial Oil Sands Projects,* February edition, Alberta Upgraders, www.strategywest.com/downloads/StratWest_OSProjects.pdf.

[11] The ratio for Alberta upgraders is approximately 0.87, using the total expected bitumen input and the total volume of products, as given by Strategy West Inc. 2008. *Existing and Proposed Commercial Oil Sands Projects,* February edition, p. 3, Alberta Upgraders, www.strategywest.com/downloads/StratWest_OSProjects.pdf.

[12] The sum of projects listed in Table 1, which includes all projects announced by early 2008, is 1.9 million barrels/day, but the date when all proposed projects will be completed is unknown. The Alberta government uses a figure of "approximately 1.5 million barrels of bitumen a day" in Government of Albert. 2007. *Alberta's Environmental Plan to Deal with the Cumulative Effects of Development,* p. 2, environment.alberta.ca/documents/CEM_Environmental_Plan.pdf.

[13] Erin Anderssen, "The climatic costs of rapid growth", Shifting Sands, Part IV, *Globe and Mail,* February 1, 2008. Suncor has acquired approximately 3,000 acres of land for long-term growth and is expected to make an announcement in the 2nd or 3rd quarter of 2008. County of Sturgeon. 2008. *Economic Development: Activity at a Glance,* Alberta's Industrial Heartland Update. Presentation, January 10, slide 15, www.industrialheartland.com/pdf/RealtorUpdate-Jan10-08/Sturgeon_AIH-Update_Jan10.pdf.

[14] For example, B.A. Energy Inc. 2004. *Heartland Upgrader Application.* Vol. 1, p. 2-1. The company plans to upgrade bitumen from the Cold Lake, Peace River, Wabasca and, eventually, Fort. McMurray areas.

[15] Bitumen from in situ operations may be upgraded on site (e.g., Opti-Nexen's facility at Long Lake) and some has been sent to an upgrader in the Fort McMurray region (e.g., PetroCanada sends bitumen from Mackay River to Suncor's facility).

[16] Government of Alberta. 2006. *Alberta's Oil Sands Opportunity,* Presentation by Mike Ekelund to Oil Sands Experts Group Workshop, Houston, Texas, Appendix 2, Plenary Session Presentations, www.rqic.alternatives.ca/psp/os_spp_wwr.pdf.

[17] Strategy West Inc. 2008. *Existing and Proposed Commercial Oil Sands Projects,* February edition, Alberta Upgraders, www.strategywest.com/downloads/StratWest_OSProjects.pdf.

[18] Alberta's Industrial Heartland Association, personal communication, January 16, 2008. The area includes the river. One large addition to the region in 2007 was the result of Lamont County rezoning approximately 105 sq km for inclusion within the Heartland area. The area within Sturgeon County also increased. For comparison, the City of Edmonton covers almost 700 sq km.

Note that another source uses the figure of approximately 470 sq km. Alberta Environment. 2007. *Cumulative Effects in the Industrial Heartland,* slide 6, www.energy.gov.ab.ca/Petrochemical/pdfs/IH_Global_Presentation_Oct_18_2007_HUTF.pdf.

[19] Danielson, Laurie. 2008. North East Capital Association. 2008 *AIHA Municipal Orientation,* January 10, slide 7, www.industrialheartland.com/pdf/RealtorUpdate-Jan10-08/NCIA-AIHA-Jan10.pdf.

[20] Alberta Electric System Operator. 2007. *Powering the Growth of Alberta's Oilsands,* www.aeso.ca/files/HeartlandBroSinglePgs(4HR).pdf.

[21] County of Strathcona. 2008. *AIHA Municipal Orientation*. January 10, slide 16, www.industrialheartland.com/pdf/RealtorUpdate-Jan10-08/Strathcona-AIHA-Jan10.pdf.

[22] Alberta Electric System Operator. 2007. *Powering the Growth of Alberta's Oilsands,* p. 2 and 3, www.aeso.ca/files/HeartlandBroSinglePgs(4HR).pdf.

[23] Canada Pacific. 2007. *Canada Pacific seeks approval to better service Alberta's oil sands development,* media release, May 28, including backgrounder, *Canadian Pacific and Alberta's Industrial Heartland*, www8.cpr.ca/cms/English/Media/News/General/2007/Oil+sands+development.htm.

[24]Canadian Pacific. 2007. *Industrial Heartland Expansion Project.* November, www.industrialheartland.com/pdf/Realtor-update-11-28-08/IH-RealtorsConferenceCP07.pdf.

Canadian National and Canadian Pacific Rail have acquired, respectively, approximately 220 and 240 acres for rail expansion in Sturgeon County. County of Sturgeon. 2008. *Economic Development: Activity at a Glance,* Alberta's Industrial Heartland Update. Presentation, January 10, slide 15, www.industrialheartland.com/pdf/RealtorUpdate-Jan10-08/Sturgeon_AIH-Update_Jan10.pdf.

[25] The Petro-Canada Refinery, which has been converted to refine bitumen products, will also upgrade 30,000 barrels per day of bitumen, as well as some partly-processed sweet and sour synthetic crude oil. Since this is an integrated refinery operation, it is not possible to separate the inputs that relate purely to the upgrader.

[26] Strategy West Inc. 2008. *Existing and Proposed Commercial Oil Sands Projects,* February edition, Alberta Upgraders, www.strategywest.com/downloads/StratWest_OSProjects.pdf This report is used for project status. Bitumen throughput and synthetic crude oil production are from company environmental impact assessments and personal communications.

[27] Eight upgraders are expected to purchase approximately 127 million gigajoules of gas when all phases are complete. In 2006 the average household consumption of natural gas in Edmonton was approximately 137 gigajoules. ATCO Gas, personal communication, June 2007. There were 405,270 households in Edmonton in 2006. Statistics Canada, 2007. *Household Size by Metropolitan Census Area,* www40.statcan.ca/l01/cst01/famil122f.htm. Thus, total natural gas consumption for all households in Edmonton was approximately 55 million gigajoules in 2007.

[28] Total natural gas requirements for eight upgraders are expected to be approximately 3.4 billion cubic metres. This is 72% of the total production from coalbed methane wells in Alberta in 2006, which was 4.7 billion cubic metres. Energy Resources Conservation Board. 2007. *Alberta's Energy Reserves 2006 and Supply/Demand Outlook 2007-2016,* Statistical Series 98, p.4-1, www.ercb.ca/docs/products/sts/st98_current.pdf. There were 6905 producing CBM wells. Energy Resources Conservation Board. 2007. *Bulletin 2007-05: 2006 Alberta Coalbed Methane Activity Summary and Well Locations,* www.ercb.ca/portal/server.pt/gateway/PTARGS_0_0_323_253_0_43/ http%3B/ercbContent/publishedcontent/publish/ercb_home/industry_zone/rules__regulations__requirements/ bulletins/bulletin_2007_05.aspx.

[29] When all eight upgraders are fully operational, they are expected to generate, on average, about 30% of their total electricity requirement (although the proportion varies and some upgraders plan to buy all their requirements). The combined generating capacity for purchased electricity and that at the upgraders is expected to exceed 1600 MW. The demand for electricity from the grid will depend on the extent to which companies generate their own power.

[30]Alberta Electric System Operator. *Current Supply Demand Report,* ets.aeso.ca/ets_web/ip/Market/Reports/ CSDReportServlet EPCOR's Genesee power plant has three units, rated at 384, 384 and 450 MW, for a total of 1218 MW.

[31] Alberta Electric System Operator. 2007. *Powering the Growth of Alberta's Oilsands,* p. 3, www.aeso.ca/files/ HeartlandBroSinglePgs(4HR).pdf.

[32] Speaking notes for Mayor Stephen Mandel's address to the Urban Development Institute AGM, Edmonton, March 15, 2007.

[33] Alberta Environment. 2007. *Current and Future Water Use in Alberta*, www.waterforlife.gov.ab.ca/watershed/current-future_water_use.html Prepared by AMEC Earth and Environmental. The chapter on the North Saskatchewan River Basin, p. 15-37, says the petroleum sector is licensed to use 77% of its water allocation and the Petro-Canada upgrader will use 72-80% of its water allocation. As can be seen from Table 5 in this Pembina report, the consumptive use varies considerably between companies.

[34] The definition used in this report is similar to that used by Stantec in *Northern Lights Upgrader Project, Surface Water Assessment,* Consultant Report #8; see Table 2.3, p. 2.4, where "consumptive use" refers to withdrawals minus the return flows. In the report *Current and Future Water Use in the North Saskatchewan River Basin,* North Saskatchewan Watershed Alliance. 2007, p. 1-3, the definitions are slightly different and the term "water use" is defined as water consumption and loss.

[35] The sketch is based on information from two different upgraders and two different phases in their operations. North American Oil Sands Corporation Application. 2007. *Application to Alberta Energy and Utilities Board and Alberta Environment.* Volume 1, p. 82-83 and Petro-Canada/Forthills Energy Ltd. 2006*. Application for Approval of the Sturgeon Upgrader*, Volume 1, Project Description, p.5-8 and 5-9.

[36] Alberta Environment. 2007. *Overview: Land in the Industrial Heartland,* p. 1, environment.alberta.ca/documents/ Land_Overview_Oct_16_07.pdf.

[37] Energy Resources Conservation Board. 2007. *Decision 207-058: North West Upgrading Inc. Application to Construct and Operate an Oil Sands Upgrader in Sturgeon County,* p. 14, www.ercb.ca/docs/documents/decisions/2007/2007-058.pdf.

[38] Alberta's Industrial Heartland Land Trust Society. 2008. *Voluntary Resident Property Purchase Program (VRP) and Land Trust Society (LTS),* Presentation to Alberta Industrial Heartland Association, January 10, slide 2, www.industrialheartland.com/pdf/RealtorUpdate-Jan10-08/LandTrust-AIHA-Jan10.pdf See also slide 4 which refers to the need for fair and equitable treatment for affected rural landowners.

[39] Erin Anderssen. 2008. "The climatic costs of rapid growth", Shifting Sands, Part IV, *Globe and Mail,* February 1.

[40] Alberta Environment. 2007. *Overview: Land in the Industrial Heartland,* p. 2, environment.alberta.ca/documents/ Land_Overview_Oct_16_07.pdf.

[41] County of Strathcona. 2008. *AIHA Municipal Orientation*. January 10, slide 14, www.industrialheartland.com/pdf/RealtorUpdate-Jan10-08/Strathcona-AIHA-Jan10.pdf.

[42] Alberta Environment. 2007. *Overview: Land in the Industrial Heartland,* p. 2, environment.alberta.ca/documents/Land_Overview_Oct_16_07.pdf See also, *Cumulative Effects in the Industrial Heartland,* slide 15, www.energy.gov.ab.ca/Petrochemical/pdfs/IH_Global_Presentation_Oct_18_2007_HUTF.pdf.

[43] Maschmeyer, D., and B. Eastwoood. "Sulphur glut poses storage nightmare", *Edmonton Journal,* May 7, 2007.

[44] Alberta Wilderness Association. 2007. "Two Natural Areas Down – How Many More to Go?", *Wildlands Advocate,* 15(3), June, issues.albertawilderness.ca/PL/archive/AR0706PL3.pdf

[45] Shell Canada. 2007. *Application for Scotford Upgrader 2. Environmental Impact Assessment,* Section 18: Wildlife, p. 18-13, www.shell.com/static/ca-en/downloads/about_shell/what_we_do/oil_sands/aosp/shell_web_pdfs/eia_vol2b/document/aosp_vol2_sec_18b.pdf.

[46] Government of Alberta. 2007. *Alberta's Environmental Plan to Deal with the Cumulative Effects of Development,* p. 2, environment.alberta.ca/documents/CEM_Environmental_Plan.pdf See also October 2, news release: *Alberta rolls out new environmental strategy to protect air, land and water,* alberta.ca/home/NewsFrame.cfm?ReleaseID=/acn/200710/222176124AD64-E75E-2FFB-6DF1F0D2D55B2075.html.

[47] Alberta Environment. 2007. *Overview: Land in the Industrial Heartland,* p. 1, environment.alberta.ca/documents/Land_Overview_Oct_16_07.pdf

[48] Alberta Environment. 2007. *Provincial Wetland Restoration/Compensation Guide,* www.environment.alberta.ca/documents/Provincial_Wetland_Restoration_Compensation_Guide_Feb_2007.pdf.

[49] Fietshans, Theodore. 2003. "Meshing Regulatory and Compensatory Approaches in the Preservation of Farmland", in *Compensating Landowners for Conserving Agricultural Land: Papers from a California Conference,* edited by Nora De Coir, Alvin Sokolow and Jeff Woled, p. 40, aic.ucdavis.edu/research1/Conserv.ag.pdf#page=42.

[50] Government of Alberta. 2008. Municipal *Government Act, Capital Region Board Regulation,* section 11.

[51] Alberta Municipal Affairs. 2008.*Capital Region board chair to lead long-range planning,* media release, March 19, alberta.ca/acn/200803/23193C7C60765-B6E0-D151-0805A88735B101CB.html.

Long-range Capital Region Planning, Cooperation Gets Underway, media release, April 15, www.alberta.ca/acn/200804/2332053872D91-CAEB-D235-A9E31D09CE32A46A.html.

[52] Concerns about air quality have been confirmed in public surveys conducted by the Fort Air Partnership (a voluntary multi-stakeholder partnership focused on the airshed around the Upgrader Alley region) and by the City of Fort Saskatchewan and Dow Chemical Canada. Fort Air Partnership. 2005. *Fort Air Partnership Business Plan 2005-2007,* p.1 www.fortair.org/FortAir_businessplan_2005-2007.pdf.

[53] Nitrogen oxides are produced by a range of combustion processes, including those used in industrial facilities (such as gas turbines) and vehicles.

[54] Volatile organic compounds are carbon-based molecules that may be bonded to other elements and easily form vapours at normal temperatures and pressures. Volatile organic compounds are found, for example, in fuels (including natural gas combustion), solvents, paints and adhesives. Natural sources include forests and swamps. See Fort Air Partnership. *What We Monitor,* www.fortair.org/what_we_monitor.php.

[55] Fort Air Partnership. www.fortair.org/ Eight stations make continuous measurements of various pollutants, which provide detailed information on air quality, and there are also passive samplers for nitrogen oxides, sulphur dioxide, hydrogen sulphide and ground-level ozone, from which data is collected on a monthly basis. See *How We Monitor* at www.fortair.org/how_we_monitor.php.

[56] Clean Air Strategic Alliance. Data Warehouse. Air *Quality Index Summary Reports for 2006,* www.casadata.org/airqualityindex/AQI.asp.

[57] Waller, Lori T., 2007. "Passing Out in Upgrader Alley", *The Dominion,* October 20, www.dominionpaper.ca/articles/1437.

[58] For example, in 2007, the hydrogen sulphide levels at the Scotford 2 station exceeded the hourly Alberta Ambient Air Quality Objective 10 times and the daily value for one day; the sulphur dioxide levels at the Redwater station exceeded the hourly objective 12 times and the daily value on one day. See www.casahome.org/?page_id=223.

[59] Eight upgraders have been announced. As mentioned in an earlier endnote; there has not yet been a formal announcement of the Suncor upgrader, although land has been acquired and an announcement is expected in 2008.

[60] Total E&P Canada Ltd. 2007. *Integrated Application for the Total Upgrader, Volume 2: Environmental Impact Assessment.* Section 3: Air, pp. 3-27.

[61] Total E&P Canada Ltd. 2007. *Integrated Application for the Total Upgrader, Volume 2: Environmental Impact Assessment.* Section 3: Air, Tables 3A-9 and 3A-12. In Table 3A-9 the emissions for the BA Energy and North West Upgraders are deducted from the Sub-Total FAP to give the base case, since those upgraders are not yet operating. For the planned development case, the figures are for "Sub-total FAP Industrial", as given in Table 3A-12. Data from the Total E&P Canada Ltd. Application is cited as this has the most recent data.

[62] Alberta Environment. 2007. *Alberta Ambient Air Quality Objectives,* environment.gov.ab.ca/info/library/5726.pdf In this report, the Alberta Ambient Air Quality Objective is referred to as "the air quality objective."

[63] Total E&P Canada Ltd. 2007. *Integrated Application for the Total Upgrader, Volume 2: Environmental Impact Assessment.* Section 3: Air, p. 3-39 and Figure 3.8-3.

[64] Total E&P Canada Ltd. 2007. *Integrated Application for the Total Upgrader, Volume 2: Environmental Impact Assessment.* Section 3: Air, p. 3-46 and Figure 3.8-6.

[65] Energy Resources Conservation Board. 2007. *Decision 207-058: North West Upgrading Inc. Application to Construct and Operate an Oil Sands Upgrader in Sturgeon County,* p. 25, www.ercb.ca/docs/documents/decisions/2007/2007-058.pdf.

[66] Total E&P Canada Ltd. 2007. *Integrated Application for the Total Upgrader, Volume 2: Environmental Impact Assessment.* Section 3: Air, Table 3.8-24.

[67] Total E&P Canada Ltd. 2007. *Integrated Application for the Total Upgrader, Volume 2: Environmental Impact Assessment.* Section 14: Human Health and Odour Assessment, Tables 14.9-1, 14.9-3 and 14.9-4.

[68] Total E&P Canada Ltd. 2007. *Integrated Application for the Total Upgrader, Volume 2: Environmental Impact Assessment.* Section 14: Human Health and Odour Assessment, p.14-88.

[69] Total E&P Canada Ltd. 2007. *Integrated Application for the Total Upgrader, Volume 2: Environmental Impact Assessment.* Section 3: Air, Figure 3.8-16.

[70] Total E&P Canada Ltd. 2007. *Integrated Application for the Total Upgrader, Volume 2: Environmental Impact Assessment.* Section 3: Air, p. 3-80 and Figure 3.8-21.

[71] "The future maximum ozone concentrations are predicted to be in the 107 to 137 μg/m3 (55 to 70 ppb) range. In comparison, the CWS is 127 $\mu g/m^3$." Total E&P Canada Ltd. 2007. *Integrated Application for the Total Upgrader, Volume 2: Environmental Impact Assessment.* Section 3: Air, p. 3-93.

[72] Energy Resources Conservation Board. 2007. *Decision 207-058: North West Upgrading Inc. Application to Construct and Operate an Oil Sands Upgrader in Sturgeon County,* p. 23, www.ercb.ca/docs/documents/decisions/2007/2007-058.pdf.

[73] Environment Canada. 2006. *Fort Saskatchewan VOC Monitoring Study: Final Report,* p. 32, www.fortair.org/file/VOC%20Final%20Report_finalR%20-%20Fort%20Sask-Sept%202006.pdf The Environment Canada data was collected for 24 hours every 6th day, so did not give hourly levels which could have been compared with Environment Canada or Alberta Environment's one-hour guidelines. There were 24 elevated 24-hour concentrations which exceeded the Ontario Ambient Air Quality Criteria. The majority of the sites sampled had volatile organic compound levels lower than other National Air Pollution Surveillance sites in Canada.

[74] Englot, Curtis. 2006. "Ambient VOC Monitoring in Fort Saskatchewan and the Potential Impact of Fugitive VOC Emissions" in *VOC Fugitive Losses: New Monitors, Emission Losses and Potential Policy Gaps.* 2006 International Workshop. US Environmental Protection Agency, www.epa.gov/ttn/chief/efpac/documents/ wrkshop_fugvocemissions.pdf There were six sampling stations, including one in Elk Island National Park.

[75] Blake, Donald R. 2007. *Air Sampling in North-Central Alberta,* Submission to the Energy and Utilities Board (now Energy Resources Conservation Board) on behalf of Northeast Sturgeon County Industrial Landowners and Citizens for Responsible Development, for public hearing on North West Upgrading Inc. application, April 2007. This study collected 70 whole air samples on public land in Upgrader Alley, at approximately 1 km intervals, on one Saturday morning. The analysis for methane, carbon monoxide and a range of non-methane hydrocarbons and alkyl nitrates, was conducted by an accredited laboratory at the University of California-Irvine. Some measurements were five times higher than comparable data in Texas (p. 6). The level of volatile organic compounds was almost always higher than for comparable data from New York City and, ethane, propane and butane were higher than for the averages for 43 cities in China (p. 13 and 14). However, these cities may have higher levels of other pollutants which were not compared.

[76] Blake, Donald R. 2007. *Air Sampling in North-Central Alberta,* Submission to Energy and Utilities Board public hearing on North West Upgrading Inc. application, April 2007, p. 18.

[77] DIAL refers to Differential Absorption Light Detection and Ranging. For a summary see Chambers, Allan and Mel Strosher. 2006. *Refinery Demonstration of Optical Technologies for Measurement of Fugitive Emissions and for Leak Detection,* Report prepared for Environment Canada, Ontario Ministry of the Environment and Alberta Environment, www.arc.ab.ca/documents/Dial%20Final%20Report.pdf.

The benzene emissions were "significantly higher" than emissions reported to the National Pollutants Release Inventory (though emissions from storage tanks vary with wind speed and other factors). The measured methane emissions were "about nine times the estimate of total methane emissions from all sources as reported by the refinery, with the exception of flare emissions which were not included in the estimated or measured emissions." (p.19) To give an idea of the order of magnitude of the total losses, "Based on DIAL measurements, fugitive emissions losses of methane and C_{2+} hydrocarbons from the refinery surveyed represent lost revenue in the order of $3.2 million per year (assuming a product value of $40/bbl)." (p. 26).

[78] Total E&P Canada Ltd., for example, has indicated that the company intends to implement a fugitive emission leak detection and repair program as part of its greenhouse gas management program. Total E&P Canada Ltd. 2007. *Integrated Application for the Total Upgrader. Volume 1. Project Description.* Section 6.4.6.

[79] Commission for Environmental Cooperation. 2005. *Taking Stock: 2002 North American Pollutant Releases and Transfers,* Overview, p. xxxiv.

[80] Source: www.acidrain.org/pages/acidEutrophications/sub3_1.asp.

[81] 2004 Canadian Acid Deposition Science Assessment: Summary of Key Results, Environment Canada, p. 10, 11.

[82] Source: www.acidrain.org/pages/acidEutrophications/sub3_2.asp.

[83] Source: www.acidrain.org/pages/acidEutrophications/sub3_1.asp.

[84] Source: www.ec.gc.ca/acidrain/acidair.html.

[85] Commission for Environmental Cooperation. 2005. *Taking Stock: 2002 North American Pollutant Releases and Transfers,* Overview, p. xxxvii.

[86] Source: www.ec.gc.ca/acidrain/acidair.html.

[87] Canadian Council of Ministers of the Environment. 2000. *Canada-Wide Standard for Benzene Phase 1.*

[88] Source: www.acidrain.org/pages/acidEutrophications/sub3_1.asp.

[89] Woynillowicz, Dan, Chris Severson-Baker and Marlo Raynolds. 2005. *Oil Sands Fever: the Environmental Implications of Canada's Oil Sands Rush,* The Pembina Institute, p. 45.

[90] Alberta Environment. 2007. *Alberta Ambient Air Quality Objectives,* p.1, environment.gov.ab.ca/info/library/5726.pdf.

[91] Total E&P Canada Ltd.. 2007. *Integrated Application for the Total Upgrader, Volume 2: Environmental Impact Assessment.* Section 3: Air, p. 3-46 and Figure 3.8-6.

[92] Alberta Environment. 2007. *Alberta Ambient Air Quality Objectives,* environment.gov.ab.ca/info/library/5726.pdf.

[93] $\mu g/m^3$ is the weight in microns, of the substance in one cubic metre of air.

[94] World Health Organization. 2005. *WHO Air Quality Guidelines Global Update 2005,* Report on a Working Group Meeting, Bonn, Germany, 18-20 October 2005, www.euro.who.int/Document/E87950.pdf p. 1, "The WHO air quality guidelines are designed to offer guidance in reducing the health effects of air pollution based on expert evaluation of current scientific evidence." The WHO also proposes interim targets. See WHO. 2006. *Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide: Global update 2005 - Summary of risk assessment,* whqlibdoc.who.int/hq/2006/WHO_SDE_PHE_OEH_06.02_eng.pdf.

[95] Alberta Environment. *Particulate matter and ozone,* www3.gov.ab.ca/env/protenf/standards/cws_participation/pm.html. Achievement is based on the fourth-highest value for a year, averaged over three consecutive years. Canada-Wide Standards for Particulate Matter (PM) and Ozone, 2000. www.ccme.ca/assets/pdf/pmozone_standard_e.pdf The value of 127 $\mu g/m^3$ is equivalent to 65 ppb.

[96] The 24-hour Planning Trigger for $PM_{2.5}$ is 20 $\mu g/m^3$ and the Surveillance Trigger is 15 $\mu g/m^3$.

[97] V.M. Goodwin Research and Consulting Ltd. 2007. *Critical Review of the North West Upgrading Inc. Application for a Bitumen Upgrader,* Section S. Alberta's Ambient Air Quality Objectives – Are They Health-Based? p. 46-47. Goodwin compared the AAAQO for benzene and four other selected substances that are emitted into the air in the Industrial Heartland Airshed, with Health Based Exposure Limits.

[98] World Health Organization. 2000. *Air Quality Guidelines.* Second edition. Chapter 5.2 Benzene, p. 12, www.euro.who.int/document/aiq/5_2benzene.pdf.

[99] Total E&P Canada Ltd. 2007. *Integrated Application for the Total Upgrader, Volume 2: Environmental Impact Assessment,* Section 14: Human Health and Odour Assessment, p. 14-67.

[100] World Health Organization. 2000. *Air Quality Guidelines.* Second edition. Chapter 6.6 Hydrogen Sulfide, p. 6, www.euro.who.int/document/a0iq/6_6hydrogensulfide.pdf. The WHO 24-hour average for H_2S of 0.15 mg/m^3 (equivalent to 150$\mu g/m^3$) is based on eye irritation. See also Earthworks. Undated. *Hydrogen Sulfide,* on web site at www.earthworksaction.org/hydrogensulfide.cfm.

[101] Elsinger, M, E. Burrell, N. DeBruyn, K. Tanasichuk, and K. Timoney. 2006. "The Influence of Air Pollution on Corticolous Lichens near the Strathcona Industrial Area, Alberta". *The Canadian Field Naturalist* 121 (1), p. 17-23.

[102] Gerein, Keith. 2007. "Air quality study convinces ecologist it's time to move," *Edmonton Journal,* August 9, 2007. Kevin Timoney supervised the study of lichens in Strathcona County.

[103] Alberta Environment. 2007. *Overview: Land in the Industrial Heartland,* p. 2, environment.alberta.ca/documents/Land_Overview_Oct_16_07.pdf.

[104] Soil sensitivity reports for a wider region are being prepared but the information on soils has not yet been compared with the areas subject to critical loading. Alberta Environment, personal communication, March 11, 2008.

[105] Energy Resources Conservation Board. 2007. *Decision 2007-058: North West Upgrading Inc. Application to Construct and Operate an Oil Sands Upgrader in Sturgeon County,* p. 25, www.ercb.ca/docs/documents/decisions/2007/2007-058.pdf.

[106] Alberta Environment. 2007. *Air Emissions Issues in the Industrial Heartland,* p. 2, environment.alberta.ca/documents/Air_Overview_Nov_9_07.pdf.

[107] Alberta Environment. 2007. *Air Emissions Issues in the Industrial Heartland,* p. 3, environment.alberta.ca/documents/Air_Overview_Nov_9_07.pdf.

[108] Alberta Environment. 2007. *Air Emissions Issues in the Industrial Heartland,* p. 2, environment.alberta.ca/documents/Air_Overview_Nov_9_07.pdf.

[109] The information for the greenhouse gas production is derived from individual company environmental impact assessments. The information is for direct emissions associated with operations, as not all assessments identify the greenhouse gas emissions associated with purchased electricity.

[110] This is based on the expected GHG emissions from the eight upgraders in Figure 10. The estimated production of greenhouse gases from the upgraders assumes they are all operating at full capacity, which will not occur until some time later than 2015. In 2015, it is expected that Alberta's total greenhouse gas emissions will be 254 megatonnes a year (Total E&P Canada Ltd. 2007. *Application, EIA* Vol. 2, p.3-99, Table 3.8-25 and North American Oil Sands Corporation Application, Volume 1, p. 88-89). Note that the values are estimates; they may change, depending on whether a company undertakes gasification of the coke, which is a by-product of the upgrading process, to create hydrogen for upgrading and perhaps also synthetic gas, which can be used to generate electricity. For example, if North American Oil Sands Corporation does not adopt gasification, their CO_2 emissions would be 3.7 million tonnes/year, instead of 7.9 million tonnes/year. The company has stated that if they do gasify coke they will also include a carbon capture process, to avoid emissions of CO_2 to the atmosphere. See the NAOSC Application, 2007, Vol. 1, p. 21.

[111] Total E&P Canada Ltd. 2007. *Integrated Application for the Total Upgrader, Volume 2: Environmental Impact Assessment.* Section 3: Air, gives Canadian greenhouse gas emissions in 2015 as 718 megatonne CO_2 equivalent. See also Alberta Environment. Undated; 2006 or later. *Albertans and Climate Change: Facts About Climate Change,* p. 7, www3.gov.ab.ca/env/climate/docs/Fact_Book.pdf.

[112] Each upgrader will purchase a different amount of electricity, depending on their operations. The greenhouse gases from purchased electricity may increase the total greenhouse gases by approximately 25% to 32%. See, for example, Synenco. 2006. *Northern Lights Upgrader Project Application,* Part B, Table B.8.2.1-2, p.101. Indirect emissions from the purchase of 261 MW of electricity are 1.45 megatonnes CO_2equivalent per year, compared with 5.84 megatonnes from the upgrader operations.

See also, Shell Canada. 2007. *Application for Scotford Upgrader 2. Environmental Impact Assessment,* Section 5: Air, Table 5-28 p. 5-86, which shows that indirect emissions from purchased electricity are 2.84 megatonnes CO_2 equivalent per year, compared with 8.89 megatonnes from the upgrader operations, www.shell.com/static/ca-en/downloads/about_shell/what_we_do/oil_sands/aosp/shell_web_pdfs/eia_vol2b/document/aosp_vol2_sec_18b.pdf

[113] Environment Canada. 2008. *Turning the Corner: Detailed Emissions and Economic Modelling,* March 10. Section 2.2.2, p. 8, www.ec.gc.ca/doc/virage-corner/2008-03/pdf/571_eng.pdf.

[114] Environment Canada. 2008. *Turning the Corner: Regulatory Framework for Industrial Greenhouse Gas Emissions,* March 10. *S*ection 4.6, p.10, www.ec.gc.ca/doc/virage-corner/2008-03/pdf/541_eng.pdf.

[115] Gunter, Bill and Todd Cole. 2008. *The Redwater Carbon Dioxide (CO_2) Capture and Geological Storage Pilot Project* at www.industrialheartland.com/pdf/luncheon1-30-08/Redwater%20CO2%20Information.pdf. Information provided at Alberta's Industrial Heartland Annual Luncheon, January 30th.

See also: Rick Chalaturnyk, 2008. *Carbon Capture and the Geologic Storage of CO_2,* www.industrialheartland.com/pdf/luncheon1-30-08/CarbonCapture_StorageCO2.pdf.

A study conducted for the Petroleum Technology Alliance (PTAC) and the Alberta Energy Research Institute has indicated that "significant volumes of CO2 could be aggregated in the Fort Saskatchewan area." PTAC web site, 2008, undated. www.ptac.org/about/dl/press0801.pdf The study will not be released to the public until July 1, 2009.

[116] North West Upgrading Inc. 2007. *North West Upgrading Announces CO_2 Supply Agreement with Enhance Energy.* Media release, September 27, www.northwestupgrading.com/upload/news_item/26/02/final_nw_upgrading_c02_release_-_sept_27_07.pdf.

[117] These figures are based on data from the individual companies and are more recent that information included in North Saskatchewan Watershed Alliance. 2007. *Current and Future Water Use in the North Saskatchewan River Basin.* Prepared by AMEC Earth and Environmental, Tables 10-20 and 11-18.

[118] EPCOR Greater Edmonton Region. The region has a population of about one million people and the water for household use supplies approximately 200,000 residential and multi-family dwellings, www.epcor.ca/Communities/Alberta/Operations/Water+Treatment+Plants/Edmonton.

[119] EPCOR, personal communication, May 23 2007, indicated that about 90% of treated municipal water flows back to the North Saskatchewan River after passing through the wastewater treatment system, with the proportion being somewhat lower during drought periods when more people water their lawns etc. A 2007 publication, written by AMEC Earth and Environmental for the North Saskatchewan Watershed Alliance, estimates the water use at about four or five percent of the water supplied (see *Current and Future Water Use in the North Saskatchewan River Basin,* Table 2-2 and p. 2-4 and 2-5, www.nswa.ab.ca/pdfs/WUD-Chapter_2_Methodology.pdf) If one takes a median figure and assumes that 93% of the water is consumed, the City permanently removes 7% of 130 million m^3/year or about 9 million m^3/year. The proportion of water that is discharged back to the river is likely to fall as more municipal wastewater is diverted after treatment for industrial use.

[120] The figure of 84% is derived from data for withdrawals and returns in Synenco. 2006. *Surface Water Assessment for Northern Lights Upgrader Project,* Consultant Report 8, Surface Water Assessment, Table 2.3, p. 2.4, prepared by Stantec.

[121] The consumptive use for other licensed users 2006 is taken from Synenco's *Northern Lights Upgrader Project Application,* Consultant Report 8, Surface Water Assessment, Table 2.3, which lists all facilities between Edmonton and the Saskatchewan border. The eight upgrading facilities are those in Table 5 in this Pembina report and the other major licensees are those listed in the Synenco table. The figure for "Other licensed users, 2010-2020" is derived from data used for Figure 12 in this Pembina report, which shows data for the two-sub-basins in which the upgraders are located. The total consumptive water use minus the use for water for upgraders, is expected to increase by 30% between 2005 and 2020 in those 2 sub-basins. The North Saskatchewan River also flows through one more sub-basin (the Frog) before reaching the Saskatchewan border, but total water use in 2005 was only 7.6 million m^3 and use was expected to grow by only 5% by 2025. See p. 13-36 in North Saskatchewan Watershed Alliance. 2007. *Current and Future Water Use in the North Saskatchewan River Basin,* prepared by AMEC Earth and Environmental, www.nswa.ab.ca/, which is described in the endnote to Figure 12 in this Pembina report.

[122] Rosenberg International Forum on Water Policy. 2007. *Report of the Rosenberg International Forum on Water Policy to the Ministry of Environment, Province of Alberta,* p. 11, rosenberg.ucanr.org/documents/ RegRoseAlbertaFinalRpt.pdf For information on the Rosenberg International Water Forum on Water Policy see rosenberg.ucanr.org/index.html.

[123] Synenco. 2006. *Surface Water Assessment for Northern Lights Upgrader Project,* Consultant Report 8, Surface Water Assessment, Table 2.3, p. 2.4.

[124] North West Upgrading initially proposed using 7.45 million m^3/year of water for phases 1, 2 and 3. *North West Upgrader Project Application, Supplemental Information Report,* AENV SIR2, p. 55, February 26, 2007. Reduction in volume confirmed by the company in personal communication, June 5, 2007.

[125] Government of Alberta. 2006. *Investing in our Future: Responding to the Rapid Growth of Oil Sands Development — Final Report,* Issue 11, p. 133, www.alberta.ca/home/395.cfm.

[126] Government of Alberta. 2006. *Investing in our Future: Responding to the Rapid Growth of Oil Sands Development — Final Report,* Recommendation 11(b), p.134, www.alberta.ca/home/395.cfm.

[127] North Saskatchewan Watershed Alliance. 2007. *Current and Future Water Use in the North Saskatchewan River Basin.* Prepared by AMEC Earth and Environmental, www.nswa.ab.ca/ This report has more detail than a province-wide report. Alberta Environment. 2007. *Current and Future Water Use in Alberta,* www.waterforlife.gov.ab.ca/ watershed/current-future_water_use.html This report was also prepared by AMEC Earth and Environmental.

[128] Alberta Environment. 2007. *Information synthesis and initial assessment of the status and health of aquatic ecosystems in Alberta: surface water quality, sediment quality and non-fish biota.* Prepared by North/South Consultants Inc. www.waterforlife.gov.ab.ca/watershed/information_synthesis.html.

[129] Alberta Environment. 2007. *The Water Management Framework for the Industrial Heartland and Capital Region, Appendix D,* p. 30, environment.gov.ab.ca/info/library/7864.pdf.

[130] Alberta Environment. 2007. *The Water Management Framework for the Industrial Heartland and Capital Region,* Appendix D, p. 31, environment.gov.ab.ca/info/library/7864.pdf.

[131] Not only do the withdrawals vary along the river, but so do the flows. The flows increase as the river flows downstream, from 6.7 billion cubic metres a year, on average, at Edmonton, to 7.3 billion cubic metres a year at the Saskatchewan border. North Saskatchewan Watershed Alliance, personal communication May 5, 2008. Alberta Environment points out that the system as a whole needs to be looked at, with consideration of localized reach-specific impacts. Personal communication, May 9, 2008.

[132] Definition taken from Synenco. 2006. *Northern Lights Upgrader Project Application*. Consultant Report #8 Surface Water Assessment by Stantec, p. 2.2. The 7Q10 flow is 65 cubic metres per second, compared with an annual media flow of 185 cubic metres per second (Stantec report p. 3.3).

[133] Under future projects, the table includes Alberta Oil Sands Bitumen Blending Facility, in addition to the upgraders. However, the expansion of the Scotford Upgrader #1 is included under current projects, even though the expansion is not yet operating.

[134] These values are calculated from the total for withdrawals in Table 6, column 2. The data in Table 6, taken from the Total E&P Canada Ltd. *Integrated Application for Approval of the Total Upgrader,* 2007, differs somewhat from the information taken from the Synenco EIA, which uses different boundaries for its regional study area. Synenco. 2006. *Northern Lights Upgrader Project Application*. Consultant Report #8 Surface Water Assessment by Stantec, gives data downstream of Edmonton as far as Saskatchewan border. Current and proposed projects downstream of Edmonton are approximately 728 million m^3/year or 60 million m^3/month (based on information on upgraders, Sherritt Phase 1 and the Provident salt caverns).

[135] Sherritt. *Dodds-Roundhill Coal Gasification Project Community Newsletter.* January 2008, p. 4, www.sherritt.com/doc08/files/coal/dodds/January_Newsletter_2008.pdf.

[136] EPCOR proposes piping this water from the Gold Bar Wastewater Treatment Plant in Edmonton. As indicated earlier, this is preferable to removing water directly from the river, but will still reduce the overall river flows. www.sherritt.com/doc08/files/coal/dodds/Posters_-_Open_Houses_Dec_4-5.pdf December 2007 Open House Posters.

[137] Total E&P Canada Ltd. Ltd. 2006. *Integrated Application for Approval of the Total Upgrader,* Volume 2, Table 8.9-5, with modifications for existing and future upgrader projects. The total values in this table for many projects are taken from the Total E&P Canada Ltd. EIA, except that all licensed withdrawals of less than 2.5 million m^3/year are combined. In addition, the values for upgraders (existing and future) are derived from data supplied by individual companies to the Pembina Institute, as indicated in Table 5, above. The companies in the upper part of the table are listed in approximate order of their intakes, starting from the centre of Edmonton, except that data is aggregated under the name of the licence-holder where there is more than one intake.

[138] Alberta Environment. 2007. *Current and Future Water Use in Alberta,* p. 356. Report prepared by AMEC Earth and Environmental.

[139] North Saskatchewan Watershed Alliance. 2007. *Current and Future Water Use in the North Saskatchewan River Basin.* Prepared by AMEC Earth and Environmental. 85% of the increase in water use is for the petroleum category. See Figure 12 for further details on the data.

[140] Note that these sub-basins are downstream of Edmonton and do not include the water withdrawals in Edmonton.

[141] North Saskatchewan Watershed Alliance. 2007. *Current and Future Water Use in the North Saskatchewan River Basin.* Prepared by AMEC Earth and Environmental. Data is for the Beaverhill and White Earth sub-basins, p. 10-

28, 10-29, 10-45, 11-26, 11-35. The line depicting "Upgraders, etc." refers to Alberta Environment's petroleum sub-group, which also includes allocations for gas plants and oilfield injection, but upgraders account for almost all the water in this category in these sub-basins. This is shown by a cross-check with Alberta Environment's Report, *Current and Future Water Use in Alberta,* p. 355. Table 9-24 shows the forecast water use by upgraders. The mid-scenario values range from 23,500 million m^3 in 2005 to 101,400 in 2015 (and then constant until 2025). This mid-growth scenario includes 2.4 million litres for the Sherritt Dodds-Roundhill Coal Gasification Project. The high-case scenario shows total surface water requirements for upgraders of 108,500 m^3 from 2015 onwards. The report thus shows figures in the same order of magnitude as in Figure 11, above, but the time when new facilities are expected to require water is slightly different. The Alberta Environment report assumes five new upgraders, and does not include water use for the Total Upgrader (see p. 354, Table 9-23) which is included in the NSWA publication.

[142] Alberta Environment. 2007. *The Water Management Framework for the Industrial Heartland and Capital Region,* p. 12, environment.gov.ab.ca/info/library/7864.pdf.

[143] TransAlta, personal communication, August 27, 2007.

[144] Cited by Angela Brunschot in "Upgrader Suckage", *SEE Magazine,* April 3, 2008, p. 7.

[145] Synenco. 2006. *Northern Lights Upgrader Project Application*. Consultant Report #8 Surface Water Assessment by Stantec, p. Table 2.1, p. 2.2.

[146] Synenco. 2006. *Northern Lights Upgrader Project Application*. Consultant Report #8 Surface Water Assessment by Stantec, Table 2.1, p.2.2, gives the median flow for July as 294 million m^3/month but only 65 for November in low-flow periods (defined as the 7Q10 flow).

[147] Alberta Environment. 2004. *Trends in Historic Annual Flows for Major Rivers in Alberta,* p. 9-10. For the period 1912 to 2001, the North Saskatchewan River exhibits a statistically significant negative trend (i.e. decline in flows) at the 95% level. The report states that it is uncertain if the decline is due to a natural decline in flows or to withdrawals.

[148] D.W. Schindler and W.F. Donahue, "An impending water crisis in Canada's western prairie provinces". The National Academy of Sciences, *Proceedings of the National Academy of Sciences,* May 9, 2006, vol. 103, no. 19, p. 7210-7216.

[149] Alberta Environment. 2007. *State of the Environment Report, Water Quality,* www3.gov.ab.ca/env/soe/water_indicators/20_RWQI.html The bacterial levels were fair at Devon and only marginal at Pakan; the nutrient levels were fair at both locations. These reflect discharges from agricultural land, storm sewers and municipal sewage treatment operations.

[150] Petro-Canada/Forthills Energy Ltd. 2006. *Application for Approval of the Sturgeon Upgrader*, Volume 1, Project Description, Appendix E, p. E-13 and Volume 2: Environmental and Socio-economic Impact Assessment, p. 13-10. The predicted effect of point source discharges into the North Saskatchewan River can be seen in Figures 13-8 to 13-11 in Volume 2. The phosphorus concentration at Pakan is in the "red" zone and nitrogen levels are in the "yellow" zone. Alberta Environment. 2007. *The Water Management Framework for the Industrial Heartland and Capital Region,* p. 36, environment.gov.ab.ca/info/library/7864.pdf.

[151] Synenco. 2006. *Northern Lights Upgrader Project Application*. Consultant Report #8 by Stantec, p. 2.12.

[152] "If near-instantaneous dispersal of the effluent occurs, then guidelines would be applicable near the end-of- pipe. Otherwise, a defined mixing zone might be established and water quality guidelines should be met at the edge of the defined mixing zone." Alberta Environment. 1999. *Surface Water Quality Guidelines for Use in Alberta,* p. 2, environment.gov.ab.ca/info/library/5713.pdf.

[153] Petro-Canada/Forthills Energy Ltd. 2006. *Application for Approval of the Sturgeon Upgrader*, Volume 2: Environmental and Socio-economic Impact Assessment, p. 13-35.

[154] Alberta Environment. 2005. *Analysis of Water Quality Trends for the Long Term River Network: North Saskatchewan River, 1977-2002.* See, for example, the graphs for potassium, sodium, chloride, dissolved organic carbon. www3.gov.ab.ca/env/water/swq/assets/Analysis_of_Water_Quality_Trends.pdf.

[155] North West Upgrading 2006. *North West Upgrader Project Application*. Consultant Report #7 Surface Water Assessment by Stantec, p. 4.5.

[156] Petro-Canada/Forthills Energy Ltd. 2006. *Application for Approval of the Sturgeon Upgrader*, Volume 2, Environmental and Socio-economic Impact Assessment, p. 14–30 and 14–31.

[157] Petro-Canada/Forthills Energy Ltd. 2006. *Application for Approval of the Sturgeon Upgrader*, Volume 2, Environmental and Socio-economic Impact Assessment, p. 13–47.

[158] Alberta Environment. 2007. *The Water Management Framework for the Industrial Heartland and Capital Region,* p. 7, environment.gov.ab.ca/info/library/7864.pdf.

[159] The "regulated" flow differs from the natural flow, since it is altered by the dams upstream.

[160] Alberta Environment. 2007. *The Water Management Framework for the Industrial Heartland and Capital Region,* Appendix D, p. 35, environment.gov.ab.ca/info/library/7864.pdf.

[161] Synenco. 2006. *Northern Lights Upgrader Project Application*. Consultant Report #8 Surface Water Assessment by Stantec, p. 2.2, Table 2.1. The actual monthly 7Q10 flows in the Stantec table are slightly lower than the weekly values given for the Alberta Environment targets for the red zone.

[162] The 7Q10 under natural flow conditions in the river is about 16 m^3/s, but during the past 35 years of regulated flow the 7Q10 is about 56 m^3/s. Alberta Environment, personal communication, May 9, 2008.

[163] North Saskatchewan Watershed Alliance. 2007. *North Saskatchewan River Instream Flow Needs Scoping Study,* nswa.ab.ca/publications_IN.html This preliminary study, prepared by Golder Associates Ltd., reviews potential methods and data sources for determining instream flow needs to maintain the integrity of the aquatic ecosystems within the North Saskatchewan River Basin.

[164] While Alberta Environment has the ultimate responsibility for managing surface and groundwater in Alberta, various other bodies are engaged in managing the river. The North Saskatchewan Watershed Alliance (NSWA) is a multi-stakeholder body, that includes representatives from government, industry and the public.

[165] This description is based on information in Alberta Environment and Fisheries and Oceans Canada. 2007. *Water Management Framework: Instream Flow Needs and Water Management System for the Lower Athabasca,* Appendix 1, www.dfo-mpo.gc.ca/regions/central/pub/water-eau/pdf/water-eau_e.pdf.

[166] Alberta Environment. 2007. *The Water Management Framework for the Industrial Heartland and Capital Region,* p. 22, environment.gov.ab.ca/info/library/7864.pdf.

[167] City of Edmonton. 2007. Submission from the Office of the City Manager to the Alberta Water Council. Report 2007CMO058. See Susan Ruttan in Edmonton Journal, August 28, 2007.

[168] The Counties of Sturgeon and Strathcona commissioned a feasibility study which proposed a centralized water intake and treatment plant for the Industrial Heartland, which could maximize water recycling and potentially avoid any discharge of wastewater to the N. Saskatchewan River. Fanson, Brian. Morrison Hershfield Limited. 2007. *Alberta's Industrial Heartland Water Supply Feasability Study.* Presentation to the Canadian Institute conference on "Successful Produced Water Management in Oil and Gas," Calgary. November 8, 2007.

Wastewater suitable for treatment and reuse may come from industries, as well as municipal wastewater treatment plants. Another potential source is water produced from oil and gas well operations. In the Redwater area there are 50 sites were water is injected deep underground and in 2006 over 20 million m^3 of water was injected there. Petroleum Technology Alliance Canada. 2007. *Produced Water Beneficial Re-Use – High TDS Waters,* p. 11. This study was prepared for PTAC by Fossil Water, www.ptac.org/etalk/dl/HighTDS.pdf.

[169] The Petro-Canada refinery will also use a heat loop process to reduce the need for cooling water. In addition to refining, the facility will also upgrade about 30,000 m^3/year bitumen, but since it uses an integrated process, it is not possible to determine what proportion of the water is used for upgrading. Petro-Canada, personal communication, July 18, 2007.

[170] Petro-Canada. 2007. *Fort Hills Energy L.P.: Environmental Win-Win for the Sturgeon Upgrader.* News release, September 25. www.petro-canada.ca/en/media/1886.aspx?id=773541.

[171] The municipal wastewater treatment plant removes some metals, dissolved solids and phosphorus, but salts are still discharged to the North Saskatchewan River. Thus if the waste water is diverted for use in an upgrader, these salts are not immediately discharged to the river. Whether this is an overall benefit to the river depends on how the waste water from the upgraders, etc. is treated. If the wastes from water treatment are sent for deepwell disposal or to a landfill, the level of salts in the river will be less than if the wastewater were discharged from the waste treatment plant. However, it would require a mass balance to decide whether there are overall benefits from diverting and reusing municipal waste water.

[172] Alberta Environment. 2007. *The Water Management Framework for the Industrial Heartland and Capital Region,* p. 19, environment.gov.ab.ca/info/library/7864.pdf.

[173] Alberta Environment. 2007. *The Water Management Framework for the Industrial Heartland and Capital Region,* p. 19 and 21, environment.gov.ab.ca/info/library/7864.pdf.

[174] Alberta Environment. 2007. *The Water Management Framework for the Industrial Heartland and Capital Region,* p. 19 and 20, environment.gov.ab.ca/info/library/7864.pdf.

[175] Alberta Environment Industrial Heartland Cumulative Effects Project, personal communication, January 17, 2008.

[176] Rosenberg International Forum on Water Policy. 2007. *Report of the Rosenberg International Forum on Water Policy to the Ministry of Environment, Province of Alberta,* p. 10.

[177] Alberta Environment. 2007. *Current and Future Water Use in Alberta,* p. 355, Table 9-24, www.waterforlife.gov.ab.ca/watershed/current-future_water_use.html Prepared by AMEC Earth and Environmental. Total groundwater use was about 2% of water use for upgraders in 2005 and the volume is not expected to increase.

[178] Alberta Environment. 2007. *Cumulative Effects in the Industrial Heartland,* slides 12 and 15, www.energy.gov.ab.ca/Petrochemical/pdfs/IH_Global_Presentation_Oct_18_2007_HUTF.pdf.

[179] Alberta Environment. 2007. *Overview: Land in the Industrial Heartland,* p. 3, environment.alberta.ca/documents/ Land_Overview_Oct_16_07.pdf.

[180] Alberta Environment. 2007. *Overview: Land in the Industrial Heartland,* p. 2, environment.alberta.ca/documents/ Land_Overview_Oct_16_07.pdf. See also Danielson, Laurie. 2008. North East Capital Association, 2008 AIHA Municipal Orientation, January 10, slide 9, www.industrialheartland.com/pdf/RealtorUpdate-Jan10-08/NCIA-AIHA-Jan10.pdf.

[181] Alberta Environment. 2007. *Overview: Land in the Industrial Heartland,* p. 3, environment.alberta.ca/documents/ Land_Overview_Oct_16_07.pdf and Alberta Environment. 2007. *Provincial Wetland Restoration/Compensation Guide,* www3.gov.ab.ca/env/water/reports/Prov_Wetland_Rest_Comp_Guide.pdf.

[182] Kline and Company. 2007. *From Oil Sands to a World Class Eco-Industrial Chemical Cluster for Greater Edmonton,* www.energy.gov.ab.ca/Petrochemical/pdfs/Final_17_October_Overview_17_10_07_final.pdf See also other presentations on the Hydrocarbon Upgrading Task Force web site at www.energy.gov.ab.ca/ Petrochemical/844.asp.

[183] Area structure plans can be viewed at www.industrialheartland.com/pages/casp.html.

[184] Hydrocarbon Upgrading Task Force, Government of Alberta. 2007. *The Making of Three Energy Complexes—Integration at Work,* www.energy.gov.ab.ca/Petrochemical/pdfs/Nancy_Wu_Three_Energy_Complexes.pdf.

[185] Hydrocarbon Upgrading Task Force, Government of Alberta. 2007. *A Study of Environmental Benefits of Industrial Integration.* Presentation by AMEC Earth and Environmental, Edmonton Alberta, June 2007, www.energy.gov.ab.ca/Petrochemical/docs/HUTF_Final_AMEC_presentation_June_20_2007.pdf.

[186] Kline and Company. 2007. *From Oil Sands to a World Class Eco-Industrial Chemical Cluster for Greater Edmonton,* www.energy.gov.ab.ca/Petrochemical/pdfs/Final_17_October_Overview_17_10_07_final.pdf. See also other presentations on the Hydrocarbon Upgrading Task Force web site at www.energy.gov.ab.ca/ Petrochemical/844.asp.

[187] The Alberta Industrial Heartland Association has started looking at eco-industrial networking, which could help integrate some activities. Alberta's Industrial Heartland website; see Eco-Ind tab at www.industrialheartland.com/ pages/main.html.

[188] Alberta Municipal Affairs. 2007. *Working Together: Report of the Capital Region Integrated Growth Management Plan Project Team,* p. 1, municipalaffairs.alberta.ca/documents/Working_Together.pdf.

[189] Alberta Environment has indicated that "recent approvals have been issued with enabling clauses to ensure alignment with the results of air and water management frameworks as they come forward." Personal communication, May 9, 2008.