LIQUID ASSET

Could the oil sands, Canada's greatest economic project, come undone simply because no one thought about water?

Friday, March 28, 2008
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Here in Canada, we tend to think that while water scarcity, drying rivers and toxic lakes may be huge global problems, they really only affect places like China and the Middle East. But the rapid development of Alberta's oil sands, coupled with accelerating population growth and climate change, has turned arid Alberta into Canada's ground zero for water. Our history is all about exploiting our abundance of natural resources, and Alberta is the embodiment of the frontier's boundless promise. Could our tradition of taming the landscape finally have been arrested by something as humble as H20?

The water experts say yes. The Canadian dean of the discipline, the University of Alberta's David Schindler, wrote in 2006 that Alberta, along with Saskatchewan and Manitoba, will soon face "a crisis in water quantity and quality with far-reaching implications." Natural Resources Canada has predicted shortages for Calgary as early as 2050 if conservation efforts don't improve drastically. The federal government's 2007 report on the oil sands concluded that "the Athabasca basin could encounter serious problems unless there is a radical change in water use."

While the energy boom is bringing the issue to a head, Alberta's looming water crisis owes something to natural factors as well as human-made ones. Lying in the shadow of the Rocky Mountains, the province is one of the driest places in Canada, with but 2.2% of the nation's fresh water. It's also prone to long, bone-bleaching droughts. Both historical accounts and tree-ring studies show that European immigrants settled the province during the wettest century in the last 2,000 years. This data also suggests that the dust bowl of the Dirty Thirties was a minor event and that no European has ever seen the kind of 20-year droughts that have characterized Alberta's climate over the millenniums.

In addition, Alberta shares with the rest of the nation a geographic vulnerability. Most of its water is in the north while most of its people live in the south. Albertans are concentrated in

the South Saskatchewan River basin, where the city of Calgary, industry and irrigation drink lots of water. Yet the basin and its northern cousin, which drain into Hudson Bay, hold only 20% of the province's supply. Northern rivers such as the Athabasca and the Peace carry about 80% of the province's water into Canada's largest watershed, the Mackenzie River basin, which drains into the Arctic.

Unlike most of the country, however, Alberta has a regulatory system that allocates blue gold on a "first in time and first in right" basis. The system "is designed to deal with shortages," explains John Thompson, an Edmonton-based resource economist and water expert. During periods of scarcity, the rules are clear: Those who hold the oldest licences get the water; the newest ones, as Thompson puts it, must "stand back from the trough."

River basins, of course, need water for fish, birds and wetlands as well as for human uses. Prompted by declining river flows and fish kills, the province dramatically closed the South Saskatchewan River basin two years ago, ruling that no one can put more straws into the river.

The overallocation that led to the closure has been compounded by a paucity of data on surface water and groundwater. A 2008 report by the Alberta Water Council, a non-profit watchdog set up by the province, described "the availability, quality and accessibility of data" as a concern. The alert was echoed by the Petroleum Technology Alliance of Canada, a non-profit research group that regards water as "the environmental issue of the century." In a recent paper, the alliance concluded that "rapidly growing demands for water, where data is limited due to reduced government-supported data-gathering in the last 20 to 40 years, will drive and limit development."

Climate change has also begun to disrupt the province's water budget. A warmer and more extreme climate means less water when you need it most. (It can also mean too much water when you need it least.) Thanks to temperature increases of two to four degrees over the past 30 years, most Rocky Mountain glaciers have lost nearly a third of their mass, while snow packs, the source of most drinking water, have also shrunk. As a consequence, river flows in the summer have declined by 30% to 85%. Schindler predicts that a collision of population growth, drought and climate warming will soon teach "Albertans first-hand what water scarcity is all about." He thinks that rapid oil sands development may well be water's tipping point. While some in the industry agree, many others see shortfalls as another challenging opportunity that calls for technological fixes. "With the pressure on

water in northern Alberta, one thing is for sure," says John Robertson, a senior manager with CH2M Hill, the global engineering giant: The industry will have to spend "hundreds of millions in the next few years to treat and reuse water."

In the last 12 years, the world's most powerful oil companies, including Imperial Oil, Shell, ConocoPhillips, British Petroleum, Total and Norway's StatoilHydro, have all rushed to Fort McMurray to plunk down more than $150 billion in the oil sands. The frenzied pace of investment and construction in one of the globe's last proven oil reserves has created a national project even bigger than the transcontinental railway. The oil sands are the world's largest energy project. Nothing in any sector matches it for capital investment.

The rapid approval of more than 50 oil sands projects since 1996 has not only made Canada the No. 1 supplier of oil to the United States but also the world's seventh-largest producer. Prime Minister Stephen Harper has described the oil sands "as an enterprise of epic proportions, akin to the building of the pyramids or China's Great Wall. Only bigger." Economists calculate that the oil sands will contribute nearly $1 trillion to Canada's gross domestic product by 2020.

But the prized resource really isn't oil per se, but bitumen. It's a tarry and dirty mixture of clay, water and hydrocarbons that lies, sometimes shallow and sometimes deep, under a quarter of Alberta's land mass. Extracting this bitumen from the sand takes remarkable volumes of energy and water. Indeed, every phase of production in the oil sands--from the open-pit mines to the refineries in Upgrader Alley--demands a lot of water, and dirties a lot of water too.

Mining bitumen resembles bulldozing mountaintops to excavate coal deposits in Appalachia--except that it's boreal forest that's being removed. A half-dozen city-sized mines now line the banks of the Athabasca River.

On average, the mines consume between three and four barrels of fresh water to produce one barrel of bitumen. Most of the water is heated to separate the hydrocarbons from sand and clay in a process akin to operating a giant washing machine. Although companies such as Syncrude recycle their water as many as 18 times, the industry still procures most of its water from the Athabasca River or from aquifers that feed the river.

The degree of water use directly reflects the quality of ore recovered, says Bruce Peachey, president of New Paradigm Engineering in Edmonton. "We are presently mining the best

ores. But as clay content increases, the volume of water needed in production will increase. So this is the *good* time for water."

The industry now accounts for more than 76% of the water allocations on the Athabasca River, Alberta's longest undammed waterway. Current licences allow industry to take 3.2 billion barrels of fresh water a year--enough to supply two cities the size of Calgary. Planned expansions could bring the total to 4.2 billion barrels per year, a volume Natural Resources Canada says "would not be sustainable because the Athabasca River does not have sufficient flows."

Although environmental and aboriginal groups have long campaigned for the provincial government to enact a firm water policy for the river, nothing materialized until the province released a scathing report on oil sands development in February, 2007. Written by Doug Radke, the former deputy minister of the environment, the report called the province's ability to enforce environmental regulations "inadequate" and described planning on the cumulative effects of the oil sands as "unclear, outdated and incomplete." Echoing the federal opinion, it also noted that the Athabasca River may not be able to support what's planned.

The next month, Alberta Environment and the federal Department of Fisheries produced an interim plan for the river. The framework, which gives the province two more years to figure out what quantity of water the river really needs to sustain fish, works like a stoplight. Green-light conditions allow industry to withdraw up to 15% of the flow; a yellow light encourages industry to proceed with caution by reducing withdrawals to 10% of flow; and a red light restricts allocations even further. But even during a drought, when the red light is on, industry will get enough water to fill 50 bathtubs per second.

Preston McEachern, the head of oil sands research for Alberta Environment, calls the framework conservative and precautionary. "There is a lot of water in that river...and our numbers [for withdrawals] are low compared to industrialized rivers in Europe or the United States." Still, the caps will challenge companies "to plan their projects with exceptional environmental controls."

Schindler calls the framework "inadequate." But he reckons it's probably as good as the government could do, given the data deficit on the river. He notes that current and approved withdrawals "would already put the river in red-zone conditions for several months in winter during low-flow years."

Moreover, winter and summer flows of the river have declined 30% since 1970, and could drop more than 60% by 2050.

Solutions to the imbalance of supply and demand on the river are numbered, says Paradigm Engineering's Peachey. Companies can reduce water consumption or build greater storage for water upstream of the mines on the Athabasca. Or the government could put the brakes on development. Although industry and government have set a goal of producing three million barrels a day by 2015, Peachey thinks water availability could well constrain such exuberance. "In either case, the growing public awareness of the need to protect environmental resources, and the concurrent need to protect local communities from the sudden loss of a major employer, will create considerable social conflicts over any solution proposed."

Lawsuits might also start flying. A 2007 article in the *University of Toronto Faculty of Law Review* concluded that an American company could construe the cancellation of an Alberta water licence as expropriation under the North American Free Trade Act and then sue the Alberta government for compensation. Preston McEachern of Alberta Environment agrees: "Those types of scenarios could be played out in the future and could become a real test of political will."

Some 90% of the water withdrawn from the Athabasca River for the oil sands ends up as waste in tailings ponds. Nearly a dozen ponds line both sides of the river and pose an enduring threat to the entire Mackenzie River basin. Many are already leaking and creating their own tainted wetlands. Even the pro-development Alberta Chamber of Resources considers this primitive form of long-term storage "a risk to the oil sands industry."

The ponds, which contain a ketchup-consistency mix of water, oil and clay, give off a strong aroma of hydrocarbons and rarely freeze. Minnows dropped into the ponds die within 96 hours; unwary ducks get coated by surface oil and drown.

The ponds, like everything in the oil sands, are supersized. The dykes that contain the ponds can reach 100 metres in height. Although the ponds already cover 55 square kilometres of forest and muskeg, they've just begun. Within a decade, they will cover an area of 150 square kilometres.

According to the Alberta Chamber of Resources, the industry spits out six barrels of sand and 11/2 barrels of fine tailings for every barrel of oil it makes. Altogether, the ponds contain 5.5 billion cubic metres of sand and fluid waste.

Syncrude, the largest producer in the oil sands, also owns the largest tailing pond. Every day, Syncrude dumps 500,000 tons of tailings. The Syncrude Tailings Dam is deemed by the U.S. Department of the Interior to be the world's largest dam by volume of construction material. The pond, built in 1973, covers 22 square kilometres and holds 540 million cubic metres of water, crud and sand. When China completes the Three Gorges Dam this year, Syncrude will surrender the record. "We are still second-best," quips Randy Mikula, who has been studying the tailings waste problem for 22 years.

As the team leader on the subject at Natural Resources Canada's CANMET Energy Technology Centre in Devon, Alberta, Mikula calls the tailings waste problem a "frightening" and vexatious issue. Engineers originally thought that the tailings waste would quickly settle, leaving clear water on top. But that never happened, thanks to what Mikula calls "the bad behaviour of clays." He suspects the waste won't settle to solid form for thousands of years. "So something has to be done."

The prospect of a major dyke failure has also raised concerns. Every tailings pond contains polycyclic aromatic hydrocarbons (PAHs), napthenic acids, heavy metals, salts and bitumen. The Canadian Association of Petroleum Producers reports that of 25 PAHs studied by the U.S. Environmental Protection Agency, 14 are human carcinogens. Both PAHs and napthenic acids kill fish.

In 2003, the intergovernmental Mackenzie River Basin Board identified the tailings ponds as a singular threat. It noted that "an accident related to the failure of one of the oil sands tailing ponds could have a catastrophic impact on the aquatic ecosystem of the Mackenzie River basin."

Peachey, Schindler and other water experts agree. Engineering studies also highlight an uncomfortable truth: The reliability of mine waste containment dykes is among the lowest of all earth-made structures. "The longer the tailings sit there, the more likely there will be a major extreme weather event and a big dyke failure," predicts Peachey. In Schindler's view, "the world would forever forget about the *Exxon Valdez*" if a dyke failed.

The Alberta government is getting worried. Preston McEachern calls the ponds his No. 1 concern: "We know they leak and we capture these leakages or let some fall into poor-quality water formations...but it's the long term. What do we do as they build up?" The good news, concludes Mikula, is that both industry and government are pouring millions into research on containment.

The bad news is that there is already evidence of downstream health effects. Last November, a study for the Nunee Health Board Society in Fort Chipewyan, 300 kilometres north of Fort McMurray, found elevated levels of mercury, arsenic and PAHs in local waters. The report asked if these contaminants were connected with dramatic increases in fish deformities and rare forms of cancer in the community, and called for a major health study. To date, the Alberta government has not taken up the recommendation.

Downstream users are worried. "We have tremendous concerns in terms of the pace of development and contamination issues," says Michael Miltenberger, Minister of Environment and Natural Resources for the Northwest Territories. "What happens on the Athabasca affects people as far away as Inuvik."

Open-pit mines aren't the only big water users in the oil sands. About 80% of all bitumen deposits lie too deep in the ground for open-pit mining. To access these lower-quality deposits, the oil industry has developed a number of novel technologies. The most popular, steam-assisted gravity drainage, injects high-pressure steam into a bitumen formation with one pipe and then brings the melted hydrocarbon to the surface with another pipe.

Land leased for SAGD production now covers an area larger than Vancouver Island, which means that this kind of drilling could affect water resources over an area 50 times greater than the open-pit mines. The industry calculates that it takes about one barrel of raw water (sometimes taken from deep, salty aquifers) to produce a barrel of oil using SAGD. But researchers suspect it often takes much more water. "It's just as big a problem as the mines, and it's not going away," adds Peachey. "And we don't have a plan or strategy for it other than reducing water usage as fast as possible."

SAGD's thirst for water, mostly used to make steam, has a host of implications. Industry used to think that it needed only two barrels' worth of steam to melt one barrel of bitumen out of deep formations. But the reservoirs have proved unco-operative. The multibillion-dollar Long Lake project south of Fort McMurray, a joint venture of Nexen and Opti Canada,

originally predicted an average steam-to-oil ratio of 2.4:1. But the joint venture now forecasts a 3.3:1 ratio.

This dramatic but typical loss in efficiency means companies have to drain more aquifers to produce more steam. In order to heat the water, the companies purchase more natural gas, which, in turn, means more greenhouse-gas emissions. By some estimates, SAGD could ultimately consume the equivalent of the entire gas supply of Western Canada. "A lot of projects may prove uneconomic in their second or third phases because it takes too much steam to recover the oil," says one Calgary-based SAGD developer, who asked to remain anonymous.

Due to the spectacular projected growth in SAGD (nearly $4 billion worth of construction a year until 2015), Alberta Environment can no longer accurately predict water demand. The Pembina Institute, a Calgary-based energy watchdog, reported that the use of fresh water for SAGD in 2004 increased three times faster than the government forecast of 5.4 million cubic metres a year. Despite the province's effort to get companies to switch to salty groundwater, SAGD could still be drawing more than 50% of its volume from freshwater sources by 2015.

SAGD also generates formidable piles of waste. Companies can't make steam without first desalinating the brackish water. An average SAGD producer generates as much as "15 million kilograms of salts and water-solvent carcinogens," which simply gets trucked to landfills, the SAGD developer says. Because the waste could eventually contaminate groundwater, John Robertson of CH2M Hill calls the salt disposal problem "a perpetual care issue." The anonymous SAGD developer adds, "There is no regulatory oversight of these landfills, and these problems will be enormously difficult to fix."

But the biggest sleeper issue for SAGD production may be overall changes in the water table over time. "If you take out a barrel of oil from underground, it will be replaced with a barrel of water from somewhere," explains Peachey. Here again, the lack of research data is problematic: Alberta "doesn't have enough data to understand surface and groundwater connections" in the oil sands region, says Peachey.

Given SAGD's record as a natural gas burner and producer of greenhouse gas emissions (three times that of conventional oil), both the Canadian government and the industry regard nuclear power as an energy alternative. The French nuclear giant Areva has said it can add four reactors to the province's grid, while Energy Alberta Corp. has suggested

building as many as 11 Candu reactors. While some of these reactors would provide power for bitumen mining, oil shale (a hard-rock form of bitumen) and SAGD operators, others would upgrade bitumen into marketable oil.

But that plan doesn't solve the water problem, because nuclear power requires enormous volumes of water for cooling. It is estimated that just one reactor, proposed for Grimshaw, would require 20 times the amount of water used by the city of Calgary. Such a plant would also lose nearly 57 billion litres of water a year to evaporation.

The final act of the oil sands process will be reclamation of the land. The mining will eventually dig up an area that is the size of Lake Erie and is largely comprised of boreal wetlands. Wetlands are known as the "kidneys" of a watershed because they regulate flow and remove contaminants. According to Lee Foote, a wetlands specialist at the University of Alberta, no one really knows yet how to reclaim a fen, bog or peatland in the oil sands. He calculates that the cost of replacing the projected 96,000 hectares of mined wetland, depending on the replacement standards adopted, could, at $25,000 a hectare, range between $7 billion and $24 billion. "It's a significant liability if it can be done at all," Foote says.

Turning bitumen into cleaner oil requires "upgrading" to create a product that can be refined into fuels and petrochemicals. The process also requires--surprise--lots of water for cooling and refining. Thus, proposals to build as many as 15 upgraders outside Edmonton, along the North Saskatchewan River, have spawned yet another water controversy.

Given that the industry has neither the room nor the labour force to build more upgraders in Fort McMurray, a host of oil companies have proposed building nearly $30 billion worth of upgraders in the area east of Edmonton that has become Alberta's industrial heartland. Three separate pipelines would supply the upgraders with fresh bitumen.

But the upgraders, like their bitumen-mining cousins, gulp lakes of water. The North West Upgrader, under construction by a Calgary firm, will annually use up to 5.6 billion litres of water from the North Saskatchewan--a river only a third the size of the Athabasca.

Last year, a report done by the engineering firm Morrison Hershfield for Strathcona and Sturgeon counties added up the water footprint for the upgrader boom. Each facility would require anywhere between 16 and 20 megalitres of water a day--the equivalent of six to eight Olympic-sized swimming pools. By 2026, their daily thirst could amount to between

200 and 240 megalitres or the equivalent of more than 80 Olympic-sized swimming pools. In contrast, the city of Edmonton uses 350 megalitres a day and returns most of that water to the river in treated form. The upgraders, however, won't do that: Some 70% of the water will be consumed or lost to evaporation.

The oil patch rates as the North Saskatchewan basin's second-highest water user (18%), behind other industry in general. The upgrader boom, however, will make the petroleum sector No. 1. In fact, a recent report for the North Saskatchewan Watershed Alliance says that "nearly all of the projected increase in surface water use will be in the petroleum sector." By 2015, the upgraders' demands on the river will increase water use by 278%, and, by 2025, by 339%. John Thompson, author of the report, says the absence of an authoritative study on the river's ecosystem remains the central issue. "We don't know what it takes to maintain the river's health."

Providing energy for the upgraders will also take a toll on water. Sherritt International and the Ontario Teachers' Pension Plan are proposing to strip-mine a 312-square-kilometre area just east of Upgrader Alley for coal. A gasification plant would render the coal into synthetic gas and hydrogen to power the upgraders. Current estimates suggest that the project will likely need somewhere between two million and nine million cubic metres of water from the North Saskatchewan annually. Strip-mining farmland will also "affect groundwater aquifers and surface water hydrology," according to the Pembina Institute, an Alberta energy-sustainability think tank.

Last December, Alberta Environment released a new framework for the river that concluded "ample capacity exists in the North Saskatchewan River to support a healthy industry and growing population." The report okayed all current projects but noted that "the current level of proposed development calls out for a comprehensive review." The ministry also noted that "water quality could continue to decline without cumulative limits in place and actions to mitigate further impacts."

The fix to the shortfall championed by both industry and government involves using Edmonton's grey water. Instead of allowing a dozen upgraders to stick individual straws in the North Saskatchewan, the city's utility company, Epcor, would pipe the city's treated waste water to the upgraders. This would both lessen the load of chemicals on the river (treated waste water contains nitrogen and phosphorus) and provide a secure supply for the

industry. "It's a good solution for the industrial heartland and the river," says Joe Gysel, vice-president of marketing and business development at Epcor.

But even if they use waste water--a common practice in water-short California and Colorado--the upgraders will be removing lots of water from the river. Given that no study on the river's water needs has yet been done, Schindler calls the framework's claims that there is lots of water in the river "pretty hollow." He also notes that the framework avoids any mention of declining river flows or the expected effects of climate change.

Historically, the North Saskatchewan River has been subject to extreme variations in flow, notes Dave Sauchyn, a climate change specialist at the University of Regina. In 1796, a drought year, the Hudson's Bay Co. had trouble moving furs, "there being no water in the river," as an eyewitness put it. Sauchyn says that 80 years of record keeping on the river are insufficient to predict variability in water availability. He adds that the lowest and one of the highest flows recorded on the river both took place between 2001 and 2005. Sauchyn, who has recently begun to study the impact of climate change on the river, already has a "gut reaction" to the idea of putting as many as 15 upgraders along its banks: "They should be thinking about whether it's judicious to proceed, or how to store water during low flows."

How can oil and water be diverted from their collision course in Alberta? No magic bullet has yet appeared, other than a dramatic slowdown in development. Indeed, in February, much of the industry itself--including Suncor, Petro-Canada, Husky Energy, Shell Canada and Imperial Oil--signed a letter calling on Alberta to impose a partial moratorium on oil sands development. While some industry players opposed the call, Environment Canada and aboriginal groups endorsed it. The letter addressed the need for the conservation of land rather than water per se, but the alert nonetheless signals the first groundswell recognition that the national project of the oil sands needs to pay more attention to the environment. The provincial government opposes a moratorium on the grounds that it will stymie innovation in the oil patch.

Some fixes for specific problems have been proposed. A number of companies are already working to conserve water. Suncor, the first enterprise in the sands, reduced water consumption by 30% between 2004 and 2006. One of its facilities uses no fresh water at all. "We are flipping the paradigm from the myth of water abundance to the reality of water scarcity," says Gord Lambert, Suncor's vice-president of sustainable development. "The status quo is not acceptable from an economic and environmental point of view."

Indeed, producers that have their water issues under control are likely to have an advantage over those that do not. An October, 2007, report on the oils sands by Scotia Capital warned that the industry probably has "another one to two years before this issue [water] comes to the forefront, at which point approvals will become more difficult to obtain, adding a premium to those companies whose projects are preapproved, or projects that use no water. "

To deal with the phenomenal growth of tailings waste, some companies have embraced a controversial burial system known as "end pit lakes." It entails piping the waste into excavated mine pits, covering the tailings with fresh water from the Athabasca River and then waiting hundreds of years for Mother Nature to find a solution. Mikula says there is very little evidence for the effectiveness of the scheme.

A better solution might be a sort of "brute force" centrifugal approach, says Mikula. It involves spinning the material to create something dry and stackable that could eventually be reclaimed--while recovering water at the same time. Both Syncrude and Suncor have begun pilot projects. "We could reduce water usage from four barrels to two [per barrel of oil] or maybe less, which means less water withdrawn from the Athabasca," says Mikula.

One solution to the upgrader concentration on the North Saskatchewan River might be to simply distribute the plants across Western Canada.

But such measures, even if coupled with efforts to conserve water across the industry, may not be sufficient. Even if the industry saves water, it is still drawing people to Alberta. David Schindler regards population growth driven by the oil boom in a drying climate as an intractable complication. He doubts the province's rivers can handle a projected 12 million people by the next century. He recommends keeping "human populations in the dry Prairie provinces relatively low, to avoid the water scarcity that has already become a major problem in the southwestern United States."

To John Thompson, the resource economist, the big issue now boils down to leadership: "We are water-short, and there are limits to growth. But who wants to be the politician who shatters the Alberta myth and says we are running out of stuff on the last frontier?"

RIVER UNDER STRESS: Four case studies

OVER-EXTRACTED

The Rio Grande -

The river's basin serves 10 million people in the United States and Mexico. Ever-increasing demands for agricultural and domestic use mean that the river is often dry when it reaches El Paso, Texas, less than a third of the way along its course.

POLLUTED

The Yangtze -The major source of fresh water for 430 million Chinese receives an estimated 25 billion tons of sewage and industrial waste annually. Rates for intestinal infectious diseases are 50% greater than the national average along some stretches of the river.

VULNERABLE TO CLIMATE CHANGE The Nile -Providing water to more than 160 million people in 10 nations, the Nile doesn't reach the sea in dry periods. But climate change will be the river's greatest challenge: Models project flow decreases as high as 78%.

DAMMED

Rio de La Plata -The second-largest river in South America serves 100 million people in Paraguay, Brazil, Argentina and Uruguay. Six dams are under construction; another 21 are planned.

Potential impacts include increased erosion and flooding, as well as loss of habitats and indigenous food sources.