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Strollin' Through the Country — Agriculture

If you want to find the roots of the Alberta water crisis, head out to the country.

Mike Hittinger, a stocky man in a denim jacket, hops out of his truck near a muddy stockyard about three meters away from the Sturgeon River. “Watch out,” he says, “there’s a hornet’s nest here.” He steps over a barbed wire fence and examines the shoreline. “[This rancher] has been grazing here,” he says. “There are no trees at all.”

Hittinger is a member of the Northwest Alliance Conservation Initiative, one of many local NGOs funded by Alberta Environment as part of educational efforts connected to Water for Life. It’s his job to go out to farms like this one and show people how they can save money and the environment with modern agricultural practices.

“Currently, there aren’t any big [agricultural] issues in the Sturgeon, and we want to keep it that way,” Hittinger says.

It’s the countryside that will have to change the most in Alberta’s water-scarce future. Farms are the largest consumers of water in the world. Fifteen per cent of the world’s farmland is irrigated, accounting for 65 per cent of the world’s water use. Irrigation accounts for almost half of all licensed water diversions in Alberta, with about 4.3 trillion litres allocated to it a year.¹ But

that 15 per cent produces more than a third of the world's food, making it vital to the world economy.² In other words, if farmers run short on water, we'll soon feel it in our empty stomachs.

Farms are also a major non-point source of water pollution. A sewage treatment plant is a point-source polluter: a lot of bad stuff coming from a single place. Farms are non-point source: one farm alone doesn't do much to a river, but many together can cause massive algae blooms and outbreaks of waterborne disease.

An Ecological Cow-Tastrophe?

One of the main sources of water consumption and pollution on Alberta farms is the humble cow. There are about six million cows in the province, according to Statistics Canada, most of them in Lethbridge County, where they outnumber people six-to-one.³ According to the NSWA, the Sturgeon watershed has the third highest concentration of livestock in the North Saskatchewan basin.⁴ There are about 200,000 cattle along the Sturgeon, about half of them in Lac Ste. Anne County.⁵

Cows affect water consumption indirectly through the irrigation used to grow their food. Irrigation, or the diversion of water to grow crops, is the single largest consumer of water in the Sturgeon and Alberta, and most of it goes towards growing forage for cattle. Almost half of all licensed water diversions in the province are for growing crops, according to Alberta Environment.⁶ Almost half the irrigated land in the South Saskatchewan basin, which is home to most of the province's irrigation, is dedicated to forage crops. Most of this forage is alfalfa, which has the highest water requirement of any crop grown in the region.⁷ One former Alberta

Environment economist quips that Alberta irrigates beef, not crops, and for the most part, he's right.⁸

Cows affect water pollution both directly and indirectly. Indirectly, they damage watersheds by eating shoreline, also known as riparian, vegetation. Canadian farmers spread about four million tonnes of fertilizer on their fields every year in addition to various pesticides and herbicides. Rain and melting snow can wash the excess into lakes and rivers.⁹ The grass, reeds and trees that form a riparian zone normally soak up these chemicals and keep them out of the water. But to cows, a riparian zone is lunch. The cows eat all the vegetation, destroying the riparian zone and giving all those chemicals a clear run to the water. They also trample the soil flat with their hooves, making the zone less likely to grow back.

Directly, the cows dump excess nutrients and disease-causing bacteria into rivers. How? "Head goes down, tail goes up," Hittinger explains.

Cattle in the Sturgeon crank out an estimated two million tonnes of manure each year, all of it loaded with nitrogen, phosphorous, and bacteria.¹⁰ Farm animals, mostly cows and pigs, produce eight times more waste than people in Canada, adding an astounding 600,000 tonnes of nitrogen and 300,000 tonnes of phosphorous to the land and water every year.¹¹

All those nutrients have a big effect on drinking water and river ecology, two important

A Riparian What?

Riparian zones are the green zones around rivers and wetlands. They are usually water-logged and replete with thick, water-hungry vegetation.

Riparian zones trap sediment and chemicals, reduce shore erosion, recharge aquifers, and provide food and shelter for many birds and beasts (Fitch and Ambrose 7–11).

parts of Water for Life's mandate. Phosphorous is a potent ingredient for plant growth, but it can also cause massive algae blooms when dumped in a river or lake.

When those algae die and decay, they suck up all the oxygen in the water, suffocating fish. Blue-green algae are even worse, since they release toxic chemicals

upon death. Nitrogen also promotes plant growth, although not to the same extent as phosphorous. It can, however, be transformed into nitrate, a toxin that when ingested can cause kidney failure in adults and “blue baby” syndrome in infants.¹² Pesticides and herbicides cause trouble through a process called bio-magnification. Many farm chemicals are bio-accumulative, and can build up in an animal’s fat over time. As these chemicals work their way up the food chain, they end up in fewer and fewer animals, making them more concentrated and toxic, magnifying their effects — that’s bio-magnification.

As for disease, livestock, including beef and dairy cattle, are one of the biggest environmental sources of waterborne parasites. Studies show that agricultural streams running by stockyards are the source of 56 to 80 per cent of the parasites in the North Saskatchewan River.¹³ This heavy parasite load is a major health risk, and was one of the reasons why the region’s drinking water provider, EPCOR, spent some \$10 million on an advanced ultraviolet light purification system.¹⁴

There are a lot of simple things farmers can do to reduce the impact cows have on the environment, Hittinger says. Cattle will loaf around a riverbank given the chance, so don’t give it to them — fence off the riverbank, like this farmer has, he notes, and limit the amount of time the cows stay on the shore. If the cows aren’t eating it constantly, the riparian zone will have time to grow back and become a reliable long-term food source.¹⁵ Farmers can also pump water from the river into a trough; it’s cleaner, he says, and it keeps your cows from falling through the ice in winter. Taking these simple steps not only improves the health of your watershed, he says, but also makes your farm more profitable.¹⁶

As for fertilizers, pesticides and herbicides, farmers can curb run-off by leaving a good, thick riparian zone by the water. Hittinger pulls over by a field of canola. He points to a morass

Why not regulate?

The Alberta government doesn't have many practical legal means at its disposal to stop non-point source pollution from farms.

The *Surface Water Quality Guidelines for Use In Alberta* suggests limits on it, for example, but they are non-binding.

The *Environmental Protection and Enhancement Act* lets the province fine anyone who knowingly releases a substance into the environment that could cause an adverse effect on it, but the act needs a specific person to prosecute in order to work — a rare find with non-point source pollution.

The *Agricultural Operation Practices Act* requires farmers to stay a minimum safe distance from any water body when spreading manure and requires regular testing and record-keeping of nutrients applied to the land, but only for intensive feedlot operations (Agriculture and Agri-Food Canada and Prairie Farm Reclamation Administration, 142–148).

of emerald grass and shrubs some 10 meters wide separating it from a nearby stream. “You got vegetation going right down to the edge,” he says, with approval. “Think of how much stuff this stops. Water coming through this has a lot of time to slow down, so any fertilizer or sediment has a lot of time to stop.” The plant roots also hold the shore together, he adds, preventing erosion and keeping the water clear of silt, which affects fish habitat and water quality.

Farmers can also apply fewer chemicals to their fields. Laboratory soil tests can tell a crop-grower exactly how much fertilizer they need, and selective spraying combined with natural pest

predators like ladybugs can cut back on herbicide/insecticide use.

These techniques can be expensive, Hittinger says, but there is some government funding available for them. The Canada-Alberta Farm Stewardship Program, for example, offers farmers up to \$30,000 if they implement best management practices for things like manure management, riparian zone restoration, and species protection.¹⁷

Hittinger admits that not all farmers are open to the ideas he and other agricultural groups like Cows and Fish promote, but adds that many come around once they see the financial benefits. Most of the concepts he promotes have been around for years, he notes, but now, with growing pressures on water, farmers are actually paying attention.

“This is all voluntary now, but eventually [agriculture] will be more and more regulated like the oil industry right now,” he predicts.

Irrigation Irritation

Pollution is a problem in agriculture, but it’s irrigation that really has farmers worried.

Irrigation has been a part of Alberta’s history since 1894 when the federal government started licensing water for it. Copious provincial and federal support, combined with new technologies, lead to an explosion in irrigated land in the ‘70s, with irrigation nearly doubling to 420,000 hectares from 280,000 by 1980. Today, there are over 500,000 hectares of irrigated land in Alberta.¹⁸

Irrigation, simply because it uses so much water, will make or break Water for Life. Almost three-quarters of all surface water consumed in Alberta (i.e. diverted from a water body and not put back) goes towards irrigation.¹⁹

Irrigation is the single largest water consumer in the Sturgeon. According to Alberta Environment, irrigation and stock-watering account for 65 per cent of all licensed water consumption in the Sturgeon.²⁰ But that’s nothing compared to what irrigation consumes down south. Irrigation consumes an astonishing 78 per cent of all flow in the South Saskatchewan

“Consumed,” “diverted”, “used,” “lost”

Diverted water is any water taken from a river, lake, or ocean and then used for some purpose. When we talk of water “use,” we mean water “diverted.”

Diverted water is consumed if that use makes it impossible for the water to return to the body of water it was taken from.

Irrigated fields have high water use and consumption, since the crops they grow hold onto the water they absorb for a very long time.

A power plant has high use and low consumption; it needs a lot of water to run its turbines, but can condense the water and dump it back into the environment afterwards.

Lost water is water diverted that evaporates or leaks away before it can be used. According to the Municipal Water Use Database, Canadian cities lose about eight per cent of all diverted water to leaks.

Irrigation and water quality

Intense irrigation, poorly managed, can devastate land and water.

Irrigation water picks up pesticides, fertilizers, and dissolved salts as it runs over the soil. When it returns to a river, those chemicals have the same algae-blooming, fish-killing effects as surface runoff.

If it evaporates or leeches into the soil, it leaves behind loads of salt that slowly poisons the land for future agriculture. Researchers estimate that more than a million hectares of land are lost to this salination of soil a year worldwide (de Villiers 156–162).

basin, leaving just 22 per cent for everything else.²¹

Considering that the region's population is expected to more than triple by 2046, and that the region has little to no surplus water, it's clear that this distribution is unsustainable and will have to change if Alberta is to avoid a major confrontation over water rights.²²

The problem is simply that the South Saskatchewan basin is over-allocated. Alberta Environment typically licenses no more than 70 per cent of a river's annual flow in order to protect the health of

the river, but it has licensed 80 per cent of the Belly River's annual median runoff and 127 per cent of the St. Mary's. There simply isn't enough water in the system for everyone to take all the water they're entitled to, especially in times of drought. Without that water, many farmers, industries and municipalities will go out of business.

The environment is in even worse trouble. The Bow, Oldman, St. Mary and Waterton rivers are all in a state of long-term declining health because people are taking too much water from them.²³ Alberta Environment has determined that 30 of 33 sections of waterway in the South Saskatchewan are either moderately impacted, heavily impacted, or degraded as a result of a lack of water to meet in-stream flow needs.²⁴ It also warns that unless license holders cut their water consumption by more than 20 per cent in the next few years it will be impossible to meet the ecological needs of these rivers without sacrificing the economic needs of those who live around them.²⁵

Adding yet another dimension to this problem is the Water Act itself, says John Thompson, a former senior economist for Alberta Environment who's advised the government on water licenses and irrigation for 14 years. Alberta's water license system works on the concept of "first-in-time, first-in-right," which means whoever has the oldest license gets to divert their water first; junior license holders get whatever's left. "In dry times the senior guys get just about everything and the junior guys get hammered," Thompson says. Unfortunately, since many current irrigation licenses are older than the province itself (the federal government started doling them out in 1894), those "junior guys" include groups like the City of Calgary, which might not appreciate being "hammered" by farmers.²⁶ Moreover, most licenses issued prior to 1999 are permanent, making it very tough for the government to reallocate the water rights they contain.²⁷

And then there's the Master Agreement on Appropriation with Saskatchewan, adds Thompson, which limits what Alberta can take from the South Saskatchewan. "On paper, Alberta has already allocated more than its fair share," he notes, adding that the only reason why Alberta is not in violation of the agreement is that it isn't actually using all the water it has licensed. That will change, and soon, he says, as increased demand and changing precipitation patterns from global warming push people to use more of their licenses. All these factors put Alberta in a position for a major rural-urban fight over water rights in the near future.

Albertans will not have to worry about losing their drinking water to license holders — every Alberta household has a statutory right to water that supersedes any license, no matter how senior.²⁸ But the province will have to take action if it is to have enough water to protect its aquatic ecosystems and keep its economy running, both stated objectives of Water for Life.

The Alberta Irrigation Projects Association, the group that represents Alberta’s irrigating farmers, argues that the province can do both through more irrigation. Improved technology more than doubled the efficiency of Alberta’s irrigation systems from 1965–99, and the association is confident further improvements will let them expand irrigation in the Bow and Oldman watersheds by about 10 per cent without diverting any more water. Even if water supply deficits increase as a result of the expansion, they say, Alberta farmers can stay afloat by switching to higher value crops and using more of the water they gain through efficiency improvements. The association estimates that expanded irrigation will bring 2,400 jobs and \$248 million to the Alberta economy.²⁹

Technological improvements do have the potential to save irrigators a lot of water. The High Plains region of Texas, for example, cut its agricultural water use by 43 per cent from 1974–1992 by switching to low-pressure sprinklers and implementing conservation measures.³⁰

But even the association admits its predictions might be too rosy. Their irrigation study does not precisely account for the ecological needs of rivers, for example, and may have underestimated the amount of water rivers need to survive. Nor does the study account for climate change, stating that scientists do not have enough information to accurately predict its effects. It also concludes that Alberta irrigators probably won’t manage more than a five per cent improvement in their water use in the near future. The study notes these factors could present “an overly optimistic picture of long-term water supply and demand.”³¹

Thompson adds that more efficient irrigation doesn’t necessarily mean less water used. If, as the association proposes, you improve efficiency by cutting the amount of water the irrigation system loses and divert this “saved” water to new irrigation, you actually use more water, he says — you’re diverting the same amount, but less of it is returned to the environment unused (i.e.

“wasted”). “We’re still going to see water use rise in the years to come because people will use more of what they’re allowed to use,” he says, meaning less water for other license holders and the environment.

The province has taken some significant steps to head off this water crisis, Thompson says. First, it has decided not to issue any more licenses in the South Saskatchewan. Second, it’s allowed people there to trade water licenses with each other, which is something the province says it may allow all Albertans to do in the future. Third, it has banned all inter-basin transfers of water, meaning the south won’t be able to pipe in water from the north to meet its growing needs (although technically the province could do so if it’s deemed to be in the public interest).

All of these are great ideas, he says, since they set a fixed limit on the water that’s available for use in the basin, encouraging conservation; if people use less than their full allocation, they can make money by selling the surplus. Unfortunately, he adds, none of these measures will actually reduce water use to free up some for the environment, which is what needs to happen in the South Saskatchewan.

The province says it plans to do that through water conservation holdbacks: every time someone transfers or sells a water license, the province can reserve up to 10 per cent of it for anything it likes, including the environment. But this alone won’t be enough; at 10 per cent per trade, farmers would have to trade the equivalent of 80 per cent of the Lethbridge Northern Irrigation District to improve flows in one stream by a measly one cubic meter per second — not a likely prospect.³²

If the province really wants to protect its rivers, Thompson says, it will have to shell out some serious cash and buy water licenses to reserve water for the environment. Since an acre-foot of licensed water sells for about \$1,500, that could get expensive fast.³³ “We handed

out a very secure system of water rights 100 years ago,” he notes. “If the province wants water back, they’re going to have to pay for it, and hoping the [water] system will fix itself ain’t going to work.”

In the future, Johnson predicts, industry will have to buy water allocations from farmers to sate their growing demand. This could be a win-win situation, he notes: farmers who can’t make money off their crops sell the water they don’t need, and industry gets the resources it needs to expand. Both will have a financial incentive to save water as well; farmers, so they can sell more of it, and industrialists, so they don’t have to buy as much. As for the future of farming itself, senior irrigators, Johnson concludes, are sitting pretty when it comes to water supply — it’s junior farmers and other junior license holders that have to worry.

Water for Life Summary: Agriculture

To summarize, says Hittinger, agriculture is a lot like industry; it can have a big impact on the environment if it isn’t done responsibly. Albertans reap immense benefits from agriculture (their irrigated farms alone add some \$800 million to the provincial economy), but also risk immense harm to their environment and economy through the water pollution and consumption agriculture represents.³⁴

The two engines of Alberta agriculture, irrigation and cattle, both need major tune-ups if they are to run smoothly in days ahead. Otherwise, the province will see a major clash over water rights between the city and the country in the near future, and possibly a total economic breakdown of the agricultural sector thereafter. Albertans can’t have safe drinking water if cows keep defecating in rivers, nor can they have healthy ecosystems if cattle eat all the shoreline

vegetation. Nor can the province have reliable water for industry if most of its useable supply goes towards irrigating beef and returns to its rivers laden with silt and salts.

In the long run, Water for Life will probably give Albertans the tools to make sure agriculture has a future in the province; a changed one, and perhaps a smaller one, but a future nonetheless. Farmers have been stewards of the land for years, but low crop prices and new environmental threats have put them under immense pressure. Since the headwaters of most rivers are in agricultural areas, city folk need the help of farmers to protect them. The watershed planning councils of Water for Life should help Albertans create the education and funding programs they need to co-ordinate water-saving policies on farms across the province. Funding these upgrades will come at great cost, and city dwellers should be prepared to pay some of it. After all, says Ernie Ewaschuk of the Land Stewardship Centre, if city folk want clean water and can't get it without cost to farmers, it makes sense that they compensate them for it. By buying water licenses and negotiating land protection deals, city folk can have better water without putting farmers out of business.

But time is short. The province needs to buy water licenses today if it wants these city-country deals tomorrow. Supply shortages in southern Alberta suggest that any expansion of irrigation there, no matter how efficient, will only make things worse. Someone will have to take the lead and start the water revolution on the farm. The province has the legal and financial clout to do so, and could change the water licensing system to emphasize ecological protection or buy water allocations to reserve water for cities and industries.

The draft water management plan for the South Saskatchewan basin suggests Alberta is edging towards this leadership role. The plan, issued in October 2005, urges the province to improve in-stream flows in several regional rivers by 10 per cent to restore riparian health and to

reserve water for environmental purposes. It also recommends that it calculate a “Crown reservation” of unallocated water for the purposes of environmental protection and greater water storage.³⁵ This is similar to South Africa’s “ecological reserve” principle, which allows the government to subtract a certain non-negotiable quantity of water from all licenses in order to protect drinking water supplies and the environment.³⁶ Expanded to cover the entire province, this Crown reservation could vastly improve the state of Alberta’s rivers and the reliability of its water supplies. The plan makes no mention of the province buying water licenses, however.

How does the Sturgeon size up in this issue? Right now, farmers in the Sturgeon haven’t been hit too hard by the water crisis, but that’s largely a result of luck. They don’t have huge pollution problems from cows simply because they don’t have a huge number of them; if they had the same number as Lethbridge, they’d have the same problems. They also have rich black soil, meaning they don’t need to use as much fertilizer (so less gets in the water), and a decent amount of rain, which reduces the amount of irrigation they need. But all these things give the Sturgeon but a temporary reprieve; eventually, farmers in the Sturgeon will be grappling with the same issues that farmers in the south are right now.

Hittinger is confident the Sturgeon will rise to the challenge. One of the backbones of agriculture is sustainability, he notes, and many farming families in the Sturgeon have tended the land for generations.

“One of the sayings we’re starting to hear more of is that we don’t inherit the land from our fathers, we borrow it from our children,” he says.

¹ Wilkie, 9. Irrigation accounted for 45 per cent of water licenses in 2003, with a total volume of 4,338,806,625,000 litres.

- ² I.A. Shiklomanov and N.V. Penkova, “Methods for Assessing and Forecasting Global Water Use and Water Availability,” *World Water Resources at the Beginning of the 21st Century*, I.A. Shiklomanov and John C. Rodda, eds., Cambridge, U.K.: Cambridge University Press 2003, 33.
- ³ Alberta Agriculture, Food and Rural Development, *2001 Census of Agriculture for Alberta*, Edmonton, Alta.: Alberta Agriculture, Food and Rural Development, table 19.1. In 2001, Alberta had 6,615,291 head of cattle and calves, 2,293,243 of which were south of Calgary. Lethbridge County had 583,531 cattle and (according to Statistics Canada) 97,318 people (based on the population of Lethbridge County and its main settlements of Lethbridge, Nobleford, Barons, Coaldale, Coalhurst and Picture Butte).
- ⁴ Aquality Environmental Consulting Ltd., 170.
- ⁵ The *2001 Census of Agriculture for Alberta* says Sturgeon, Lac Ste. Anne and Parkland County have 235,704 cattle and calves total, 105,632 of which are in Lac Ste. Anne County (Table 19.1).
- ⁶ Records obtained from Lorne Edinga of Alberta Environment show that of the 3.9 million cubic meters of water diverted and consumed from the Sturgeon each year, 62 per cent goes towards irrigation. The provincial average is 44.6 (Wilkie 8).
- ⁷ Irrigation Water Management Supply Study Committee, *South Saskatchewan River Basin Irrigation in the 21st Century*, vol. 1, Lethbridge, Alta.: Alberta Irrigation Projects Association 2002, 56–57. Alfalfa is a high-consumptive use forage crop and uses an average of 680 millimetres of water per year. Twenty-eight per cent of all irrigated land in the South Saskatchewan is dedicated to high-consumptive use forage crops like alfalfa.
- ⁸ John Thompson, consultant for Alberta Environment, senior economist Alberta Environment 1990–97, economist Natural Resource Conservation Branch 1997–2003, participant in drafting of 1999 Water Act, telephone interview by author, St. Albert, Alta. 22 Feb. 2006.
- ⁹ Jamie Linton, *Beneath the Surface: The State of Water in Canada*, Ottawa, Ont.: Canadian Wildlife Federation 1997, 16. Canadian farmers used four million tonnes of fertilizer in 1985, up considerably from 250,000 in 1930.
- ¹⁰ Aquality Environmental Consulting Ltd., 90. Statistics Canada estimates manure production in the Sturgeon as about 1,194,000 to 3,246,000 tonnes.
- ¹¹ Linton, 61–62.
- ¹² Nancy Hoffman and Martin S. Beaulieu, “A Geographical Profile of Manure Production in Canada, 2001,” *Agriculture and Rural Working Papers Series* (January 2006), 5; Agriculture and Agri-Food Canada and Prairie Farm Reclamation Administration, *Beneficial Management Practices: Environmental Manual for Crop Producers in Alberta*, Edmonton, Alta.: Alberta Agriculture, Food and Development 2004, 22.
- ¹³ Patricia Mitchell, *Relationship Between Beef Production and Waterborne Parasites In the North Saskatchewan River Basin, Alberta, Canada*, Edmonton, Alta.: Alberta Environment 2002, 9–10, 17. Mitchell found that 56 per cent of all *giardia* and 80 per cent of all *cryptosporidium* parasites in the North Saskatchewan River came from agricultural streams.
- ¹⁴ Steve E. Hrudey and Elizabeth J. Hrudey, *Safe Drinking Water: Lessons from Recent Outbreaks in Affluent Nations*, Cornwall, U.K.: IWA Publishing 2004, 380.
- ¹⁵ Lorne Fitch, Barry Adams, and Karen O’Shaughnessy, *Riparian Areas and Grazing Management*, Lethbridge, Alta: Cows and Fish 2003, 22–23.
- ¹⁶ *Ibid.*, 43.

- ¹⁷ Agriculture and Agri-Food Canada, “The Canada-Alberta Farm Stewardship Program,” [online] (Ottawa, Ont.: Agriculture and Agri-Food Canada 2005); available from http://www.agr.gc.ca/env/efp-pfa/index_e.php?section=nfsp-pnga&page=ab-nfsp-pnga; Internet; accessed 1 April 2006.
- ¹⁸ Irrigation Water Management Supply Study Committee, 9–17.
- ¹⁹ Alberta Environment, *Water for Life: Facts and Information on Water*, Edmonton, Alta.: Alberta Environment 2002, 27. Alberta Environment says 70.95 per cent of all surface water consumption is the result of irrigation.
- ²⁰ Based on records obtained from Lorne Edinga, Alberta Environment. Note that this excludes municipal use, since most Sturgeon communities get their water from Edmonton, which is outside the watershed.
- ²¹ Wilkie, 10.
- ²² Alberta Environment, *South Saskatchewan River Basin Water Management Plan Phase Two Background Studies*, 11; Alberta Environment, *South Saskatchewan River Basin Water Management Plan Phase One Water Allocation Transfers*, 3.
- ²³ Alberta Environment, *South Saskatchewan River Basin Water Management Plan Phase One Water Allocation Transfers*, 2–3; John Thompson, “People to Water or Water to People?” Banff, Alberta: Alberta Institute of Agrologists 2005, 11.
- ²⁴ Alberta Environment, *South Saskatchewan River Basin Water Management Plan Phase Two Background Studies*, 3.
- ²⁵ Alberta Environment, *South Saskatchewan River Basin Water Management Plan Phase Two Scenario Modelling Results Part 1*, Edmonton, Alta.: Alberta Environment 2003, iv.
- ²⁶ Irrigation Water Management Supply Study Committee, 16. As of 1991, there were 524,528 hectares of irrigated land in Alberta. 419,730 of these were established prior to 1980. That means over three quarters of all acres under irrigation have licenses attached to them have at least 26 years of seniority over any passed after that date.
- ²⁷ Licences issued after 1999 have fixed expiry dates, but can be renewed.
- ²⁸ Alberta Environment, *South Saskatchewan River Basin Water Allocation*, Edmonton, Alta.: Alberta Environment 2005, 2.
- ²⁹ Irrigation Water Management Supply Study Committee, xii, xvi–xv, 60–61, 144.
- ³⁰ Sandra Postel, *The Last Oasis*, London, U.K.: Earthscan Publications Ltd., 1992, 101.
- ³¹ *Ibid.*, 42–46, 60–61.
- ³² Alberta Environment, *South Saskatchewan River Basin Water Allocation*, 11.
- ³³ An acre-foot is the amount of water needed to submerge an acre of land to a depth of one foot, equal to about 1,233 cubic meters.
- ³⁴ Irrigation Water Management Supply Study Committee, xv.
- ³⁵ Alberta Environment, *Draft (Approved) Water Management Plan for the South Saskatchewan Basin*, Edmonton, Alta.: Alberta Environment 2005, 1–2, 7.
- ³⁶ Postel and Richter, 85.