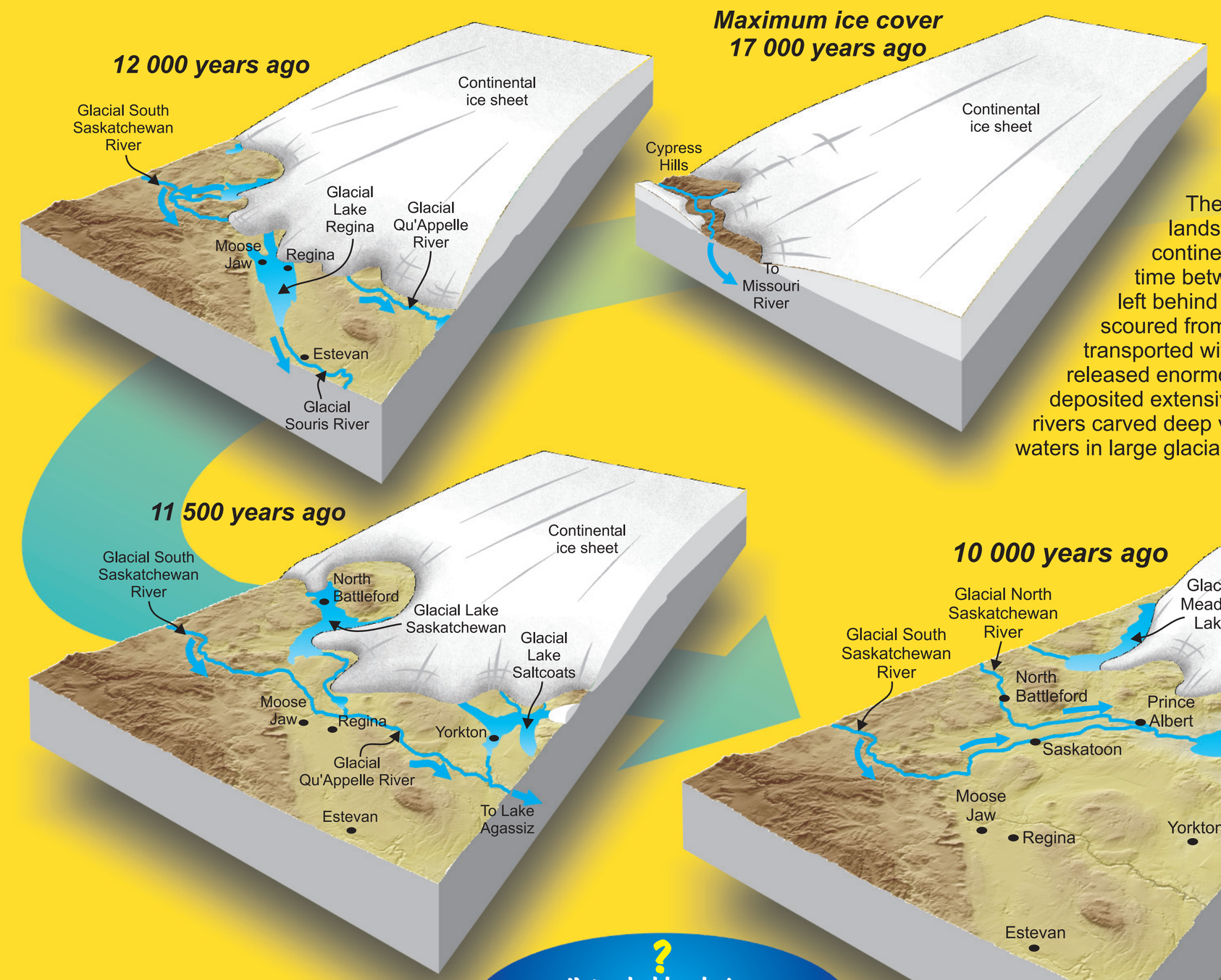
GEOSCAPE SOUTHERN SASKATCHEWAN

Geoscience for prairie communities

We are prairie people, inhabiting a dry grassland landscape — a mosaic of flat plains, rolling hills, steep-sided valleys, and forested coulees. Two centuries ago, this prairie was an ocean of grass, and home to First Nations peoples and millions of bison; today the grasslands are largely gone, the soil tilled into farmlands. Most of us live in cities and towns, but all of us are tied to our geological landscape — or **geoscape** — by the energy we draw from it, the earth on which our homes are built, the water we drink, and the food that grows from our soil and water. Rich resources lie hidden below the prairie surface and our modern life is fueled by energy from coal, oil, and natural gas. Water has always posed limits on prairie life; where it was sufficient, ranches, farms, and towns sprang up. Our agriculture is built upon Saskatchewan's soil, formed from mineral-rich debris left by retreating glaciers more than 8000 years ago. As custodians of this land, we are responsible for its care. By understanding our geoscape, we can promote its wise use: conserving water, energy, and mineral resources; minimizing the impact of natural hazards; and protecting natural ecosystems that sustain our life.

OUR DIVERSE PRAIRIE LANDSCAPE: SASKATCHEWAN IS NOT JUST FLAT!

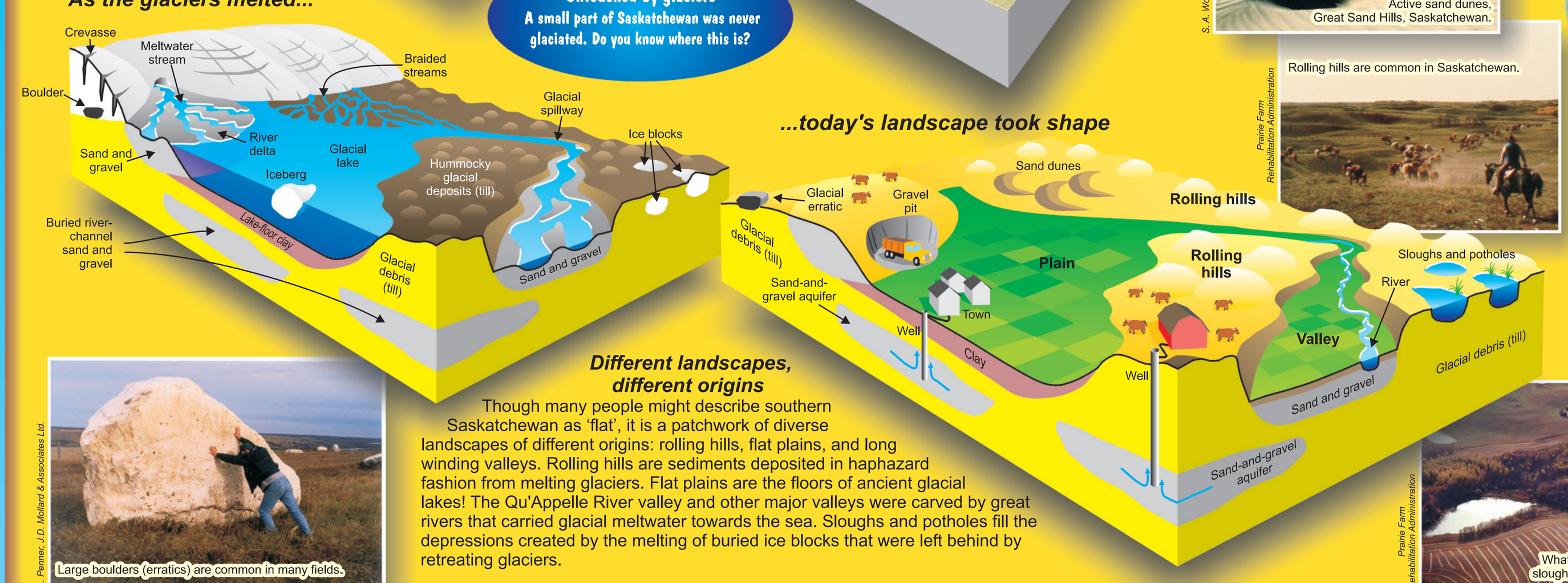


The Ice Age: architect of our landscape

The Ice Age glaciers shaped the landscapes we know today. As the continental ice sheet retreated for the last time between 17 000 and 8000 years ago, it left behind a carpet of glacial debris, or **'till'**, scoured from underlying materials and transported with the moving ice. Melting ice released enormous volumes of water that deposited extensive sands and gravels. Giant glacial rivers carved deep valleys, while depressions trapped waters in large glacial lakes.


Active sand dunes, Great Sand Hills, Saskatchewan.
Rolling hills are common in Saskatchewan.

? Untouched by glaciers
A small part of Saskatchewan was never glaciated. Do you know where this is?

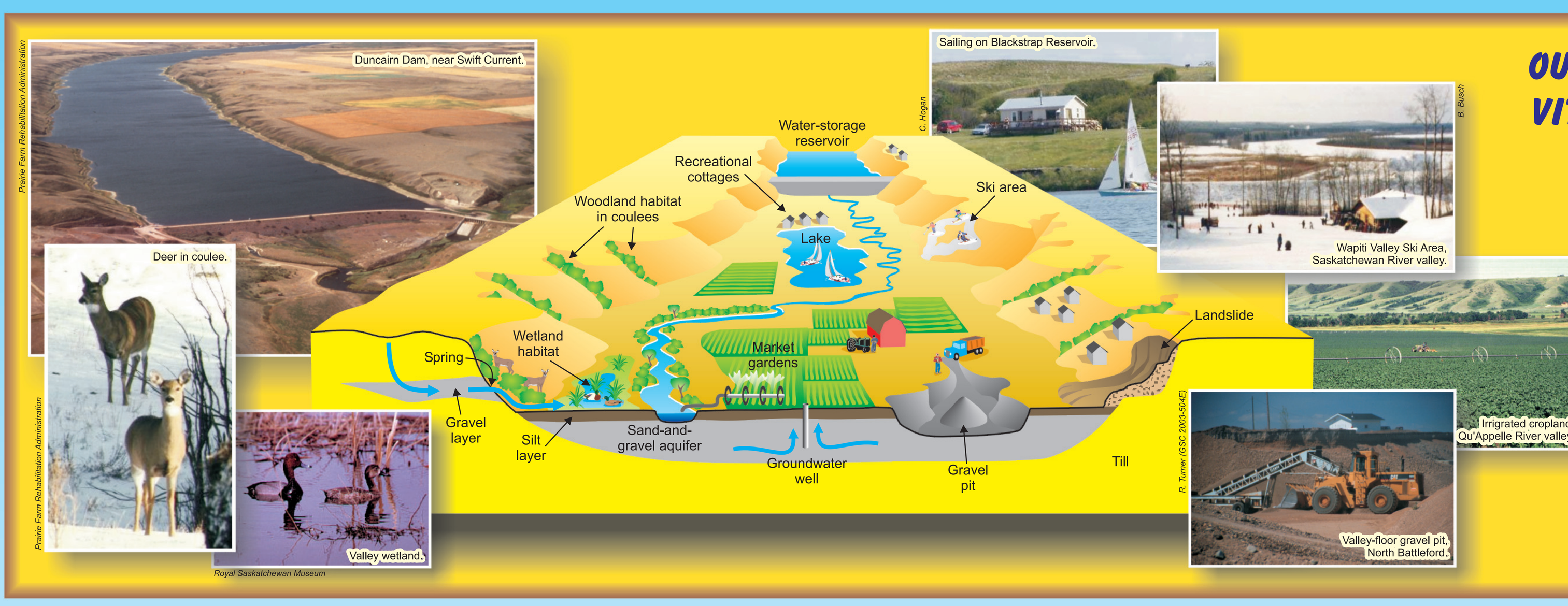


Large boulders (erratics) are common in many fields.
What ecological roles do wetland sloughs play in our dry landscape?

Different landscapes, different origins

Though many people might describe southern Saskatchewan as 'flat', it is a patchwork of diverse landscapes of different origins: rolling hills, flat plains, and long winding valleys. Rolling hills are sediments deposited in haphazard fashion from melting glaciers. Flat plains are the floors of ancient glacial lakes! The Qu'Appelle River valley and other major valleys were carved by great rivers that carried glacial meltwater towards the sea. Sloughs and potholes fill the depressions created by the melting of buried ice blocks that were left behind by retreating glaciers.

OUR BIG VALLEYS: VITAL MULTI-USE CORRIDORS



Duncairn Dam, near Swift Current.
Deer in coulee.
Valley wetland.
Sailing on Blackstrap Reservoir.
Wapiti Valley Ski Area, Saskatchewan River valley.
Irrigated cropland, Qu'Appelle River valley.
Valley-floor gravel pit, North Battleford.

Large valleys, such as the Qu'Appelle and Souris river valleys, are major landscape features of vital importance to southern Saskatchewan. These valleys provide for diverse uses — water storage, farmland, wetland habitat, woodlands, gravel pits, and even ski areas. Try to imagine Saskatchewan without its valleys!

? A puzzle:
Many large valleys such as the Qu'Appelle, Souris, and Frenchman contain streams that are too small to have carved them. How did these valleys form?

'Scotty' — Saskatchewan's own T. rex

In 1994, a remarkably complete skeleton of a *Tyrannosaurus rex* dinosaur was discovered in badlands along the Frenchman River in southwestern Saskatchewan. Dubbed 'Scotty', the fossil dates from the end of the Cretaceous Period, about 65 million years ago. Analysis of fossil plants, plant pollen, and other animals contained in the same rock layers allows scientists to interpret the environment in which Scotty lived — a deciduous forest with seasonal rainfall and no winter frost. Things sure have changed!

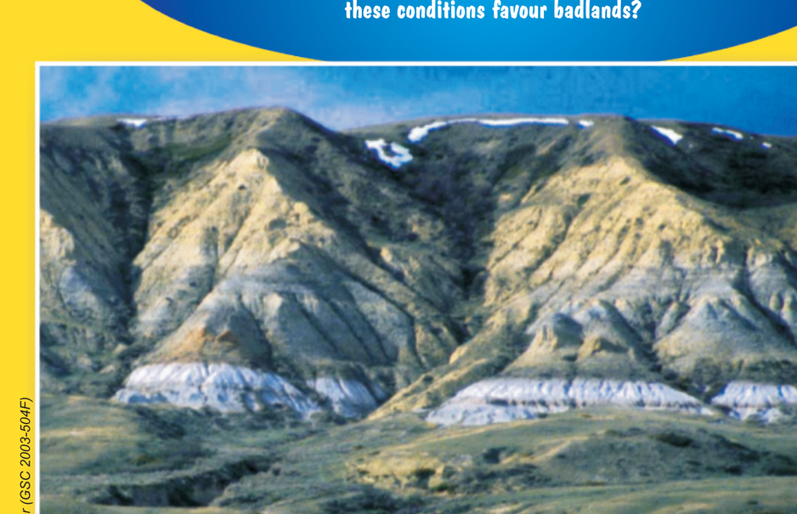
THE BADLANDS: DINOSAUR COUNTRY!

What's so bad about badlands?

Badlands are a complex terrain of largely unvegetated gullies and hills formed by differential erosion of soft shale and harder sandstone. Buttery slick when wet, and without shade in the hot sun, these lands were referred to by French explorers as "bad lands to travel through" — giving rise to the term 'badlands'. However, to many they are beautiful and fascinating.

Scotty's teeth in place in *T. Rex* quarry.
Triceratops skull.

? Making badlands — what's the recipe?
Badlands form where the natural recipe is right — the required ingredients are a semiarid climate resulting in sparse vegetation, steep slopes, summer thunderstorms that produce flash floods, and underlying soft rocks. Why do these conditions favour badlands?


Badlands, Frenchman River valley near Eastend.

For dinosaur detectives: why badlands are a good place to look

Badlands are ideal places for paleontologists to look for fossils. There is little vegetation to cover the rock that contains the fossils. The rock is being continually eroded, exposing new material every year. To find dinosaur bones, rocks of the right age — that is, rocks that formed during the Age of dinosaurs — must be exposed. Younger and older rocks can contain fossils, but not of dinosaurs.

Badlands: not just in Alberta!

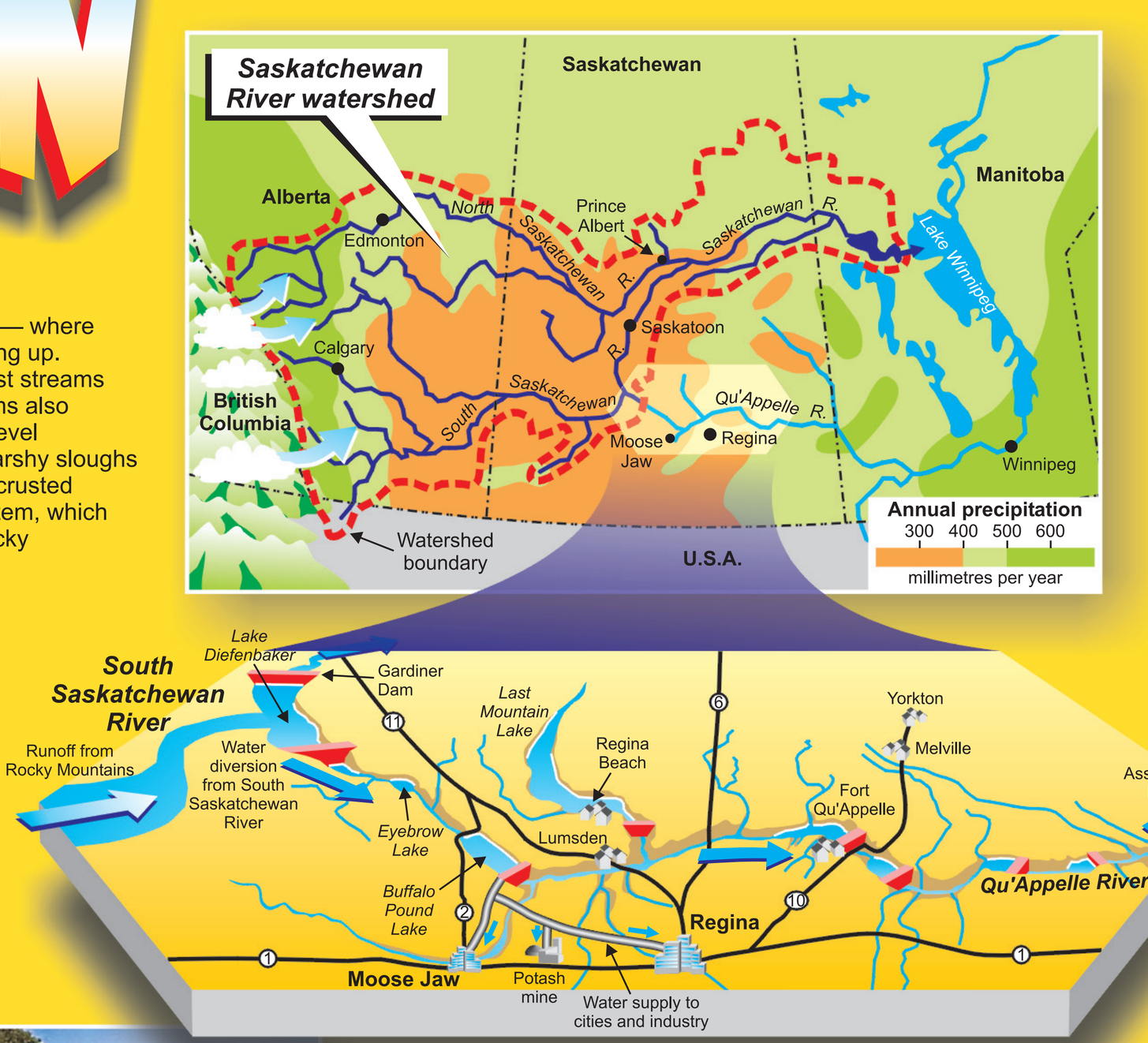
The Drumheller and Dinosaur Provincial Park areas in southern Alberta may be Canada's best known badlands, but southern Saskatchewan can lay claim to its own, in the Big Muddy, Frenchman River valley, Grasslands National Park, and Avonlea regions.

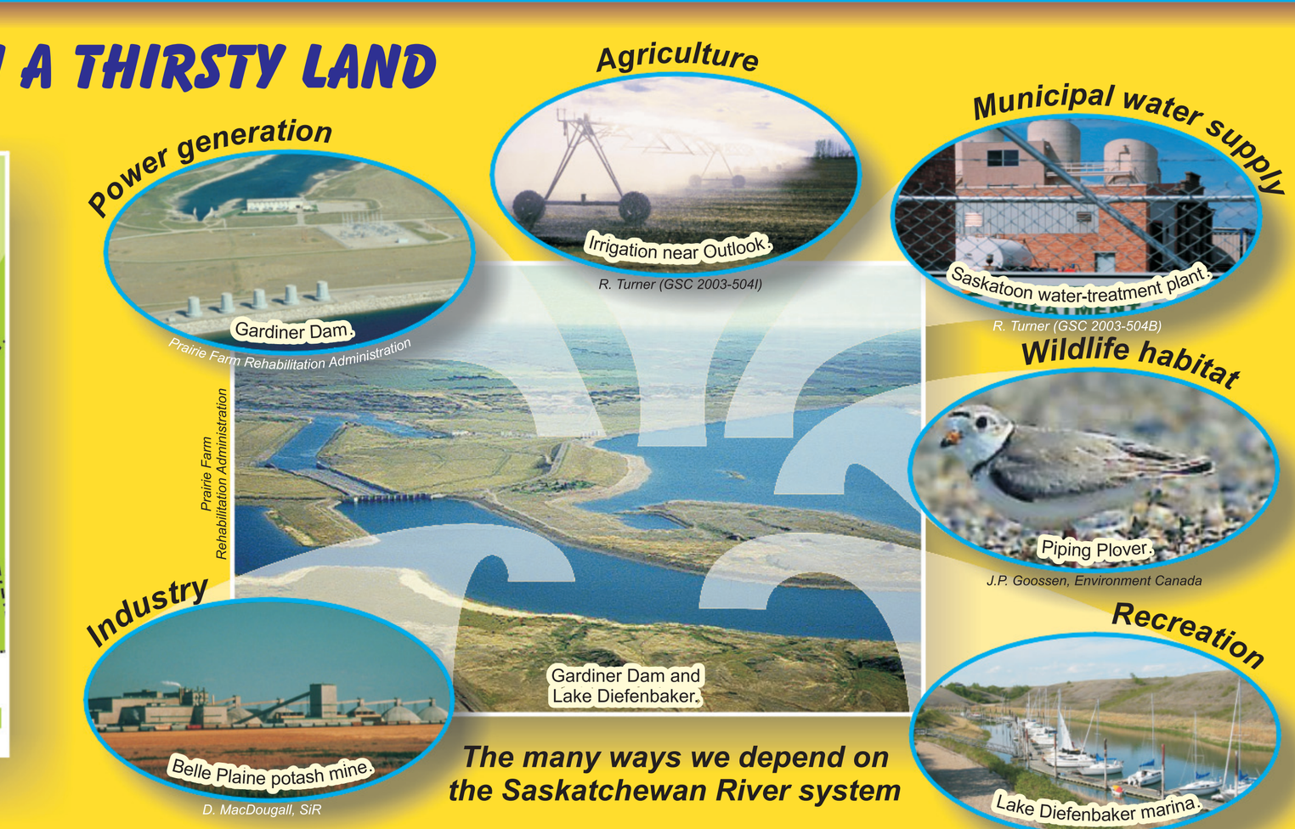
WATER: A PRECIOUS RESOURCE IN A THIRSTY LAND

Watering a dry land

Water has always been the limiting resource for prairie life — where there was sufficient water, ranches, farms, and towns sprang up. Because rainfall in southern Saskatchewan is meagre, most streams are small and originate from spring snowmelt. Many streams also receive flow from springs that help maintain a base water level throughout the year. Local streams and springs support marshy sloughs filled with the chatter of birds, and saline lakes with salt-encrusted shores. The vital exception is the Saskatchewan River system, which crosses Saskatchewan carrying waters from the far-off Rocky Mountains.

? Where does your water come from?
Every day we drain the sink, tub, and toilet. Where does your water come from? Where does your waste water go?

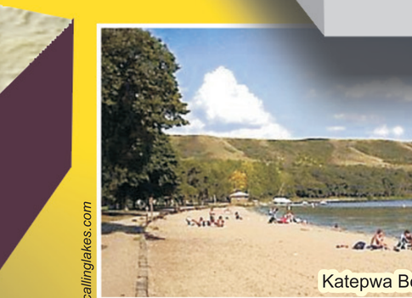




Gardiner Dam.
Irrigation near Outlook.
Saskatoon water-treatment plant.
Piping Plover.
Belle Plaine potash mine.
Gardiner Dam and Lake Diefenbaker.
Lake Diefenbaker marina.

The many ways we depend on the Saskatchewan River system

The Saskatchewan River system is the most reliable source of good-quality water in southern Saskatchewan. Over 30 communities, including Saskatoon, Regina, Prince Albert, the Battlefords, and Moose Jaw, draw their water from the river system. River water is increasingly used to irrigate farmland and generate hydroelectric power.


Katepwa Beach.

The Qu'Appelle River: borrowed water

At the end of the last ice age, the South Saskatchewan River flowed down the Qu'Appelle River valley. Today, 11 500 years later, about one per cent of the South Saskatchewan River is diverted into the Qu'Appelle River. Here, a series of reservoirs and lakes are used for recreation, irrigation, and industrial and municipal use.

? A continental divide in southern Saskatchewan
The well known continental divide in the Rockies separates streams that flow west to the Pacific from streams flowing east to Hudson Bay. Another continental divide separates waters bound for the Gulf of Mexico from those that flow north to Hudson Bay. Where is this divide?

Sodium-sulphate lake.

Where streams don't flow to the sea

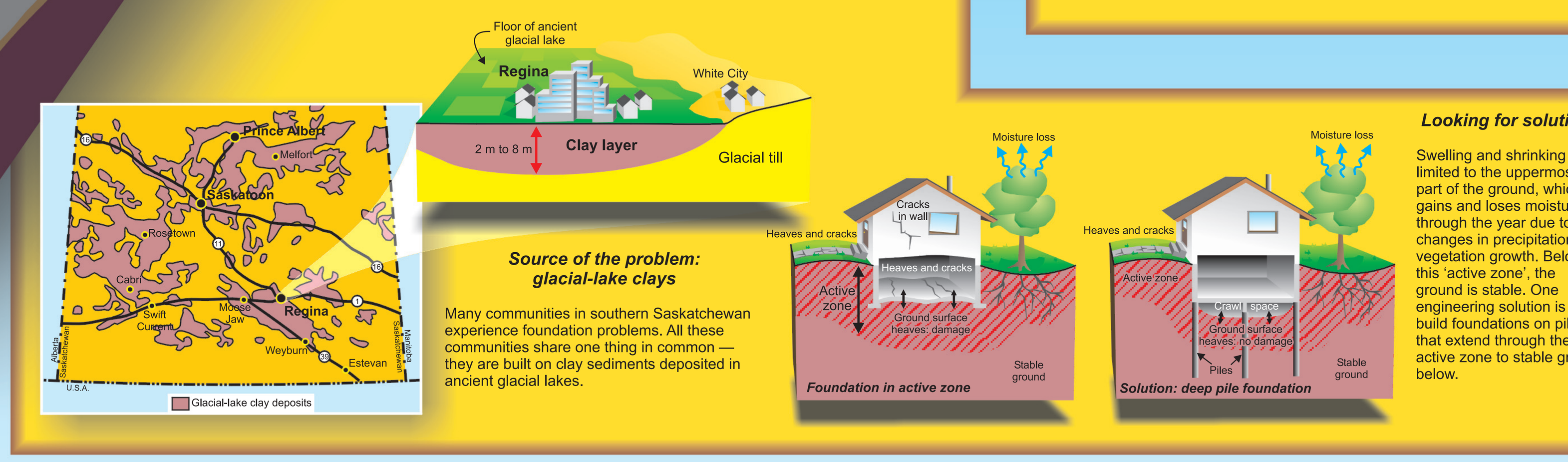
Most rivers run to the sea. However, there are large areas of southern Saskatchewan where the drainage is internal and water does not escape to the sea. Such areas are rare elsewhere in Canada. Runoff within these internal drainage basins can produce saline lakes surrounded by white salt crusts. Dissolved salts are transported in surface and ground waters to the lakes. As the lakes have no outlet stream, the salts are trapped, and concentrated by ongoing evaporation of the lake waters.

HEAVES AND CRACKS: BUILDING ON EXPANSIVE CLAYS


Cracked wall
Cracked basement wall

Regina's woes

Many Regina homeowners know these problems: cracks appear in walls, sidewalks, and driveways; the basement floor heaves and cracks, and doors and windows won't open or close. What's going on? These problems are caused by glacial-lake sediments below Regina that expand and shrink with changes in moisture content so that house foundations, sidewalks, and roads shift. These sediments contain clays that swell when they become wet, and shrink when they dry.



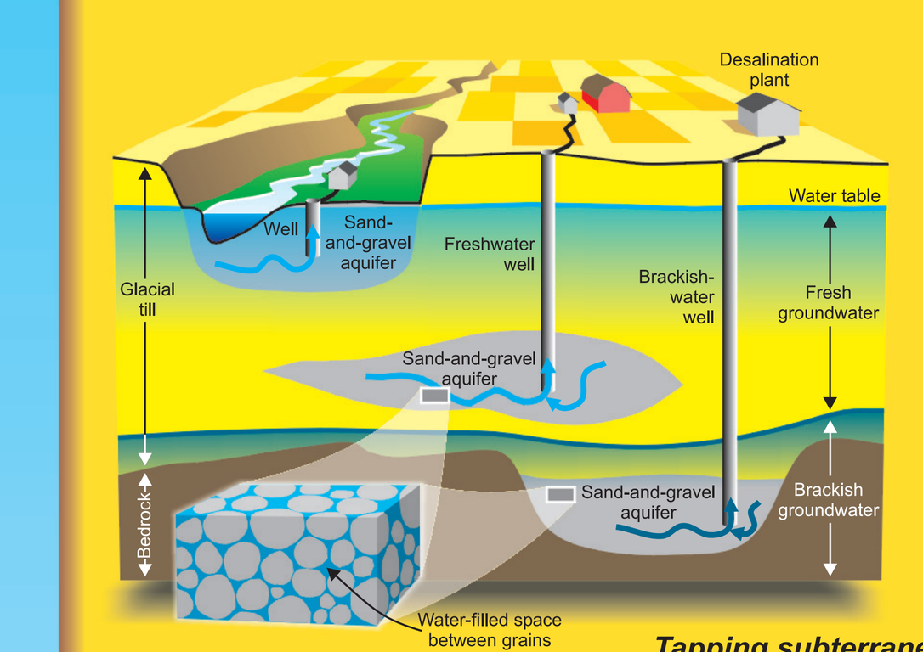
Source of the problem: glacial-lake clays

Many communities in southern Saskatchewan experience foundation problems. All these communities share one thing in common — they are built on clay sediments deposited in ancient glacial lakes.

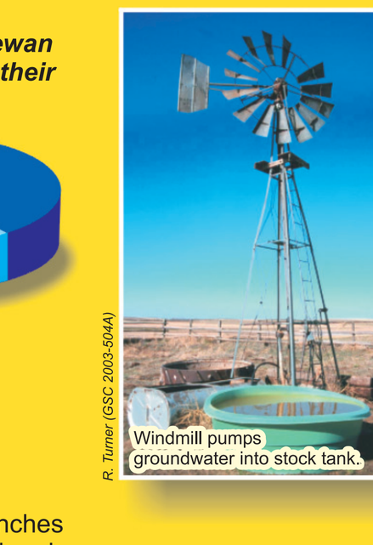
Looking for solutions

Swelling and shrinking are limited to the uppermost part of the ground, which gains and loses moisture through the year due to changes in precipitation and vegetation growth. Below this 'active zone', the ground is stable. One engineering solution is to build foundations on piles that extend through the active zone to stable ground below.

GROUNDWATER: VITAL BUT VULNERABLE

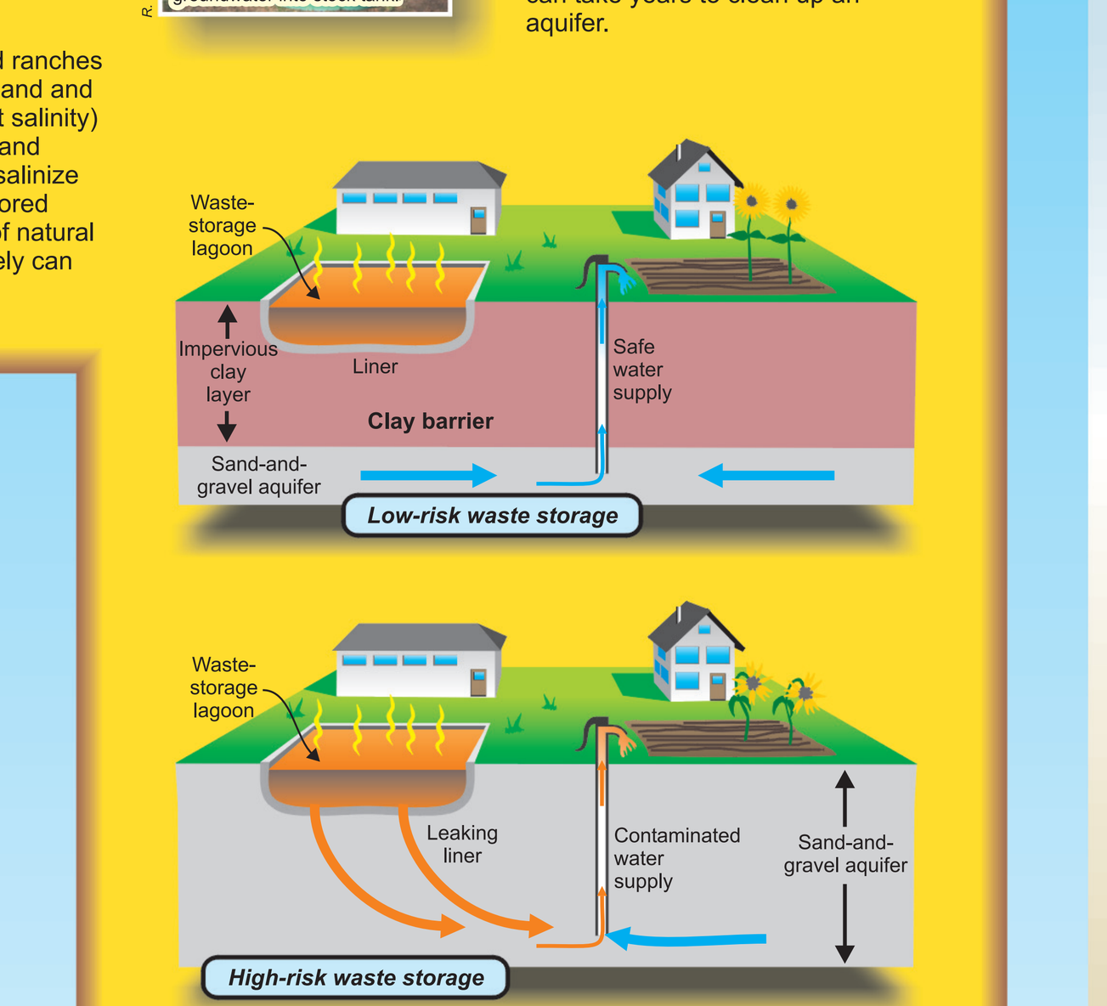


Groundwater meets the needs of about 75% of all communities and most of the farms and ranches in southern Saskatchewan. Much of this groundwater comes from aquifers composed of sand and gravel deposits that lie tens to hundreds of metres below the surface. The freshest (lowest salinity) groundwater tends to be at shallow depths. Deeper groundwater is generally more saline and therefore less useful, although some towns, such as Melville, Rosetown, and Wawota, desalinize groundwater to make it potable. If not properly managed, the amount of available water stored underground can be reduced by withdrawal of groundwater at rates that exceed the rate of natural recharge. Such depletion lowers the water table, increases the pumping cost, and ultimately can exhaust water supplies.

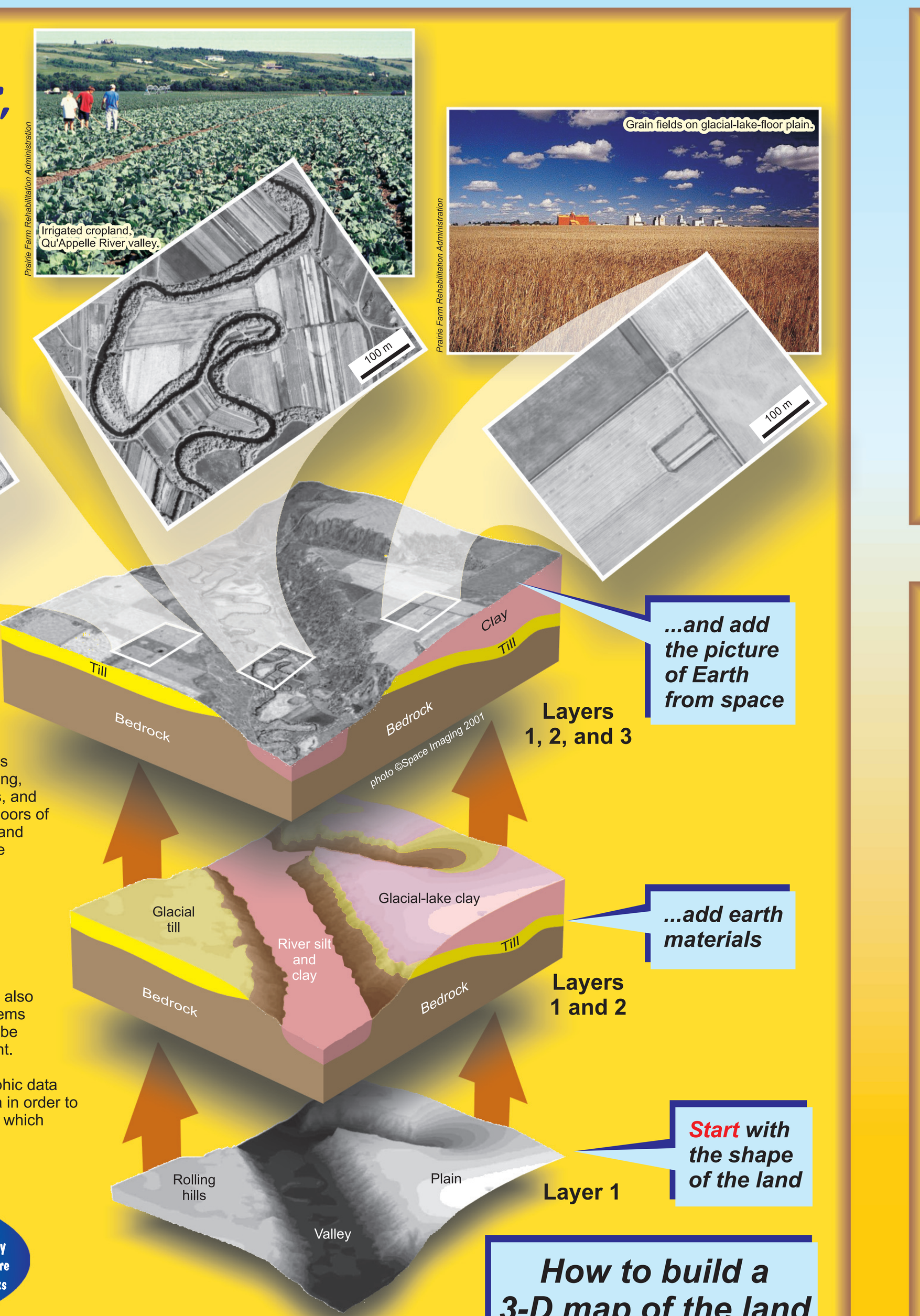

Windmill pumps groundwater into stock tank.

Waste storage: trouble underground?

Groundwater can be contaminated by industrial, agricultural, and household activities. Rainwater naturally infiltrates porous sand and gravel and can carry contaminants with it. Thick clays form natural barriers to contaminant flow and are the best materials above which to site waste-storage areas. The risk of contamination is much greater where aquifers extend to the surface and have no natural protection. Once contaminated, it can take years to clean up an aquifer.



FOOD FROM THE LAND: DIFFERENT LANDSCAPES, DIFFERENT HARVESTS



Rolling hills of glacial debris (till) with sloughs.
Irrigated cropland, Qu'Appelle River valley.
Grain fields on glacial-lake-floor plain.

How landscape controls agriculture

Any farmer will tell you that different landscapes are suited to different types of agriculture. For example, flat plains (floors of ancient glacial lakes) with rich soils are ideal for growing wheat and canola. Rolling hills of glacial deposits are suitable for pasture or grain farming, depending on the proportions of clay, silt, sand, pebbles, and boulders and on the amount of local precipitation. The floors of major valleys have rich stream deposits of silt and clay and provide important sites for market-garden farming where irrigation water is available.

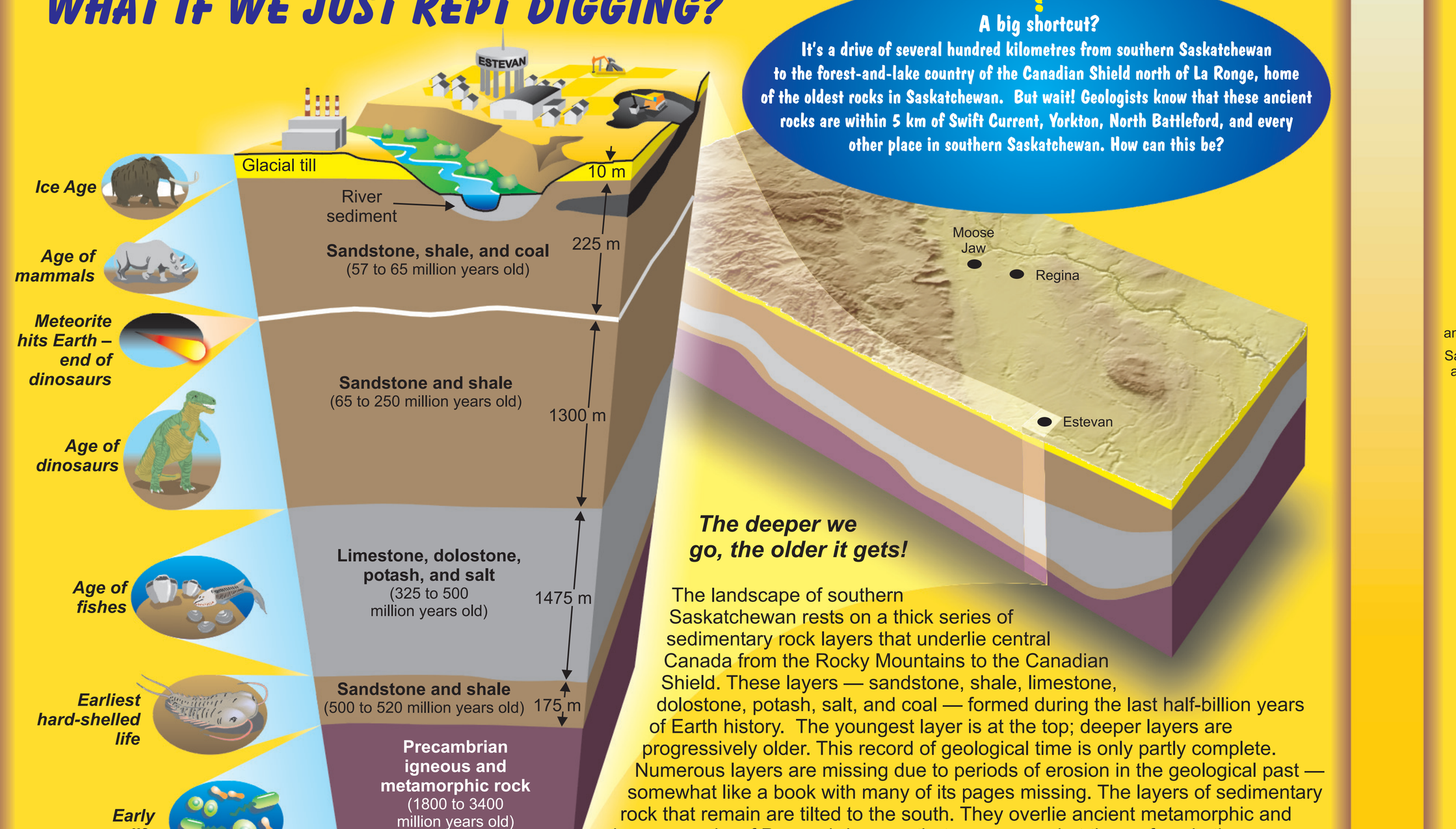
Seeing patterns in the complexity: modern management of the land

Because landscapes are complex, land management is also complex. Computer-based geographic information systems (GIS) can store complex information in 'layers' that can be combined to produce a map useful for land management. Which areas are best for cultivation? for pasture? for conservation? The map shown here combines topographic data (shape of the land) with earth-material and satellite data in order to illustrate slope, earth materials, and land cover, each of which affects the potential use of the land.

? Picking rocks
Many people who grew up on farms have memories, rarely good, of long days spent picking rocks from fields. Why are some farm soils full of rocks whereas others have no rocks at all?

WHAT IF WE JUST KEPT DIGGING?

? A big shortcut?
It's a drive of several hundred kilometres from southern Saskatchewan to the forest-and-lake country of the Canadian Shield north of La Ronge, home of the oldest rocks in Saskatchewan. But wait! Geologists know that these ancient rocks are within 5 km of Swift Current, Yorkton, North Battleford, and every other place in southern Saskatchewan. How can this be?



The deeper we go, the older it gets!

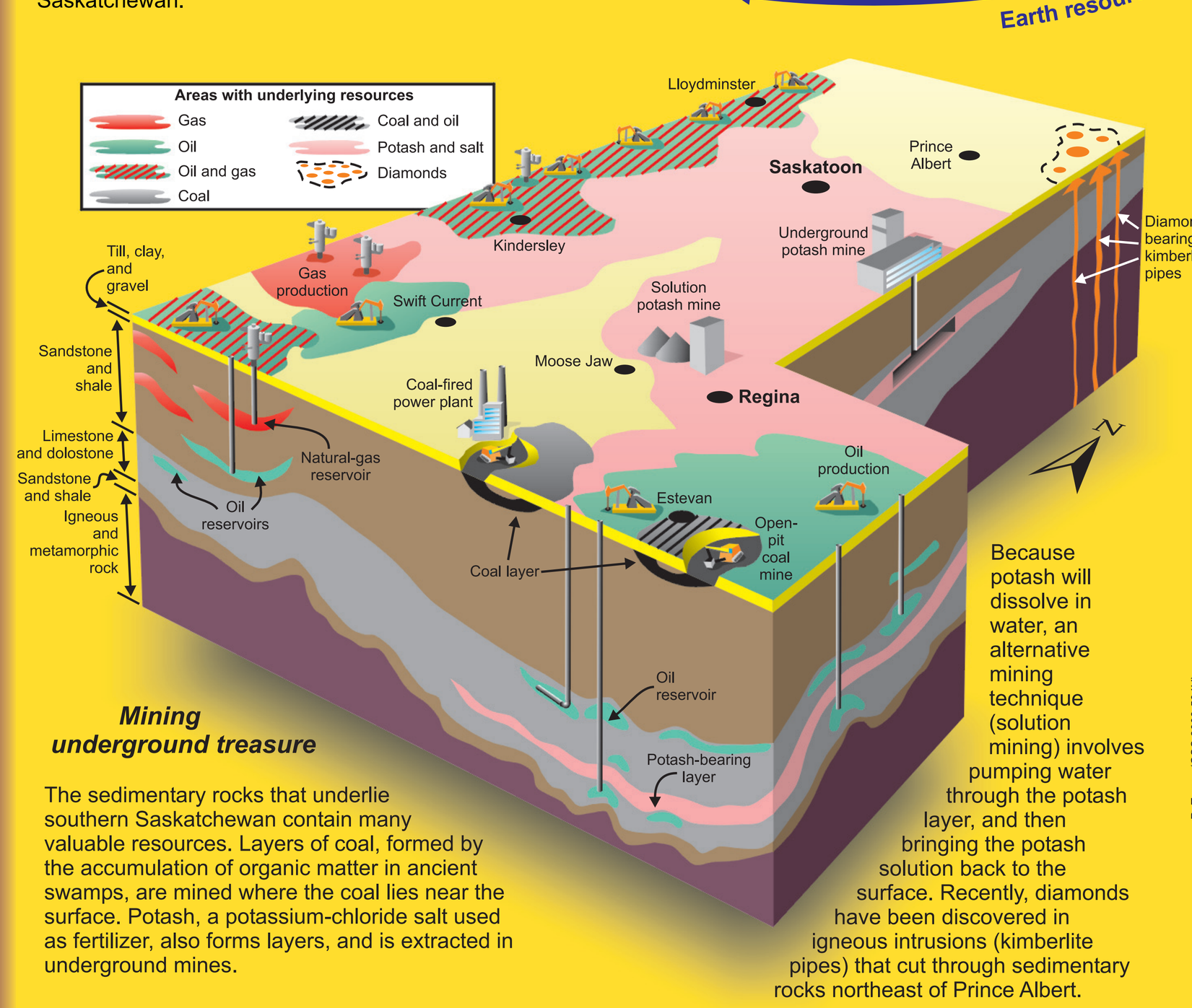
The landscape of southern Saskatchewan rests on a thick series of sedimentary rock layers that underlie central Canada from the Rocky Mountains to the Canadian Shield. These layers — sandstone, shale, limestone, dolostone, potash, salt, and coal — formed during the last half-billion years of Earth history. The youngest layer is at the top; deeper layers are progressively older. This record of geological time is only partly complete. Numerous layers are missing due to periods of erosion in the geological past — somewhat like a book with many of its pages missing. The layers of sedimentary rock that remain are tilted to the south. They overlie ancient metamorphic and igneous rocks of Precambrian age that are exposed at the surface in the Canadian Shield of northern Saskatchewan.

RICHES FROM THE EARTH: ENERGY, FERTILIZER, DIAMONDS, AND HOT WATER


Cory potash mine, near Saskatoon.

Earth resources: a billion-dollar bonanza

The production and sale of Earth resources are vital to Saskatchewan's economy. Crude oil is the largest revenue-generator, followed by potash, uranium, and natural gas. Uranium mining occurs in the Canadian Shield of northern Saskatchewan.



Mining underground treasure

The sedimentary rocks that underlie southern Saskatchewan contain many valuable resources. Layers of coal, formed by the accumulation of organic matter in ancient swamps, are mined where the coal lies near the surface. Potash, a potassium-chloride salt used as fertilizer, also forms layers, and is extracted in underground mines.

Because potash will dissolve in water, an alternative mining technique (solution mining) involves pumping water through the potash layer, and then bringing the potash solution back to the surface. Recently, diamonds have been discovered in igneous intrusions (kimberlite pipes) that cut through sedimentary rocks northeast of Prince Albert.

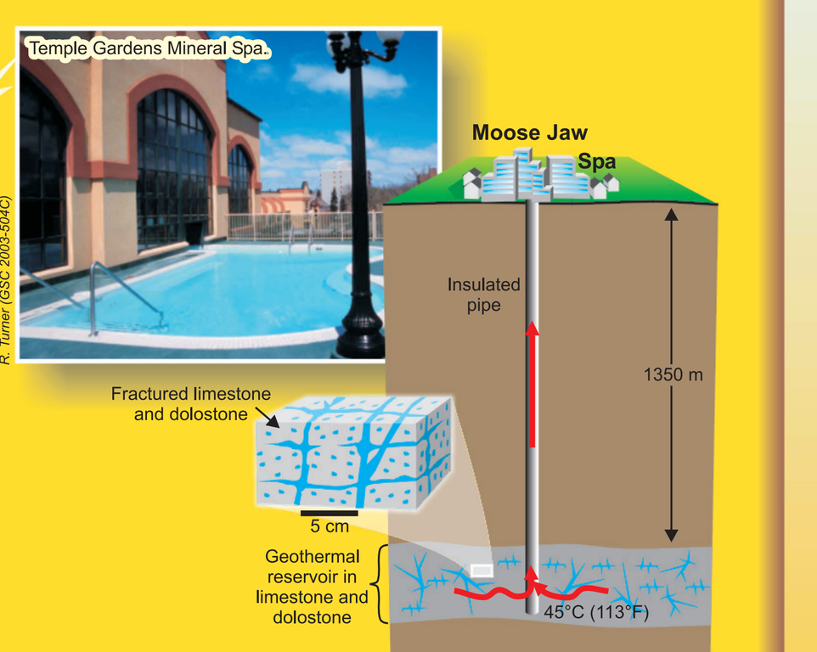
What powers Saskatchewan?

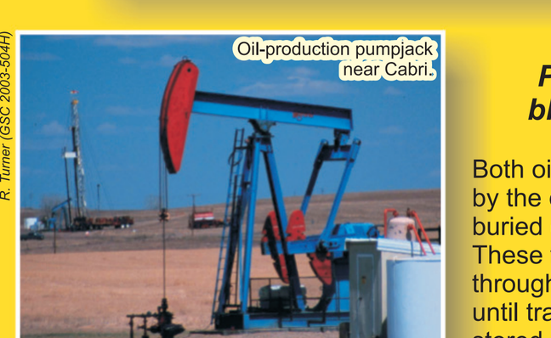
Seventy per cent of Saskatchewan's electrical power comes from coal and natural gas. Coal-fired power plants are located in Estevan and Coronach, near the coal mines that feed them. Natural-gas–fired power plants near Saskatoon, Swift Current, Landis, and Meadow Lake are used during periods of peak demand, especially in winter. Hydroelectric generating stations on the Saskatchewan River system provide most of the remaining 30% of the province's power. Wind turbines such as those near Gull Lake also contribute to Saskatchewan's energy supply.


Coal-fired power station near Coronach.
Coal-mine dragline, Estevan.

Moose Jaw spa taps deep hot water

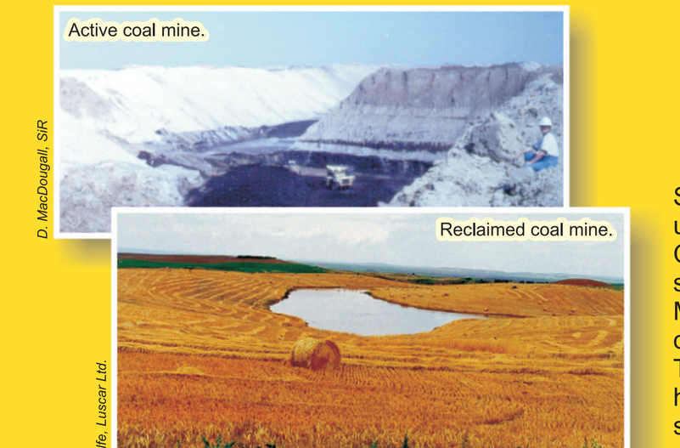
Engineers who design deep mines and drill deep wells worldwide know that the further we go into the Earth, the hotter it gets. Heated or geothermal waters circulate throughout the Earth's upper crust to depths of 10 km or more. Such hot waters underlie much of southern Saskatchewan, and the Moose Jaw spa exploits some of these. Limestone beneath Moose Jaw contains abundant water-filled fractures, making it an excellent geothermal reservoir from which large volumes of hot water are extracted. Could other towns in Saskatchewan tap into this hot-water resource?


Temple Gardens Mineral Spa.


Oil-production pumpjack near Cabri.

Pumping black gold

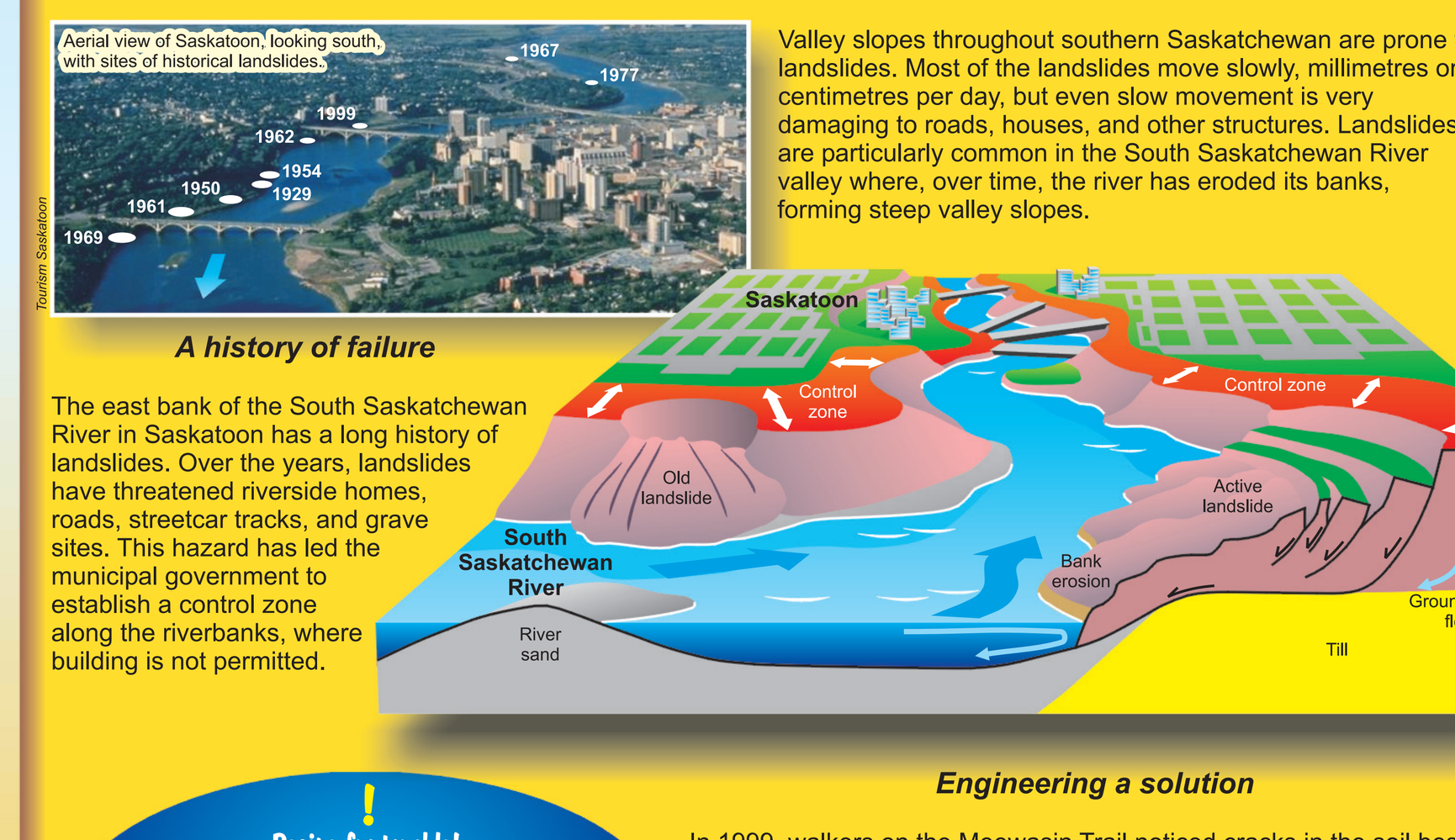
Both oil and gas form by the decay of deeply buried organic matter. These fluids migrate through layers of rock until trapped and stored in spaces (pores) between the grains or crystals in sandstone and carbonate reservoir rocks. Vertical and horizontal wells drilled into the reservoirs extract the oil and gas.


Active coal mine.
Reclaimed coal mine.

Reclaiming the land

Shallowly buried coal layers underlie the Estevan and Coronach regions of southernmost Saskatchewan. Mining this coal in surface pits disturbs large areas each year. The coal-mining industry, however, has had considerable success in returning the land to agricultural use. Prior to mining, the soil is removed and stockpiled. Afterwards, pits are filled with compacted waste-rock debris, the land surface is contoured to its original form, and the soil layer is replaced and replanted.

THE TROUBLE WITH VALLEY SLOPES: LANDSLIDES


Aerial view of Saskatoon, looking south, with sites of historical landslides.

Valley slopes throughout southern Saskatchewan are prone to landslides. Most of the landslides move slowly, millimetres or centimetres per day, but even slow movement is very damaging to roads, houses, and other structures. Landslides are particularly common in the South Saskatchewan River valley where, over time, the river has eroded its banks, forming steep valley slopes.


Beaver Creek landslide, looking north.

A history of failure

The east bank of the South Saskatchewan River in Saskatoon has a long history of landslides. Over the years, landslides have threatened riverside homes, roads, streetcar tracks, and grave sites. This hazard has led the municipal government to establish a control zone along the riverbanks, where building is not permitted.

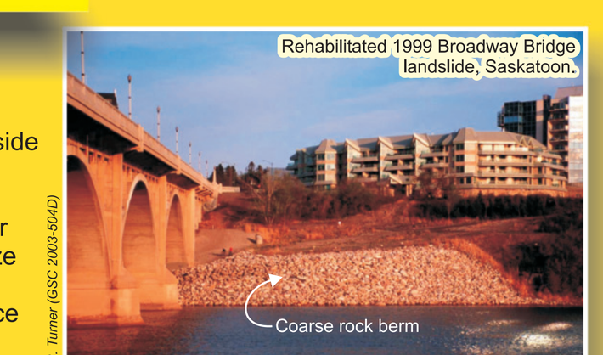
Collapsing riverbanks

The Beaver Creek landslide, which is located on the South Saskatchewan River 13 km south of Saskatoon, has expanded eastward 40 m since 1944. Movement is greatest during spring snowmelt and early summer rainstorms, when high groundwater levels lubricate the slide.

! Recipe for trouble!
What conditions favour a landslide? Here's the recipe — start with the natural pull of gravity, add some riverbank erosion to ensure the slope is steep, make sure the slope materials include soft clay, add groundwater to lubricate the slide, and presto, a landslide!

Engineering a solution

In 1999, walkers on the Meewasin Trail noticed cracks in the soil beside the Broadway Bridge over the South Saskatchewan River in Saskatoon. Within a week, the land had moved several metres. The cause of the landslide was a plugged and leaking underground water drain that elevated water pressures in the slope materials. To stabilize the landslide, the underground drain was repaired, and a berm of coarse rock was placed along the river edge to hold the slope in place and prevent bank erosion.


Rehabilitated 1999 Broadway Bridge landslide, Saskatoon.

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Geoscape Southern Saskatchewan

Geological Survey of Canada Miscellaneous Report 84, 2004
Saskatchewan Industry and Resources Miscellaneous Report 2004-7

Produced by Robert Turner, Richard Franklin, Fran Haidl, Chris Gilboy, and John Clague
Graphics and design by Richard Franklin
Central image map created by Kaz Shimamura using Canadian Digital Elevation Data from Geomatics Canada

Contributors:
Saskatchewan Industry and Resources: Chris Gilboy, Fran Haidl, and Andrew Nimegeers. **Geological Survey of Canada, Natural Resources Canada:** Robert Turner, John Clague, Kaz Shimamura, and Natalie Morisset. **University of Regina:** Janis Dale. **Prairie Farm Rehabilitation Administration:** Ophelia Dagenais, Barry Jones, Wade Nyirfa, and Malcolm Black. **Saskatchewan Watershed Authority:** Nolan Shaheen. **Royal Saskatchewan Museum:** Harold Bryant. **GE Ground Engineering:** Paul Kozicki and Tim Adelman. **Others:** Phillip Currie, Richard Franklin, Brian Eckel, and Gordon Domm.

Government of Saskatchewan

Reviewers:
We thank the many scientists, teachers, and others who reviewed this poster at various phases of its development.

Contributors to an early draft of Geoscape Southern Saskatchewan:
Saskatchewan Industry and Resources: Kim Kreis and Lynn Kelley. **Geological Survey of Canada, Natural Resources Canada:** Don Lemmen, Laverne Stasiuk, Bill McDougall, and Harvey Thorleifson. **Prairie Adaptation Research Collaborative:** Dave Sauchyn.

Recommended citation:
Turner, R.J.W., Franklin, R.G., Haidl, F.M., Gilboy, C.F., and Clague, J.J. 2004: Geoscape Southern Saskatchewan; Geological Survey of Canada, Miscellaneous Report 84; Saskatchewan Industry and Resources Miscellaneous Report 2004-7.

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Publications
- **Geological Highway Map of Saskatchewan.** Illustrated with 60 photographs and figures of roadside geological features. Available through the Saskatchewan Geological Society at Box 234, Regina, SK S4P 2Z6, or Tourism Saskatchewan, http://www.sasktourism.com
- **Geological History of Saskatchewan** by John Storer. A richly illustrated review of Saskatchewan's landscapes through geological time. 90 pages. Available through Royal Saskatchewan Museum (see web site address below).

Museums
- Royal Saskatchewan Museum, 2445 Albert Street, Regina, SK S4P 3V7, http://www.royalsaskmuseum.ca/
- T. rex Discovery Centre, Eastend, SK S0N 0T0 (306) 295-4009, http://www.dinocountry.com

Government agencies
- Saskatchewan Industry and Resources (SIR), 201 Dewdney Avenue East, Regina, SK S4N 4G3, http://www.ir.gov.sk.ca
- Saskatchewan Watershed Authority, 111 Fairford Street East, Moose Jaw, SK S6H 7X9, http://www.swa.ca
- Agriculture and Agri-Food Canada, Prairie Farm Rehabilitation Administration 403-1800 Hamilton Street, Regina, SK S4P 4L2, http://www.agr.gc.ca/pfra

Universities
- Department of Geography, University of Regina, Regina, SK S4S 0A2, http://www.uregina.ca/arts/geography/
- Department of Geology, University of Regina, Regina, SK S4S 0A2, http://www.uregina.ca/geology/
- Department of Geography, University of Saskatchewan, Saskatoon, SK S7N 5A5, http://www.usask.ca/geography/
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Canada

Catalogue no. M41-8/84E
ISBN 0-660-19193-8