Water-Quality Assessment of the Central Nebraska Basins—

Entering a New Decade

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In 2001, the U.S. Geological Survey's (USGS) National Water-Quality Assessment (NAWQA) Program began its second decade of intensive water-quality assessments (Cycle II). NAWQA scientists plan to revisit 42 major river-basin and aquifer systems (called study units) that were assessed in the first decade (Gilliom and others, 2001).

The NAWQA Program is a primary source for long-term, nationwide information on the quality of streams, ground water, and aquatic ecosystems. The goals of NAWQA are to assess the status and trends of water quality and to understand the factors that affect it, thus addressing the questions:

- What is the condition of our Nation's streams and ground water?
- How is water quality changing over time?
- How do natural features and human activities affect the quality of streams and ground water?

For Cycle II assessments, study units were selected that represent a wide range of important hydrologic environments; contain critical contaminant sources, including agricultural, urban, and natural sources; and include more than 60 percent of national water use for drinking and irrigation (Gilliom and others, 2001). Many of the predominantly agricultural study units and most of the large urban areas included in the first cycle of NAWQA assessments were retained for Cycle II. Central Nebraska (fig.1) is one of the most intensively agricultural areas being examined in Cycle II, as determined from the extent of agricultural land and intensity of estimated pesticide and fertilizer use.

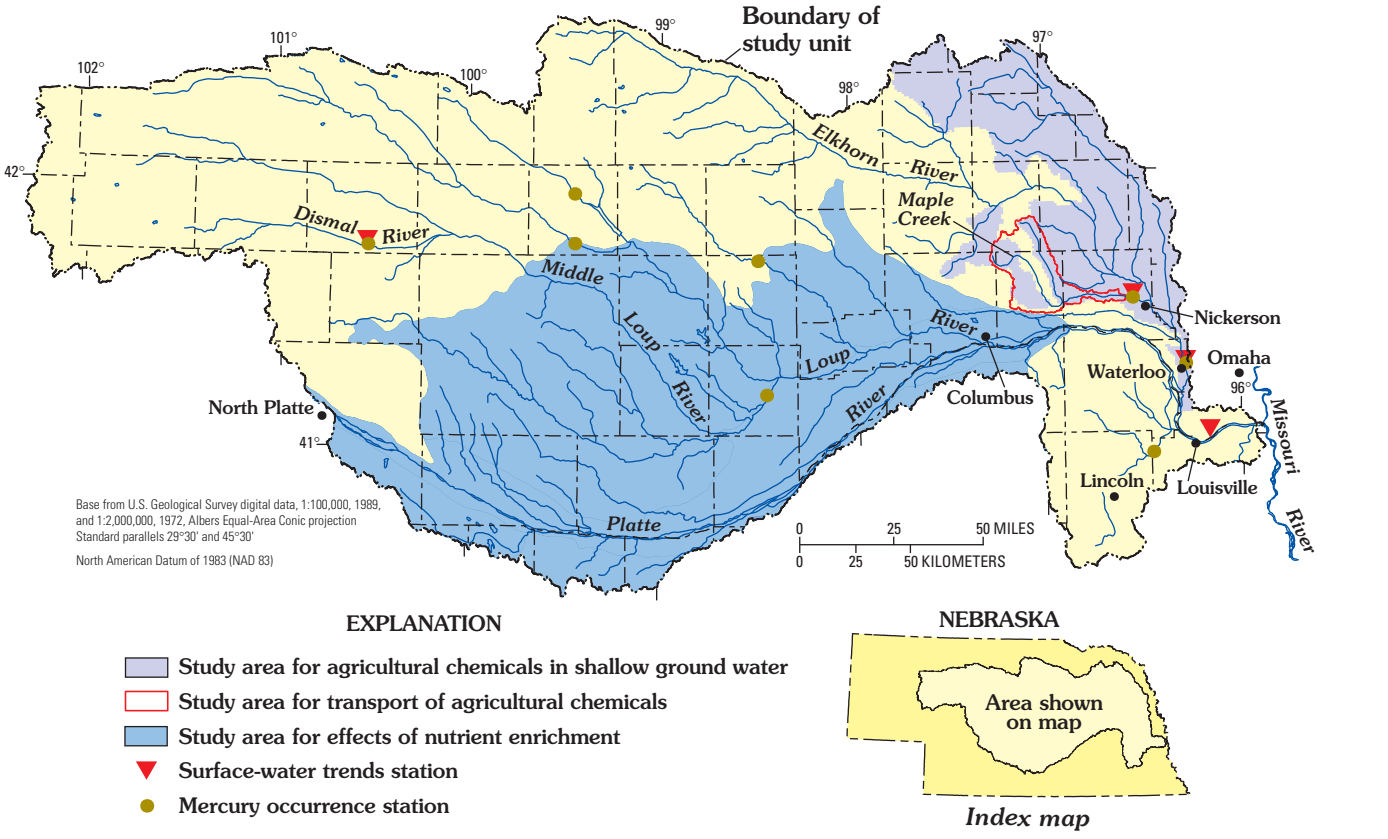

Figure 1. Central Nebraska Basins study unit showing studies planned for Cycle-II revisit.

Aerial view of a sandy, braided channel of the Platte River.

Central Nebraska Basins

The Central Nebraska Basins assessment focuses on the area drained by the Platte River downstream of the confluence of its forks near North Platte, Nebraska (fig. 1). Within this approximately 30,000-mi^2 (square-mile) study unit, USGS scientists collect and analyze information on water chemistry, hydrology, land use, stream habitat, and aquatic life. By continuing this study-unit assessment during Cycle II as an interdisciplinary and long-term resource evaluation, findings will describe the general health of water resources, as well as current and emerging water-quality issues. Such information is essential for developing management strategies for protecting and restoring water quality.

Through adherence to the NAWQA national design and use of nationally consistent sampling and analytical methods, water-quality conditions in the Central Nebraska Basins can be compared to those in other geographic regions, and to those documented during Cycle I, to advance an understanding of water-quality changes through time.

Although NAWQA is a comprehensive effort to assess the quality of streams and ground water, no single program can address or anticipate all relevant water-resource issues. Only through collaboration with numerous government agencies, researchers, and interest groups can the program address the information needs of local, State, regional, and national stakeholders. Input from these partners continues to be critical and helps to define the key water-quality issues on which to focus as the Central Nebraska Basins assessment moves into its second cycle.

Major Water-Quality Issues

Agriculture is the dominant land use in central Nebraska (Zelt, 1996), and agricultural practices can affect the quantity and quality of water resources. For example, agricultural nonpoint sources have been linked to contamination of streams by runoff containing fecal bacteria and nutrients (that is, forms of nitrogen and phosphorus) (Nebraska Department of Environmental Quality, 2002). During 1992–95, nitrate levels in the Platte River alluvial aquifer averaged among the highest of any NAWQA study unit, and nutrient concentrations in streams draining central Nebraska cropland where corn and soybeans predominate were among the largest in the Nation (Frenzel and others, 1998). Sources of nutrients include raw or treated sewage, commercial fertilizers, and animal manure. In 2000, Nebraska ranked second nationally in total numbers of cattle and cattle on feed (National Agricultural Statistics Service, 2000), and cattle waste, together with wastes from other livestock, wildlife, and pets, constitutes a major nutrient source in the environment. Pesticide concentrations in Nebraska streams during 1992–95 were among the largest measured at any NAWQA site, and pesticides were detected in all water samples from the Platte River alluvial aquifer (Frenzel and others, 1998). Mercury contamination of fish tissue exceeded water-quality criteria during 1997–2000 in five streams and five lakes in the study unit (Nebraska Department of Environmental Quality, 2002).

Several water-quality concerns are most evident in eastern parts of the study unit. NAWQA results from Cycle I indicated that the Elkhorn River Basin contributed the majority of herbicides transported from the Platte River Basin (Frenzel and others, 1998). Infiltration of herbicides and other surface-water contaminants to shallow alluvial ground water concerns some municipal water suppliers along the Platte Valley (Verstraeten and others, 1999; Heberer and others, 2001). Recent legislation requires State inspections of livestock feeding operations—more common in eastern Nebraska than in western Nebraska—to identify water contamination by livestock wastes, primarily from cattle and hogs. Nebraska's pork industry, primarily in eastern Nebraska, was the sixth largest in the country in 2000 (National Agricultural Statistics Service, 2000). Sedimentation is especially common in eastern parts of Nebraska where fine-textured soils predominate. Recovery efforts for the pallid sturgeon in Nebraska are focused on the lower Platte River and the Missouri River.

Central Nebraska Basins Revisited

As part of the second cycle of NAWQA assessments in the Central Nebraska Basins, efforts will focus on five major activities, including (1) water-quality trends in streams draining cropland, grassland, and mixed land uses; (2) agricultural chemicals in shallow ground water underlying the lower Elkhorn River Basin; (3) transport and fate of agricultural chemicals in the intensively farmed drainage of Maple Creek; (4) effects of agriculture and associated nutrient enrichment on stream biology; and (5) occurrence of mercury contamination in stream ecosystems.

Water-Quality Trends in Streams

The trends component of NAWQA is intended to identify significant time trends in water-quality conditions in streams through long-term monitoring from 2002 through 2010, which can enable resource managers and policymakers to assess the value of programs such as conservation, farming practices, and planned urban growth. Data are being collected at four surface-water trends stations in the study unit (fig. 1) where NAWQA monitoring began in 1992.

Two of the surface-water trends stations represent the effects of a specific land use. The Dismal River near Thedford represents grazing of mostly undeveloped grassland in the Sand Hills region. Because overland flow is minimal and base flow is maintained by ground-water discharge from the High Plains aquifer system, streamflow varies little. With just 3 percent of its drainage area used for cropland, effects of agriculture on stream-water quality are minimal. Maple Creek near Nickerson represents agricultural production of corn and soybeans. Its drainage area of 370 mi^2 is 85-percent cropland, mostly underlain by fine-textured soils that produce its runoff-dominated hydrology.

The remaining two surface-water trends stations represent effects of mixed land uses across large drainage basins. The Elkhorn River at Waterloo is located immediately upstream from the confluence of the Elkhorn and Platte Rivers. Principal land uses in this drainage area of 6,900 mi^2 are cropland (56 percent) and pasture and rangeland (33 percent). The Platte River at Louisville is downstream from the confluence of the Platte River with the Elkhorn River and integrates the water quality of the entire Platte River Basin. Mean annual streamflow from its drainage area of 85,400 mi^2 is 7,160 ft^3/s (cubic feet per second), or 5.19 million acre-feet. Within the study unit, the Platte River drains chiefly cropland (36 percent) and pasture and rangeland (54 percent).

Continuous monitoring of water quality began in April 2002 at all four surface-water trends stations. Specific conductance, water temperature, pH, and dissolved oxygen are being monitored at three stations. Continuous monitoring of the Platte River at Louisville is currently limited to recording specific conductance and temperature because the single monitoring point may not be representative of the highly varied conditions across the channel.

During 2002, from 12 to 25 water samples were collected at each surface-water trends station. Samples were submitted for laboratory analyses of chloride, sulfate, nutrients, organic carbon, pesticides, and suspended sediment. In subsequent years, fewer samples will be collected and, in some cases, fewer analytical determinations will be made per sample or selected additional contaminants of concern (glyphosate and endosulfan) will be determined. Ecological monitoring at the four trends stations includes NAWQA's standard ecological reach assessment—samples of fish, invertebrate, and algal communities; and habitat characterization. Biological samples are being collected annually during low-flow conditions in late summer.

Ben Dietsch, USGS hydrologist, lowers a water sampler into the Platte River near Louisville.

Agricultural Chemicals in Shallow Ground Water

Studies of agricultural land-use effects in the NAWQA Program track the changes in contaminant levels in shallow ground water in selected important agricultural areas of the Nation where contaminant sources are intense and where drinking-water sources may be affected. Specifically, the agricultural land-use effects study begun in Nebraska in 2002 will help determine if agricultural contaminants are moving from the land surface into the shallowest part of the ground-water system underlying areas of corn and soybean production. The study area (fig. 1) is in the lower Elkhorn River Basin, a region characterized as semiarid to subhumid plains with a poorly permeable surface and subsurface. The study area includes cropland with land use of greater than 20 percent corn production and 20 percent soybean production.

Sampling locations were selected throughout the study area and 31 monitoring wells were installed. Soil samples were collected from the

soil column removed during drilling to determine how soil characteristics varied with depth. Soil samples will be analyzed for nutrients, chloride, and physical properties related to permeability and soil moisture. Ground-water samples will be collected from each monitoring well in spring 2003 and analyzed for major ions, nutrients, trace elements, dissolved organic carbon (DOC), and pesticides. In addition, one-quarter of the samples will be analyzed for indicators of the age of the ground water. Beginning in October 2003, samples will be collected quarterly from a subset of these wells, and beginning in 2005 they will be sampled only once every 2 years to monitor trends.

The results of the sample analyses will be evaluated to address four questions: (1) Occurrence—which constituents were detected and at what frequency? (2) Magnitude—which constituents occurred in the largest concentrations, and which were at concentrations of concern relative to water-quality criteria? (3) Spatial distribution—are there spatial patterns of constituent occurrence and do the patterns correlate with the factors that affect shallow ground-water quality? (4) Background—how do the levels of constituent concentrations compare with those found at sites in non-cropland areas (reference sites)?

Transport and Fate of Agricultural Chemicals

In 2002, NAWQA began a new study addressing the questions, "How do environmental processes and agricultural practices interact to affect the transport and fate of agricultural chemicals in the hydrologic system of nationally important agricultural settings, and what are the effects on water quality and implications for management of water resources?" Each agricultural setting is a unique combination of a particular agricultural system (management of crops, soil, and water) and hydrologic setting (precipitation, soil surface, soil water, shallow ground water, subsurface drains, and streamflow). The specific objectives of the study are to (1) determine the residence times and rates of movement of water and agricultural chemicals in each component of the hydrologic system; (2) identify the important chemical transformation and transfer processes for selected agricultural chemicals; (3) interpret, extrapolate, and predict the fate and transport of water and selected agricultural chemicals; and (4) identify the implications of study results for water management, agricultural systems, and water-quality policy.

In Nebraska, the study will include sampling most components of the hydrologic setting. The study area is in the intensively agricultural drainage of Maple Creek (fig. 2). A small research watershed has been selected and will be studied intensively from 2003 to 2005. Planned data-collection activities in the small research watershed include operating a weather station equipped with a precipitation sampler, overland-flow sampling sites, lysimeters for soil-water (vadose-zone) monitoring, ground-water monitoring wells, and a stream-sampling station at the outlet (fig. 2*A*). Near the Maple Creek surface-water trends station, a series of monitoring wells along a ground-water flow path will lead to lysimeters and shallow wells at a ground-water/surface-water interaction study site (fig. 2*B*). Additionally, sampling of tile-drain flow is planned in a second small research watershed yet to be selected.

The types of planned analyses dictate which laboratory determinations are required for each type of sample. Precipitation samples will be analyzed for pesticides. Surface-water samples will be analyzed for nutrients, trace metals, organic carbon, pesticides, and suspended sediment. Ground-water samples will be analyzed for major ions, nutrients, pesticides, and dissolved gases. Flow from tile drains will be analyzed for major ions, nutrients, organic carbon, pesticides, and suspended sediment. Soil-core samples will be analyzed for bulk density, particle size, percentage of organic matter, soil moisture, chloride, and nitrate.

Brenda Woodward, USGS field assistant, measures flow velocity for physical habitat characterization of Maple Creek.

Geographic data on crop types, cropland management practices, and pesticide-, fertilizer-, and water-use patterns will be collected for the Maple Creek and small research watersheds. Also, numerical ground-water and surface-water models are being developed to address the study objectives. Process-based models are used at multiple scales to refine understanding of the transport and transformation of agricultural chemicals along hydrologic pathways.

Effects of Nutrient Enrichment on Stream Biology

The goal of a new NAWQA study for Cycle II is to determine how biological communities and processes respond to varying levels of nutrient enrichment among agricultural streams from contrasting environmental settings. This study currently involves six NAWQA study units to represent different environmental

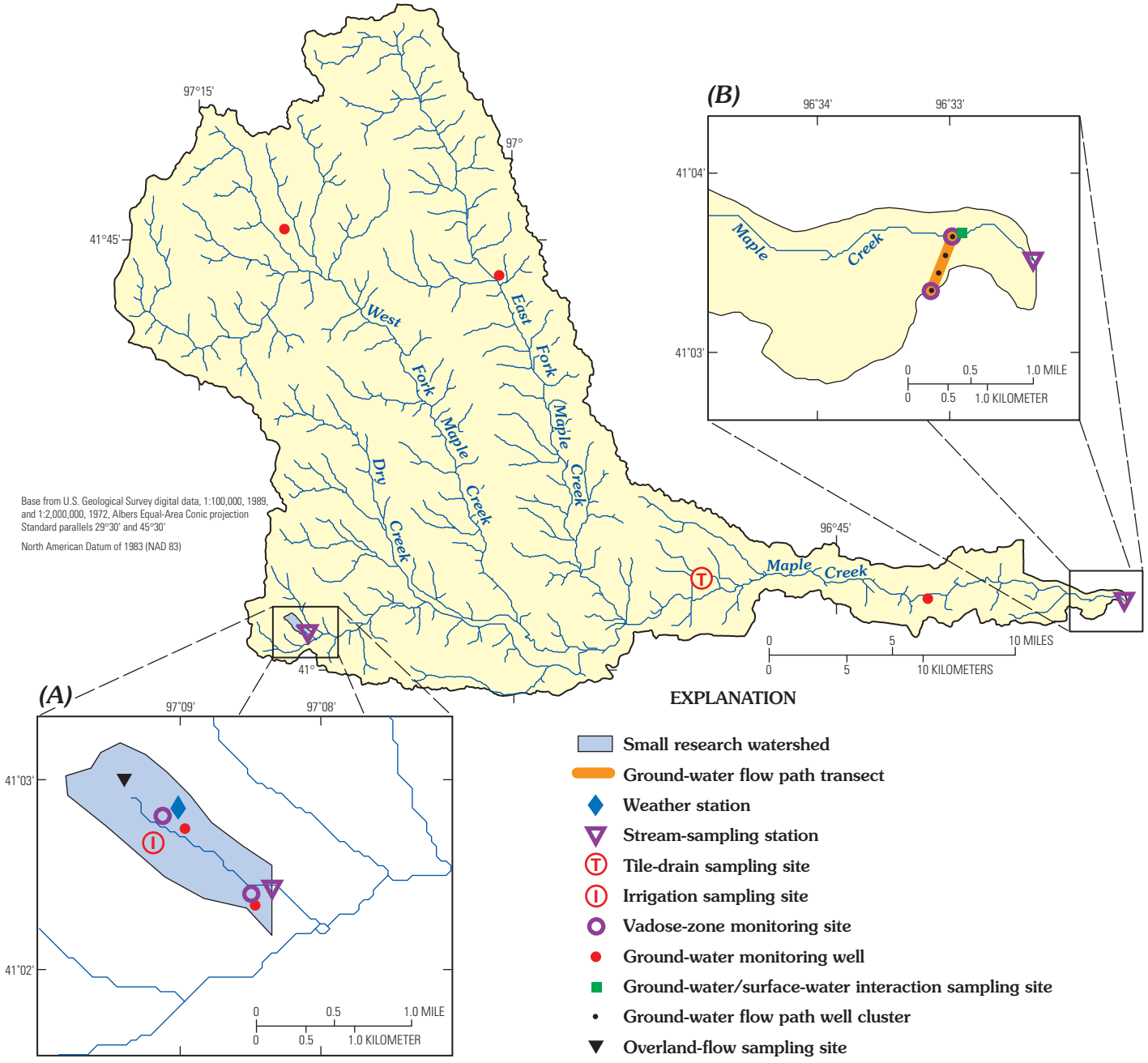

Figure 2. Study area for transport of agricultural chemicals and approximate locations of expected sampling sites.

settings affected by agricultural activities, including the Central Nebraska Basins. The study has four objectives:

- Determine how biological communities are related to nutrient conditions in streams.
- Evaluate the relations between nutrients, algae, and stream metabolism, or the processes whereby (1) carbon dioxide and nutrients are consumed by algae, producing oxygen, and (2) algal decomposition consumes oxygen and recycles nutrients.
- Determine how algae, stream metabolism, and nutrient dynamics are interrelated within short lengths of a few representative streams.
- Determine the extent to which relations between biological communities and nutrient conditions can be generalized to larger regions by using analyses of geographic factors.

For the Nebraska component of the study, a list of potential study sites was compiled, and their respective drainage areas were characterized using geographic data. Following field reconnaissance sampling, an integrated nutrient index was constructed. Study sites will be selected early in 2003 to characterize the range of the nutrient index and will be focused within a single nutrient ecoregion (U.S. Environmental Protection Agency, 2000). However, the selected sites will

Algal growth in Clear Creek near Columbus.

include as narrow a range of stream size, type, and hydrologic setting as is practical for that region.

Data for assessments of water quality, algae, invertebrates, and physical habitat will be collected from about 28 Nebraska streams during summer 2003. At each sampling site, plans include measurements of specific conductance, pH, water temperature, and dissolved oxygen on a continuous basis for a 48-hour period to allow the calculation of stream metabolism.

Mercury in Stream Ecosystems

Methylmercury, the most toxic form of mercury, accumulates in low-level members of aquatic food webs, and its concentration in tissue progressively increases as higher level predators consume lower level organisms. At the top of the food web, fish, wildlife, and humans that consume fish can be exposed to harmful levels of methylmercury. As part of NAWQA, a recently begun study of mercury contamination in streams across the Nation will describe the occurrence of total mercury and methylmercury in water and sediment, and total mercury in fish. Sampling sites were selected to represent the large national range of mercury deposition and across the ranges of the transport and methylation of mercury in differing aquatic ecosystems. The study of mercury occurrence complements additional NAWQA work that will examine in detail the cycling of mercury in the environment and food webs at a small subset of the sites sampled nationally in 2002.

Of approximately 112 sites sampled nationally in 2002, 8 are in Nebraska (fig. 1). Samples of fish fillets, water, and bed sediments were collected during low-flow conditions in July 2002. Widely available predacious fish species, of approximately 3 to 4 years of age, were targeted for sampling. Channel catfish were sampled at five Nebraska sites, and black crappie, creek chub, and largemouth bass were sampled at one site each. Laboratories will determine mercury concentrations and fish-specimen age.

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NAWQA Data are Readily Available

The large NAWQA database about water-quality conditions and other information is accessible on the World Wide Web (http://water.usgs.gov/nawqa/data). The NAWQA Program encourages use of these data for a wide range of analyses.

NOTE: Parts of this fact sheet were modified from USGS Fact Sheet 071–01.

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