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NORTH PLATTE NATURAL RESOURCES DISTRICT

Surface-Water/Ground-Water Interaction and Implications for Ground-Water Sustainability in the Dutch Flats Area, Western Nebraska

—*Gregory V. Steele*[1], *Ingrid M. Verstraeten*[1], *and James C. Cannia*[2]

SIGNIFICANT FINDINGS

Surface water, and to a lesser extent ground water, are used extensively in western Nebraska for agricultural, domestic, and industrial supplies. In the Dutch Flats area, Nebraska, the surface water and ground water interact such that the ground water is sustained by seepage of surface water from irrigation canal systems. Seasonal infiltration of surface water from canal seepage raises ground-water levels about 10 feet above seasonal low water levels near the canals and locally dilutes nitrate concentrations in ground water near the canals and their laterals. However, away from the canals, ground-water-level rises are not as pronounced, and water applied for irrigation transports nitrogen from the land surface to the ground water. Direct seepage of water from canals and laterals recharges the ground water with water containing small nitrate concentrations, whereas recharge from water that is applied to the fields tends to recharge water at shallow depths with larger nitrate concentrations.

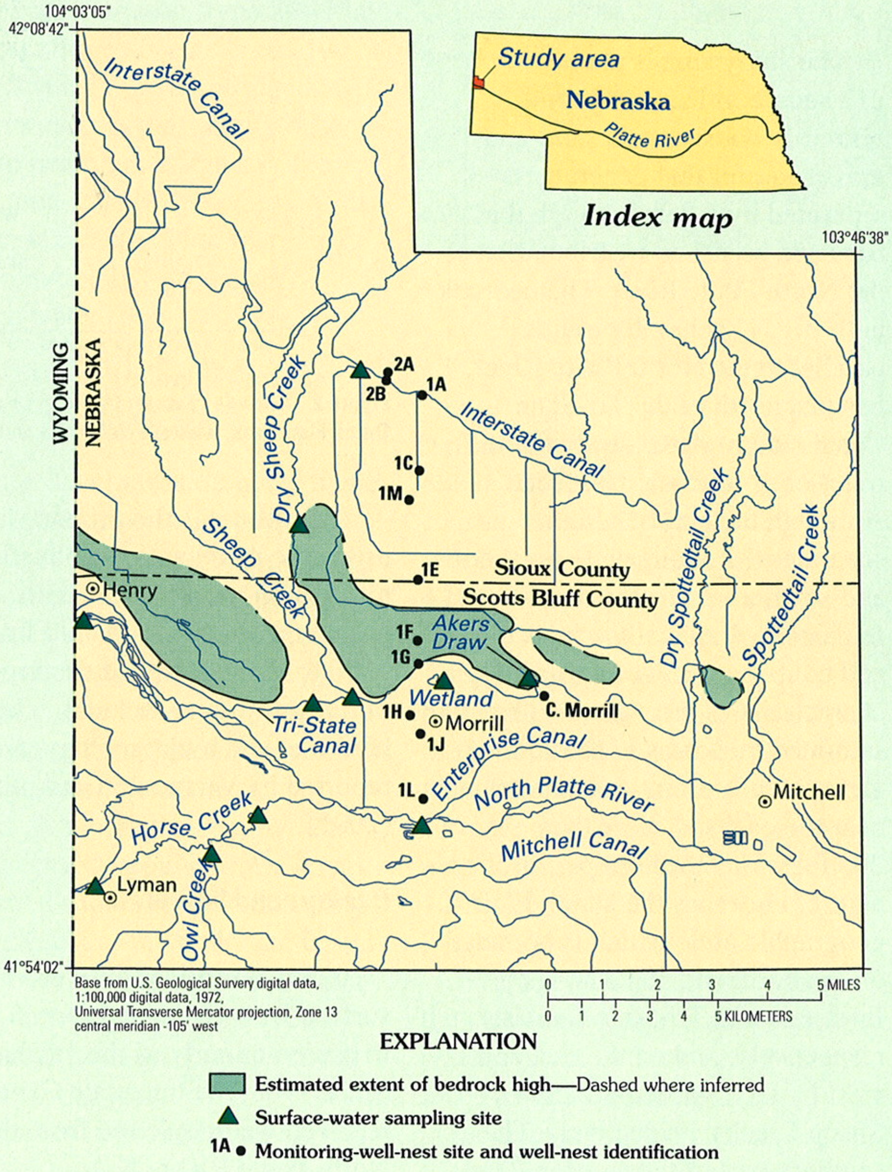


Figure 1. Location of study area, including rivers, canals, and selected monitoring wells, Dutch Flats area, western Nebraska.

INTRODUCTION

Nitrate concentrations detected near or above the U.S. Environmental Protections Agency's Maximum Contaminant Level (MCL) of 10 mg/L (milligrams per liter) in ground water in the Dutch Flats area of the North Platte Natural Resources District (NPNRD) have become an important issue. However, nitrate concentrations measured in surface-

[1] U.S. Geological Survey, Lincoln, Nebraska.
[2] North Platte Natural Resources District, Gering, Nebraska.

water systems in the area have remained below the MCL. In 1995, the U.S. Geological Survey (USGS) and the NPNRD began a study to characterize the spatial distribution of selected water-quality constituents in surface and ground water and to evaluate the surface-water/ground-water interaction in the Dutch Flats area of western Nebraska (Verstraeten and others, 2001). This fact sheet briefly summarizes the effects of seepage from irrigation canals and the implication to ground-water sustainability.

Study Area

The study area is about 212 square miles (fig. 1) and primarily consists of a sand-and-gravel aquifer that generally is separated by a bedrock high that has been breached by tributaries of the North Platte River. The bedrock high (fig. 1) generally trends parallel to the North Platte River, lies just north of the Tri-State Canal, and imparts a topographic relief of as much as 100 feet. Although the bedrock high separates the aquifer into northern and southern parts, the aquifer remains hydraulically connected and contains similar hydrogeologic characteristics throughout. The saturated thickness of the aquifer varies locally from less than 10 feet near the edges to more than 200 feet. The northern part of the aquifer underlies the Dutch Flats geographic area, which is bounded on the north and south by the Interstate and Tri-State Canals, respectively, and on the east and west by Dry Spottedtail and Dry Sheep Creeks, respectively. The southern part of the aquifer underlies the North Platte River Valley.

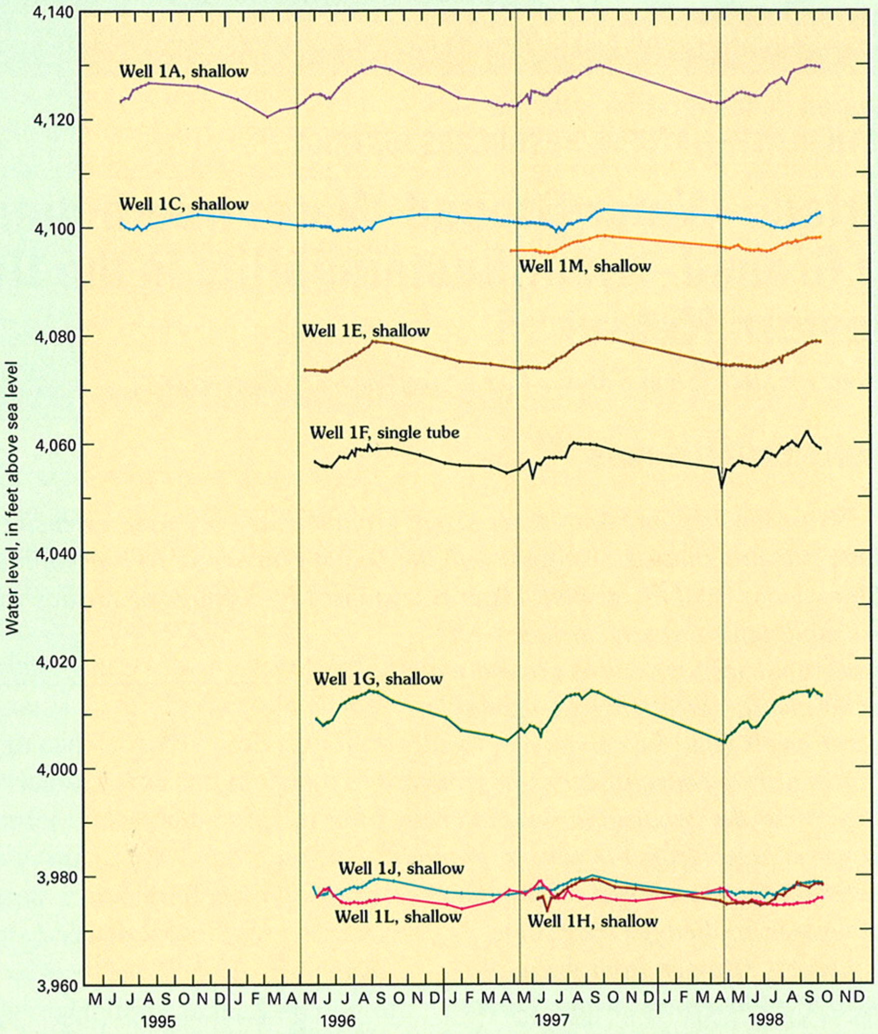


Figure 2. Altitude of water levels in selected shallow and single-tube monitoring wells in the Dutch Flats area, western Nebraska, July 1995 through September 1998.

Agriculture is the primary land use in the study area. Application of nitrogen in commercial fertilizers has increased about 15-fold from 1950 to 1994. Detailed descriptions of the study area, including climate, land use, and hydrogeology, are reported by Verstraeten and others (2001).

Background Information

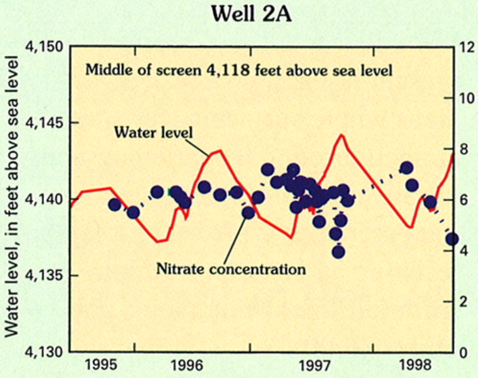
In the North Platte River Valley, surface water was used for irrigation as early as the 1870s. Since 1908, the Interstate Canal has received water diverted from the North Platte River about 50 miles upstream from the study area. The Interstate Canal supplies water for irrigation to western Nebraska including the Dutch Flats area (fig. 1). The Bureau of Reclamation (BOR) (1949 and 1957) and Babcock and Visher (1951) reported seepage estimates from the Interstate Canal, at or near the Dutch Flats area, at 3.8 cubic feet per second per mile or about 2,460,000 gallons per day per mile. As a result, the BOR (1957) reported that a part of the Dutch Flats area had become waterlogged from a combination of canal seepage and the application of surface water for irrigation.

Pre-canal water-level data are unavailable. However, if the estimated predevelopment water level in the northern part of the aquifer was approximately equal to or slightly higher than the current (2001) water level in the southern part of the aquifer, water levels in the northern part of the aquifer could have risen 120 to 140 feet above the estimated predevelopment water levels since diversions started in the Interstate Canal. Consequently, if not for the seepage from the Interstate Canal, ground water for irrigation in the northern part of the aquifer likely would be insufficient because the deeper ground-water levels would reduce substantially the volume of water available to large-capacity wells. The Interstate Canal replenishes water in the aquifer through infiltration of surface water applied to fields and seepage of water from the canal and its laterals.

SURFACE-WATER/GROUND-WATER INTERACTION

Water-level measurements made in nested monitoring wells (fig.1) from July 1995 through September 1998 indicate that seepage from the canals into the aquifer plays a substantial role in the sustainability

Surface-water gravity-feed irrigation in the Dutch Flats area.



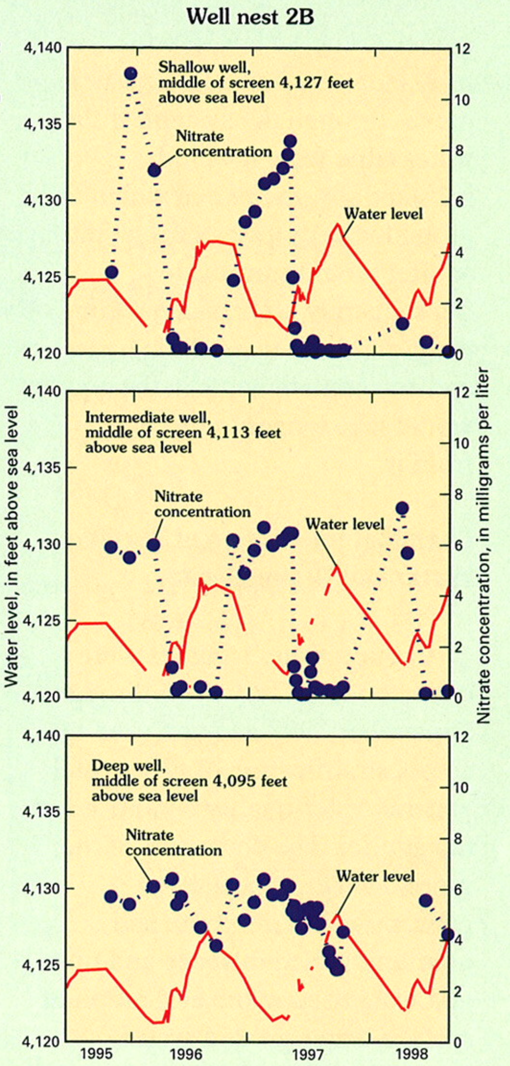


Figure 3. Variation of nitrate concentrations and water levels in monitoring wells 2A and 2B, Dutch Flats area, western Nebraska, July 1995 through September 1998.

of ground water that is available for use. The continued recharge of surface water to the aquifer during the irrigation season (typically May to September) sustains ground-water levels in the aquifer and sustains springs that supply base flow to perennial streams in the study area. The water quality of the aquifer is affected both favorably and unfavorably by seepage of surface water.

Physical Interaction of Surface Water and Ground Water

Water-level measurements made in the monitoring wells near the Interstate Canal show that ground-water levels started to rise about 3 weeks after the start of diversions into the Interstate Canal (fig. 2). The water-level rises continued throughout the irrigation season until diversions into the canal ceased. When diversions into the canals ceased, ground-water levels continued to rise in the monitoring wells closest to the Interstate Canal until about October. Ground-water levels then declined from about November until diversions started the following year.

Changes in ground-water levels near the canals were greater than those farther from the canals. Water levels in some monitoring wells within 1,000 feet of the canals rose about 10 feet during the irrigation season. However, water levels in monitoring wells more than 1,000 feet away from the canals typically did not rise more than 4 feet. Water-level rises in monitoring wells within 1,000 feet of the Interstate Canal were significantly greater during the summer than water-level rises in monitoring wells farther than 1,000 feet from the Interstate Canal (Verstraeten and others, 2001).

Seepage of surface water from the canals also affects the ground-water system by increasing water levels over the estimated predevelopment water levels. Rising water levels increase the hydraulic gradient of the water table above estimated predevelopment levels, which, in turn, increase the rate that water moves through the system. If the water table were lowered substantially, the rate at which the ground water moves through the aquifer would start to slow. Subsequently, the residence time of the ground water would increase, and any contaminants in the aquifer would take longer to discharge from it.

Chemical Interaction of Surface Water and Ground Water

Ground-water samples were collected from July 1995 through September 1998 and analyzed to assess stratification of nitrate and general water-quality conditions in the aquifer. The chemistry of the ground water, especially concentrations of nitrate and uranium, varied in space and time and were used in the evaluation of surface-water/ground-water interaction. Some nitrate concentrations in ground-water samples exceeded 10 mg/L, and occasionally exceeded 20 mg/L, in shallow monitoring wells (screened less than 30 feet below the water table). Nitrate concentrations were generally less than 5 mg/L in water from the deeper wells. However, in areas within several hundred feet of major canals and laterals, nitrate concentrations in the ground water were diluted by infiltration of surface water containing nitrate concentrations less than 2 mg/L (fig. 3). Near the Interstate Canal, surface water appeared to displace ground water in the upper 30 feet of the aquifer. As a result, nitrate and uranium concentrations decreased in shallow ground water, but specific conductance and sulfate concentrations increased. Away from the canal this effect was present but less pronounced. In areas where surface water was applied through irrigation systems, nitrate concentrations generally increased over time because of the leaching and transport of nitrogen from fertilizer (Verstraeten and others, 2000).

GROUND-WATER SUSTAINABILITY

Ground-water sustainability in the Dutch Flats area is important to the local economy. In times of severe drought, water produced from irrigation wells can supplement surface-water irrigation systems. Overall, seepage of water from canals and laterals provides substantial artificial recharge to the aquifer and improves the ground-water quality through dilution of nitrate concentrations with surface water containing nitrate concentrations less than 2 mg/L. However, away from the canals, leaching of fertilizer from surface water and ground water applied to the fields transports nitrate from the land surface to the ground water. Generally, higher concentrations of nitrate are found in the shallow, younger water. In summary, seepage from canals in the Dutch Flats area helps to sustain ground-water quantity and quality.

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For further information contact:
U.S. Geological Survey
Federal Building, Room 406
100 Centennial Mall North
Lincoln, NE 68508
(402) 437–5082

USGS Nebraska District Home Page:
http://ne.water.usgs.gov

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