PART B: LOCATION AND MOVEMENT OF GROUNDWATER IN THE FLORIDAN LIMESTONE AQUIFER

Figures 6–8 show karst features developed in the Floridan Limestone Aquifer in the northern part of Tampa, Florida. Notice in Figures 6 and 7 that most of the lakes occupy sinkholes. They are indicated on Figure 6 with hachured contour lines (contours with small tick marks that point inward, indicating a depression). These depressions intersect the water table and the subjacent limestone bedrock, as shown in Figure 7. By determining and mapping the elevations of water surfaces in the lakes, you can determine the slope of the water table and the direction of flow of the groundwater here (as in Figure 1B).

Questions

6. On Figure 8, mark the elevations of water levels in the lakes (obtain this information from Figure 6). The elevations of Lake Magdalene and some lakes beyond the boundaries of the topographic map already are marked for you.

7. Contour the water-table surface (use a 5-foot contour interval) on Figure 8. Draw only contour lines representing whole fives (40, 45, and so on).

8. The flow of shallow groundwater in Figure 8 is at right angles to the contour lines. The groundwater flows from high elevations to lower elevations, just like a stream. Draw three or four flow lines with arrows on Figure 8 to indicate the direction of shallow groundwater flow in this part of Tampa. The southeastern part of Figure 6 shows numerous closed depressions but very few lakes. What does this indicate about the level of the water table in this region?

9. Note the Poinsettia Sinks, a pair of sinkholes in the southeast corner of the topographic map (see Figure 6). Note their closely spaced hachured contour lines. Next find the cluster of five similar sinkholes, called Blue Sinks, about 1 mile northwest of Poinsettia Sinks (just west of the WHBO radio tower). Use asterisks (*) to mark their locations on Figure 8, and label them "Blue Sinks."

a. Draw a straight arrow (vector) on Figure 8 along the shortest path between Blue Sinks and Poinsettia Sinks. The water level in Blue Sinks is 15 feet above sea level, and the water level in Poinsettia Sinks is 10 feet above sea level. Calculate the hydraulic gradient (in ft/mi) along this arrow and write it next to the arrow on Figure 8. (Refer to Figure 1 to review hydraulic gradient as needed.)

b. On Figure 6, note the stream and valley north of Blue Sinks. This is a fairly typical disappearing stream. Draw its approximate course onto Figure 8. Make an arrowhead on one end of your drawing of the stream to indicate the direction that water flows in this stream. How does this direction compare to the general slope of the water table?

10. In March 1958, fluorescent dye was injected into the northernmost of the Blue Sinks. It was detected 28 hours later in Sulphur Springs, on the Hillsborough River to the south (see Figure 8). Use this data to calculate the approximate velocity of flow in this portion of the Floridan Aquifer:

a. in feet per hour

b. in miles per hour

c. in meters per hour

The velocities you just calculated are quite high, even for the Floridan Aquifer. But this portion of Tampa seems to be riddled with solution channels and caves in the underlying limestone. Sulphur Springs has an average discharge of approximately 44 cubic feet per second (cfs), and its maximum recorded discharge was 165 cfs (it once was a famous spa).

11. During recent years, the discharge at Sulphur Springs has decreased. Water quality has also worsened substantially.

a. Examine the human-made structures on Figure 6. Note especially those in red, the color used to indicate new structures. Why do you think the discharge of Sulphur Springs has decreased in recent years?

b. Why do you think the water quality has decreased in recent years?

12. Imagine you are selling homeowner's insurance in the portion of the Sulphur Springs quadrangle shown in Figure 6. List all the potential groundwater-related hazards to homes and homeowners in the area that you can think of.

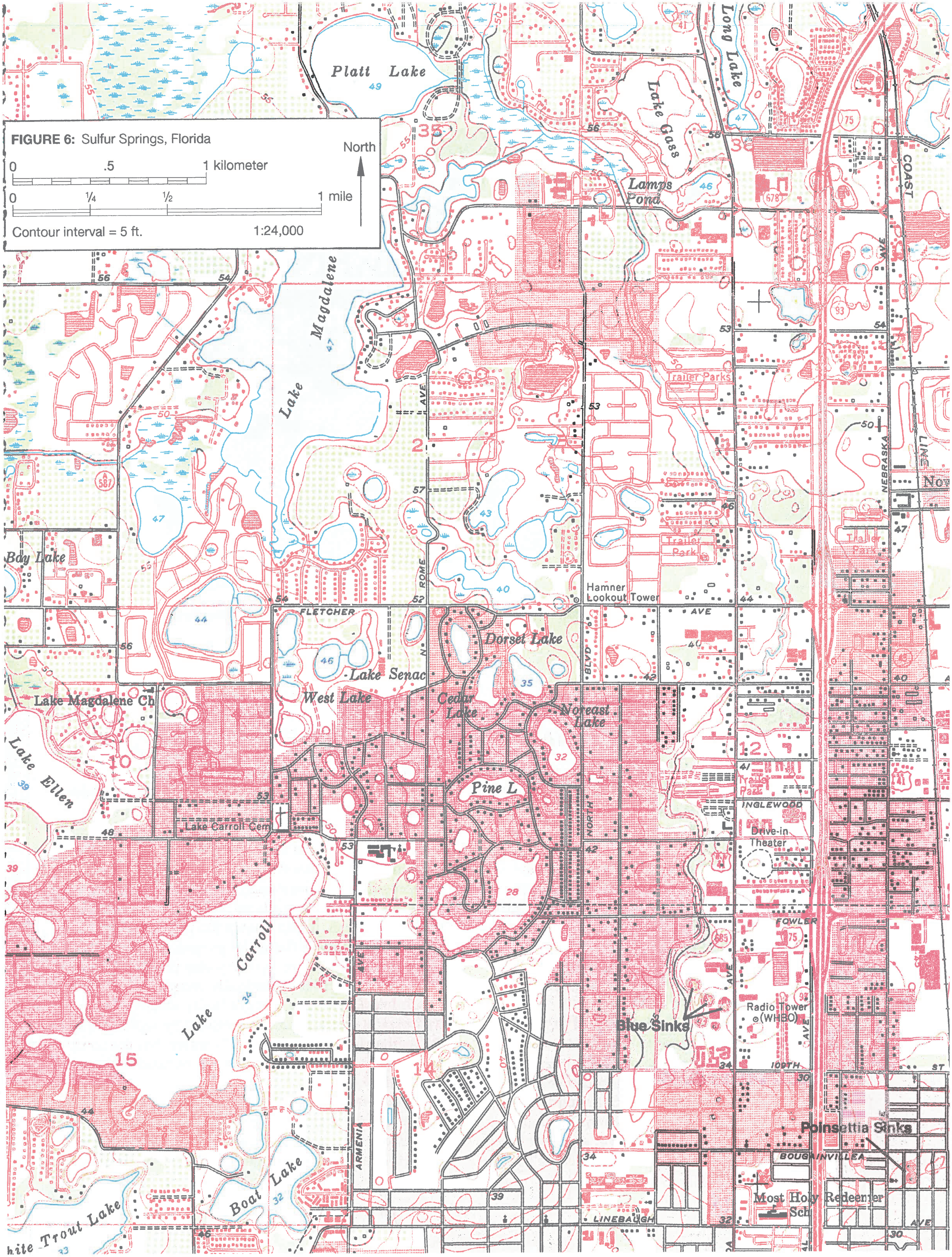

FIGURE 6: Sulfur Springs, Florida

0 .5 1 kilometer

0 ¼ ½ 1 mile

North

Contour interval = 5 ft. 1:24,000

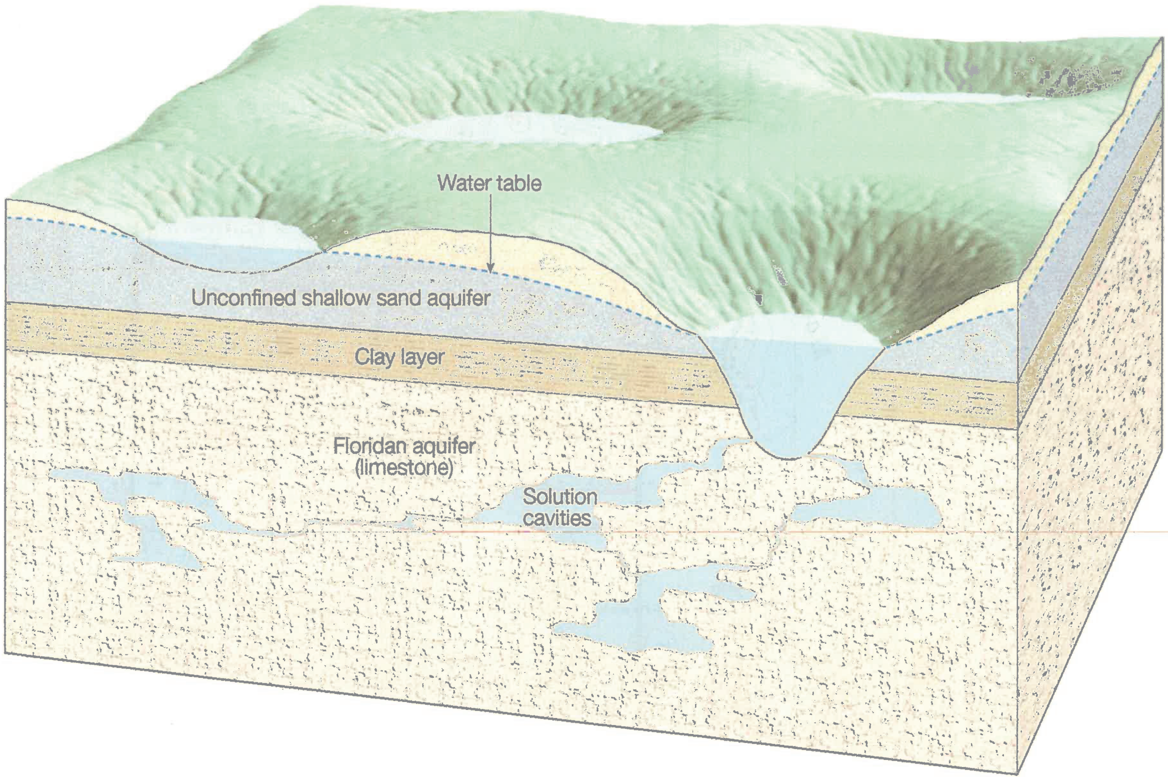

FIGURE 7 Geologic cross section showing groundwater distribution in strata underlying the Tampa, Florida, area.

PART C: LAND SUBSIDENCE HAZARDS CAUSED BY GROUNDWATER WITHDRAWAL

Land subsidence caused by human withdrawal of groundwater is a serious problem in many places throughout the world. For example, in the heart of Mexico City, the land surface has gradually subsided up to 7.6 m (25 ft). At the northern end of California's Santa Clara Valley, 17 square mi of land have subsided below the highest tide level in San Francisco Bay and now must be protected by earthworks. Other centers of subsidence include Houston, Tokyo, Venice, and Las Vegas. With increasing withdrawal of groundwater and more intensive use of the land surface, we can expect the problem of subsidence to become more widespread.

Subsidence induced by withdrawal of groundwater commonly occurs in areas underlain by stream-deposited (alluvial) sand and gravel that is interbedded with lake-deposited (lacustrine) clays and clayey silts (Figure 9A). The sand-and-gravel beds are aquifers, and the clay and clayey silt beds are confining beds.

In Figure 10, the water in the lower aquifer ("sand and gravel") is confined between impermeable beds of clay and silt and is under pressure from its own weight. Thus, water in wells **A** and **C** rises to the *potentiometric* (water-pressure) *surface.* Such wells are termed **artesian wells** (water flows naturally from the top of the well) The sand in the water table aquifer (Figure 10) contains water that is not confined under pressure, so it is an *unconfined aquifer.* The water in well **B** stands at the level of the water table and must be pumped up to the land surface.

Land subsidence (Figure 9B) is related to the compressibility of water-saturated sediments. Withdrawing water from wells not only removes water from the system, it also lowers the potentiometric surface and reduces the water pressure in the confined artesian aquifers. As the water pressure is reduced, the aquifer is gradually compacted and the ground surface above it is gradually lowered. The hydrostatic pressure can be restored by replenishing (or **recharging**) the aquifer with water. But the confining beds, once compacted, will not expand to their earlier thicknesses.

The Santa Clara Valley (Figure 11) was one of the first areas in the United States where land subsidence due to groundwater overdraft was recognized. The Santa Clara Valley is a large structural trough filled

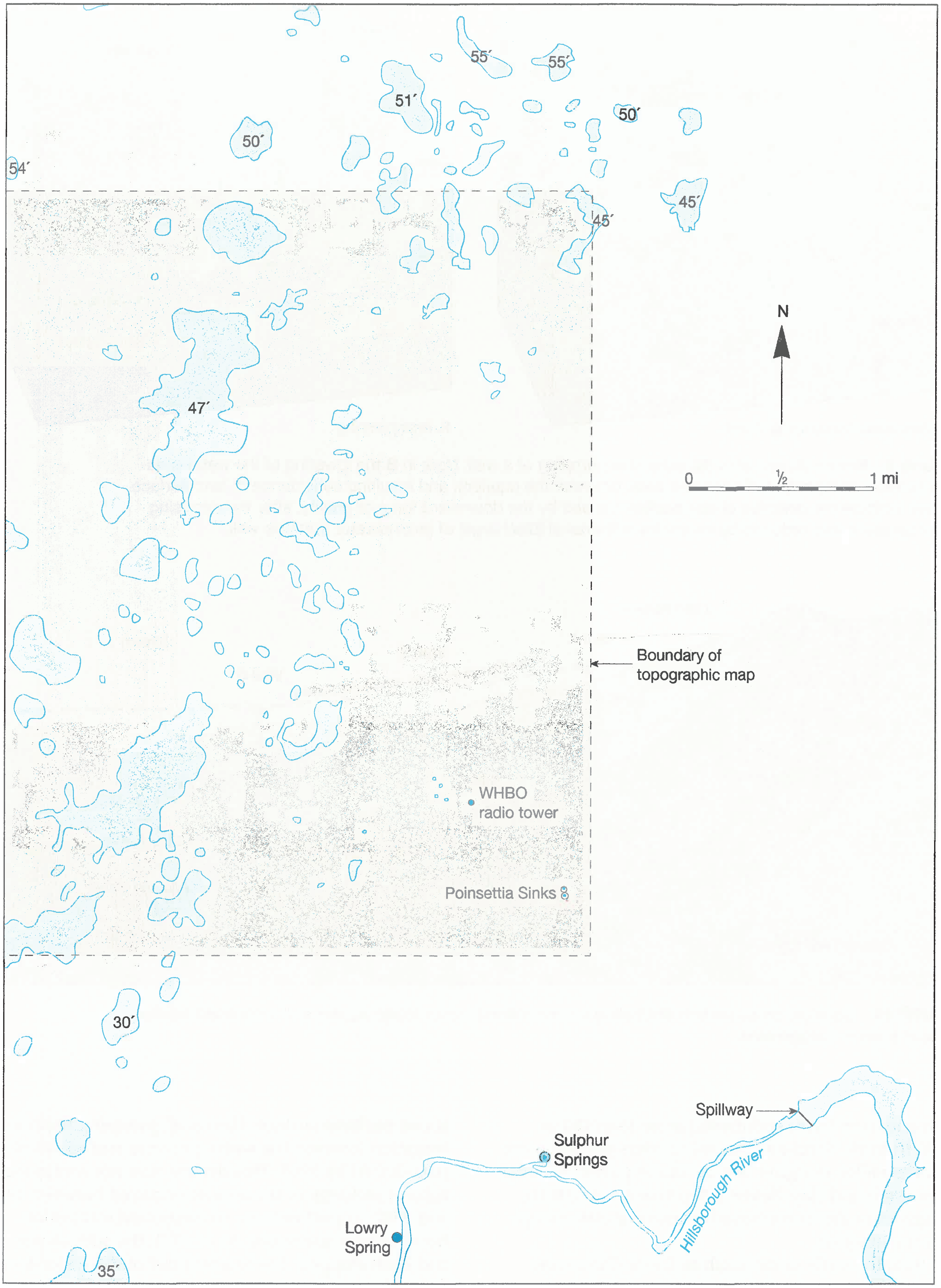

FIGURE 8 Sketch map of the area shown in Figure 6 (topographic map) and neighboring areas to the north, east, and south.