LABORATORY FOURTEEN
Dryland Landforms, Hazards, and Risks

OBJECTIVES

A. Understand basic eolian (having to do with wind) processes that lead to formation of specific kinds of sand dunes and other eolian deposits.
B. Identify and understand the formation of landforms typically developed in drylands (lands in arid, semi-arid, and dry subhumid climates) of Arizona, California, and the midwestern United States.
C. Analyze the Utah desert to evaluate the history of pluvial Lake Bonneville.
D. Understand the nature and magnitude of desertification hazards.
E. Analyze drylands and evaluate their risk of desertification.

STUDENT MATERIALS **(Remind students to bring items you check below.)**

_____ laboratory manual
_____ laboratory notebook
_____ pencil with eraser
_____ set of colored pencils
_____ metric ruler (cut from GeoTools sheet 1)
_____ calculator (optional)
_____ pocket stereoscope (or provided by instructor)

_____:

INSTRUCTOR MATERIALS **(Check off items you will need or provide.)**

_____ calculator (or obtained by students)
_____ colored pencils (if not obtained by students)
_____ pocket stereoscopes (or provided by students)

_____:

INSTRUCTOR NOTES AND REFERENCES

1. General information. Refer to Laboratory 14 on the Internet site at http://www.prenhall.com/agi for additional information and links related to all parts of this laboratory.

2. Reading Fine Print. Some printed words and numerals on maps are very small and difficult for some students to read. Plastic sheet magnifiers aid in map reading. They can be purchased in most bookstores for a few dollars (or less) each. They also come in large sheet or credit card sizes.

3. Misconceptions about Desertification. There is much discussion on Internet sites regarding both land degradation and desertification. A common misconception among students is that desertification means that the land turns to desert covered with sand dunes and sparse palm trees. Desertification actually refers to the process of land degradation toward drier more desert-like conditions, but not necessarily to sandy deserts with palm trees. It is important to discuss this with students and help them understand the similarities and differences between desertification and land degradation (a state of declining agricultural productivity). It is also important for students to understand ways that degradation and desertification are influenced by natural and human factors.

ANSWERS TO QUESTIONS IN LABORATORY 14

Part 14A: Eolian Processes, Dryland Landforms, and Desertification

1. There are three (3) surfaces on this ventifact that have apparently formed from natural sandblasting (by windblown sand). The east facing facet (flat sandblasted surface) is significantly larger than the other two, so it has been sandblasted the most by windblown sand. The winds that caused this to occur must have come **from the east**.

2. Star dunes form in regions that have winds approaching from several different directions on a regular basis. None of the directed winds is significantly stronger or more sustained than the others, so the star-shaped pattern develops.

3. Notice that the cross-bedding within this dune complex is oriented in two directions that are opposite one another. This is bimodal cross-bedding (refer to lab manual Figure 6.11). It indicates that these dunes formed in a region where winds blow from two opposing directions at different times.

4. **A** is a butte that formed by erosion of the edges of a sequence of flat-lying rocks.

5. The Table Top Mountains consist of erosional remnants of rock that rise steeply from their surrounding apron of alluvial fans. Some are relatively flat on top, and thus their name. The Table Top Mountains have flat tops (form mesas) because they formed by erosion of horizontal layers of rock.

6. **B** is an arroyo (wadi, dry wash) that transports sediments and water from the Table Top Mountains onto an alluvial fan during flash floods.

7. Both **C** and **D** developed as alluvial fans. **C** is still actively forming and is fed by arroyo **B.** **D** is an older fan that has been bypassed by arroyo **B**, is no longer receiving sediment, and is now being isolated as an erosional remnant of the complete alluvial fan that it once was.

8. **D** formed as a depositional feature, an alluvial fan at the end of an arroyo that transported water and sediment from the eroding Table Top Mountains. At some time in the past, erosion cut through the mountains between **D** and Indian Butte, and arroyo **B** formed, carrying sediment to form alluvial fan **C.** Arroyo **B** eroded below the level of **D;** as a result, **D** no longer receives flood waters and sediment. It is topographically higher than its surroundings. Note the steep erosional surfaces on the southern and northwestern sides of **D.**

Part 14B: Death Valley, California

9a-f. Refer to the next page for completed Figure 14.5.

10a. The highest visible contour is 1840 feet, and the alluvial fan starts at about 800 feet. The distance between these points is about 1.7 miles. So the stream gradient is 1040 feet over 1.7 miles, or **612 feet/mile.**

10b. There would be very coarse grained sediments and boulders in the highest parts of the arroyo and alluvial fan. Storm/flood water loses its velocity as it spreads out over the alluvial fan, so its ability to carry large particles of sediment decreases rapidly. Thus, grain size would decrease as one walks down the alluvial fan. From the downstream end of the fan to the letter **E**, grain size would also decrease. Only silt and clay, plus evaporite minerals, would be expected at **E.**

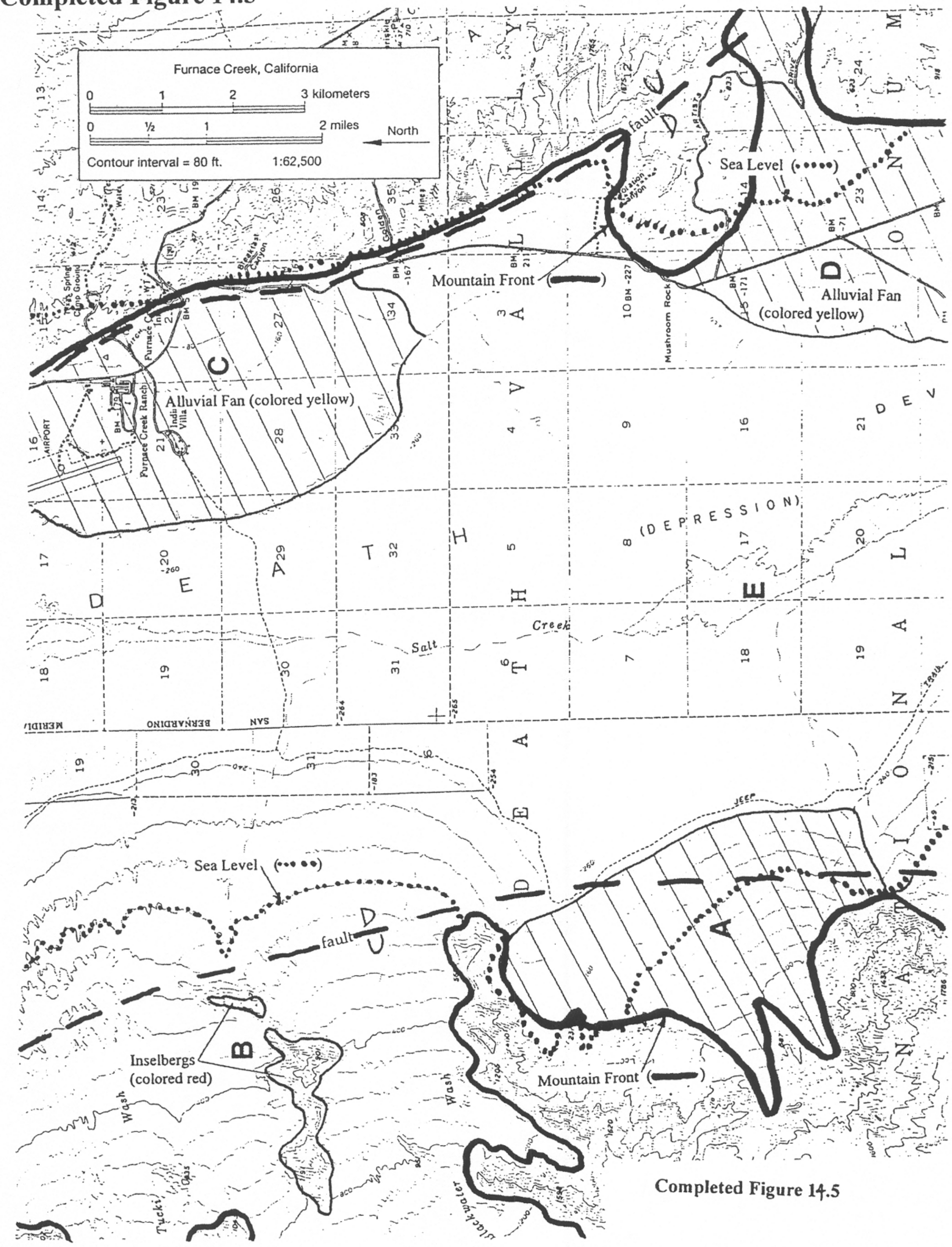
11. The main fault on the west side of the graben should occur approximately at the leading edge of the mountain front and at the leading edge of the chain of inselbergs. On the east edge of the graben, the main fault could be expected to occur along the mountain front, where there is a dramatic change in the slope of the valley wall and where alluvial fans **C** and **D** begin. These faults have been labeled with a dashed line on completed Figure 14.5 and the symbols U (up-side or horst-side of the fault) and D (down-side or graben-side of the fault).

12. -There is a mountain spring only a mile upstream from the fan (a source of drinking water that is not alkaline).

-The stream on alluvial fan **C** flows due south along the mountain front, so only the southern half of this fan is active with a significant flash flood hazard.

-This is the only fan with significant vegetation on it (notice the green coloring on the map), so it is moist enough for lawns, gardens, trees, and crops.

Completed Figure 14.5



Completed Figure 14.5

Part 14C: Dryland Lakes

13. Wah Wah Valley Hardpan is a **playa**.

14. Refer to the completed Figure 14.8 on the next page (page 102) of this book.

15. This is the approximate position of the modern shoreline of the playa.

16. The lowest elevation of the lake is 4637 feet and the highest point in the valley to the northeast is 4670 feet. So the lake would have to be 33 feet deep before it would overflow. Students could also say that the lake simply has to get deep enough that its level exceeds 4670 feet in elevation.

17. Ancient shorelines are preserved high up on the piedmont slope. Wave-eroded cliffs and former deltas are truncated at former lake shoreline levels. One of the alluvial fans is also truncated by a wave-eroded cliff northeast of location **B**.

18. The bajada seems to have grown beyond the shores of the ancient lake (note that sediment has been transported over some of the ancient shorelines), so the modern bajada and playa are younger than the shorelines. Part of the alluvial fan northeast of location **B** has a wave-cut cliff, so that fan and bajada were probably present with the lakes.

19. They are wave-cut terraces from former shorelines of the lake.

20. They are deltas that migrated basinward (toward the playa) as the lake level fell. Therefore, they appear as a line of deltas, rather than as one single delta with a typical triangular shape.

21. There are springs here, from which the tufa (limestone) is precipitating.

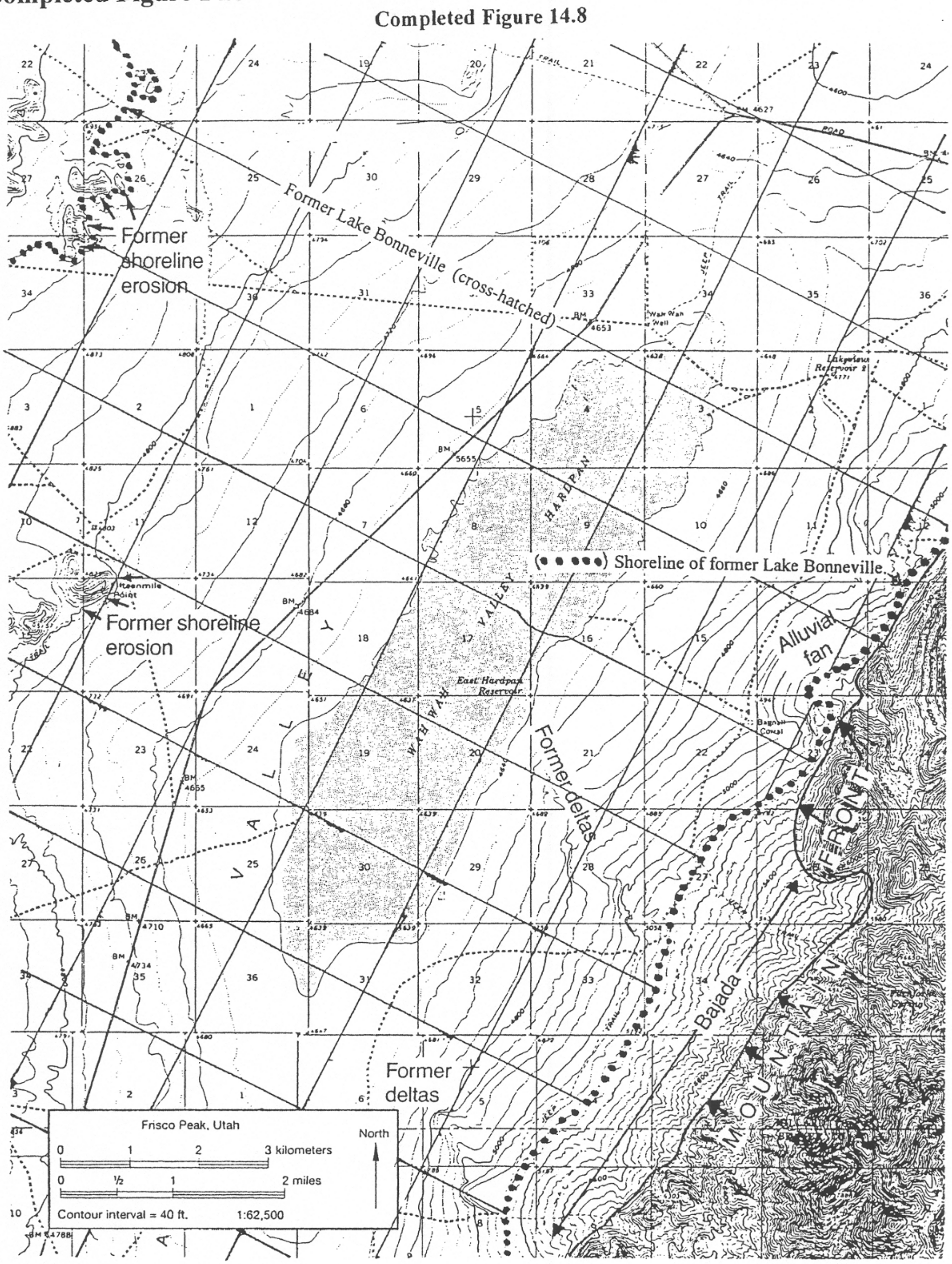
22. The shoreline is drawn as a dotted line on completed Figure 14.8 on the next page of this book. The area to be colored blue is crosshatched in the completed figure.

23a. about 4960–5120 feet
23b. about 17,000 years old
23c. 4960 ft – 4200 ft = 760 ft, and 760 ft + 30 ft = 790 feet
5120 ft – 4200 ft = 920 ft, and 920 ft + 30 ft = 950 feet

So the Great Salt Lake location was about **790–950 feet deep**.

24a. less than 5%
24b. about 30–40%

Completed Figure 14.8



Part 14D: Dryland Hazards and Risks in Nebraska's Sand Hills

25a. Most have elevations of 4070 to 4190 feet and are developed on a surface of about 3900 feet in elevation, so their relief varies from **170 to 290 feet**.

25b. They are all about a mile (1.6 to 2 km) long.

25c. The steep slip faces of the megabarchans and barchanoid ridges face southeast, so the winds that formed them must have come from the northwest.

25d. As wind blows over a region it erodes and carries sand-, silt-, and clay-sized grains of sediment. As the wind loses its velocity and energy the sand is deposited first, followed by the silt, and then the clay. Such eolian deposits of silt and clay are called loess (as in lab manual Figure 14.2). Since the Nebraska loess deposits are all southeast of the sand hills (eolian sand deposits), the source of the sand and loess must have been northwest of Nebraska.

26a. **blowouts** (deflation basins)

26b. **parabolic dunes** (small U-shaped dunes as illustrated in Figure 14.3C). Note the parabolic dunes in the large blowout along the south margin of the map, south of Williamson Lake, in section 33.

26c. Sand is available and moving about on a small scale barely visible on a 7 ½ minute topographic quadrangle map. However, if more arid conditions develop, then these dunes may become more widespread or larger.

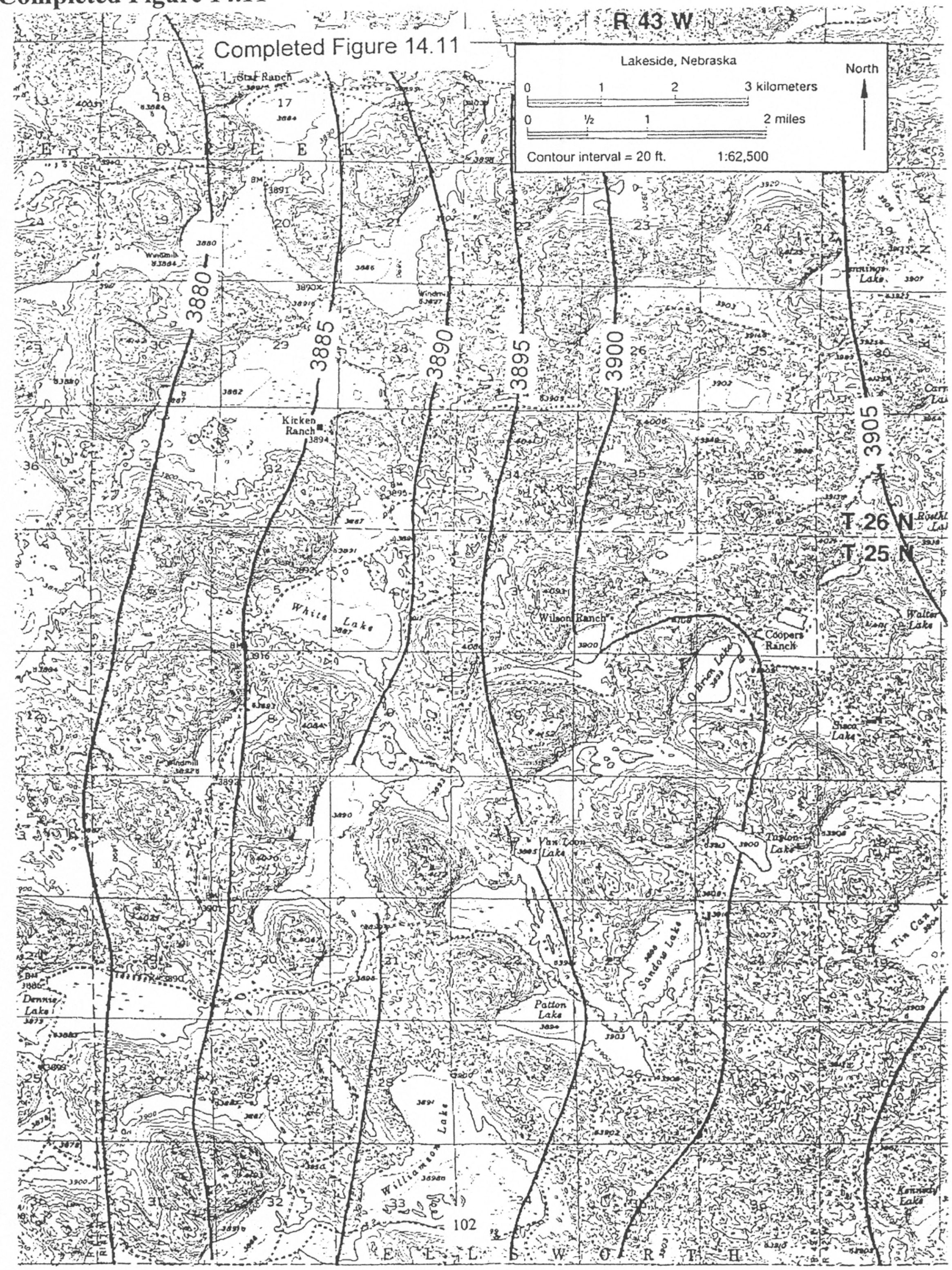
27a. If the megabarchan northwest of Star Ranch did not migrate over the ranch located on its slip face, then it must be inactive. If this dune is inactive, then the other megabarchans are also probably inactive (not moving).

27b. If these large dunes of the Sand Hills were not active during the VERY dry and windy Dust Bowl, then desertification must proceed to conditions worse (drier and windier) than experienced here in the Dust Bowl.

28. Vegetation is holding the sand in place and keeping dunes stable (from being activated), so it is important that grazing be kept to a minimum where some ground cover remains to trap and bind the sandy soil. It would be good practice to shift cattle from one field to another, or keep only a few cattle per acre, to insure that the land is not overgrazed.

29a. See completed Figure 14.11 on the next page of this book. The ground water would be expected to flow from high to low elevations, so it must be flowing from east to west.

Completed Figure 14.11



29b. Cities in other parts of Nebraska may take steps to use water from the Sand Hills or east of the Sand Hills. Thus, less ground water would be available to flow through the Sand Hills, and the Sand Hills could not sustain existing levels of vegetation. Thus, the Sand Hills would be likely to experience more desertification and all of the dunes could become active again.

G202 Lab Answer Key
Lab 9 - Desert Processes and Landforms

Q. 1 In Fig. 13.4, the strongest sustained wind direction is from east to west. This is based on the form of the ventifact, with the gentle stoss side facing upwind as it is abraded and sand blasted.

Q. 2 Given the complexity of the stoss and lee side dune forms, the star dunes likely form from variable wind directions.

Q. 3 The unidentified sand dunes in Fig. 13.3G look like a cross between barchans and transverse dunes, thus they are "barchanoid" like, with the dominant wind direction similar to that depicted in Fig. 13.3E.

Q. 5 The hilly feature labeled A is an inselberg.

Q. 6 Table top mountains got their name because they are flat-topped, plateau-like features. They probably formed by tectonic uplift of flat-lying sedimentary rocks, with the most erosionally-resistant strata forming the "table top".

Q. 7 The linear feature labeled B is an arroyo or feeder channel to an alluvial fan, and forms the upper channelized part of the fan.

Q. 8 Landform C is an alluvial fan, landform D looks like a pediment. They are similar in that they both are commonly found in mountain front environments.

Q.9 I'm not sure what this question is getting at... however, pediments require erosion over time, this implies that the mountain front has been sitting there for millions of years. Overall, this is a highly dissected mountain front with well-developed fans, pediments, and inselbergs. It seems that this mountain region has not been tectonically active for quite a while, and that erosion dominates.

Q. 10. see attached map

Q. 11A. Gradient = 1600 ft / 2.8 mi = 571 ft / mi

Q.11B. The would decrease in size from coarse to fine, downstream

Q. 12 - see map

Q. 13 Alluvial fans are made up of coarse sand and gravel, which make for good porosity and permeability, and good aquifers. This is a desert area, the ranchers are going to need groundwater to sustain a ranching operation. The alluvial fan makes for a good groundwater source. In addition, the arroyo feeding the fan provides water / recharge during storm events, which infiltrates the fan and recharges the aquifer. Once in the groundwater system, the fan aquifer does a good job of preventing evaporation. The ranch is there because the water is there.

Q. 14 Wah Wah valley hardpan is a playa - a dry lake bed associated with evaporite deposits.

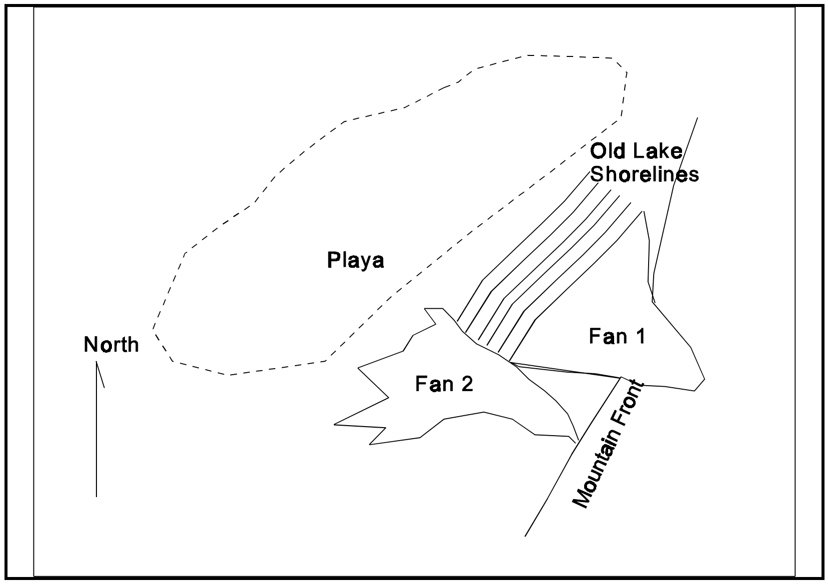
Q. 15 see attached map

Q. 16 Blue dashed line represents the present seasonal shoreline of the playa lake.

Q. 17 see map for i.d. of drainage divide / overflow to the northeast of the lake. The relief between the playa edge and the drainage divide to the northeast is about 30 feet.

Q. 18 The air photos show the old beach lines of Lake Bonneville, cut into alluvial fan deposits of the bajada.

Q. 19 a diagram of the stereo relations is shown below



Here's the sequence of events: (1) Fan 1 was deposited, (2) Lake Bonneville shorelines were cut into Fan 1, (3) Lake Bonneville receded leaving the "bath tub ring" of shorelines as the lake levels declined, (4) Fan 2 has cut through and incised Fan 1 and the old Bonneville Shorelines in the past 15,000 years.

Q. 20 The step like terraces are old shoreline levels of lake Bonneville

Q. 21 The shorelines form sequentially in a downslope direction as the lake waters recede.

Q. 22 See map, the entire area northwest of the 5000 ft high stand of lake bonneville was covered in water 15,000 years ago.

Q. 23 modern tufa would form at where mineral-charged springs rich in calcium carbonate emanate from the groundwate system ... i.e. tufa represents a "mineral spring deposit".

Q. 24 see the map for outlines of mega barchans and dune features

Q24A average relief of the barchan ridges is ~160 to 180 feet from base to top (just count the contour lines and multiply by the contour interval)

Q24B Average length of barchan ridges is ~15 km as shown on the map.

Q24C According to the dune forms, the winds blow from northwest to southeast (i.e. "northwesterly winds")

Q24D well... if the winds are blowing from the northwest, then the sediment supply would have to be northwest of the area, right?

25A the closed depressions are blow-outs
25B parabolic dunes are associated with the depressions
25C this is a screwy question because not enough information is given. I will speculate: the blow outs are associated with inter-dune lakes. The interdune lakes represent a wate source that permits trees and plants to grow and stabilize the parabolic dunes. If the climat were to dry out (i.e. "desertification"), then the lakes and soil moisture would diminish, the plants would die, and the dunes would become unstable and be subject to wind erosion and dune migration.

26A If the ranch was not covered by dune sand during the dust bowl, it suggests that the barchanoid ridges were inactive during that time in the 1930's.

26B This suggests that the climate would have to become much drier for longer periods of time than in the 1930's, if the dune fields of the Nebraska sand hills are to mobilize / erode.

Q. 27 If I were a rancher, I would not want the cattle to graze off the stabilizing grass vegetation in the area. I would try to promote sustainable grazing in areas with enough precipitation to support / preserve the grasses.

Q 28 See the map for lake contours

Q28A groundwater flow direction is toward the east.

Q28B If the groundwater is over-used, the blow-out lakes will dry up, the vegetation will decline, the area will be subject to desertificaiton, wind erosion, and dune mobilization.

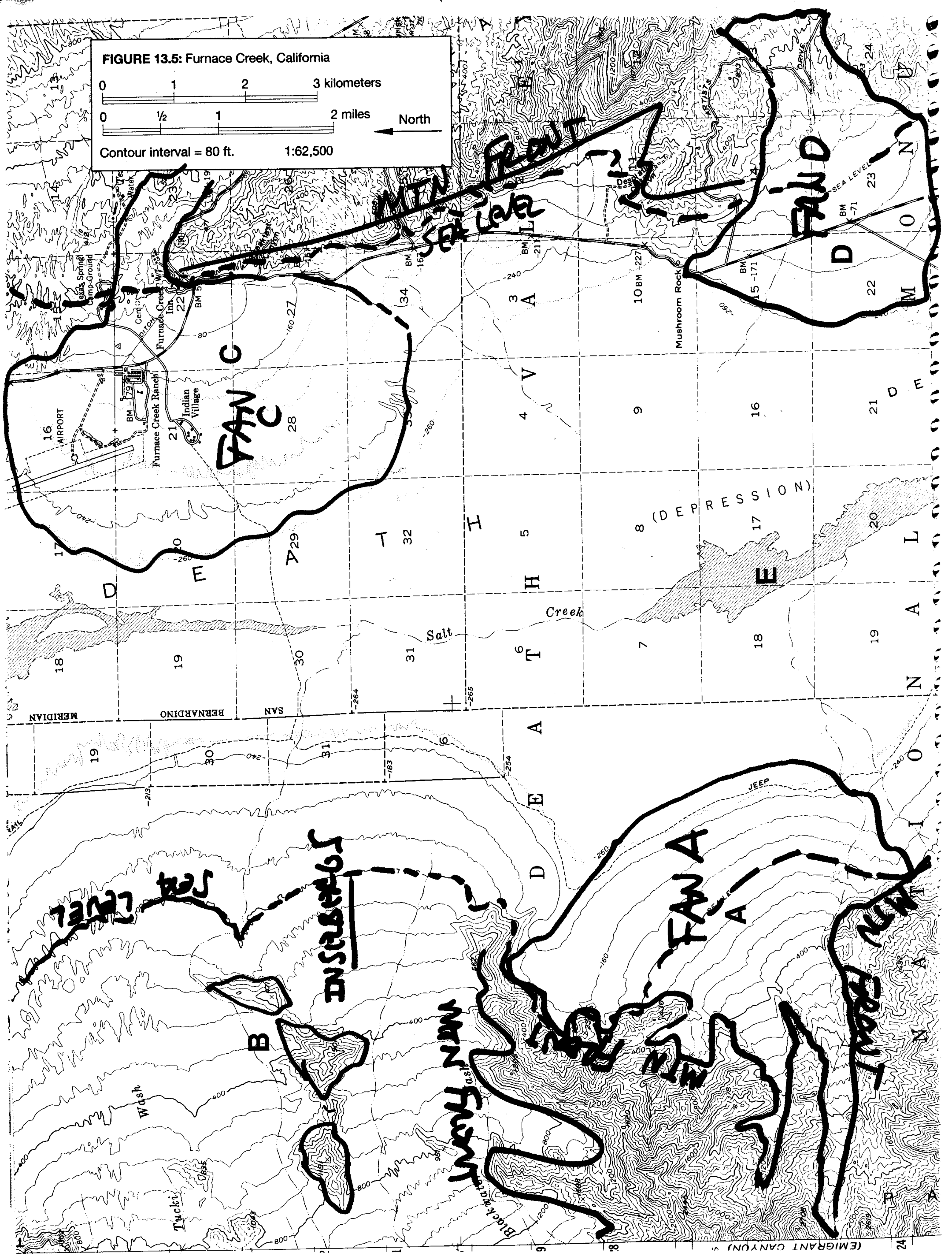


FIGURE 13.5: Furnace Creek, California

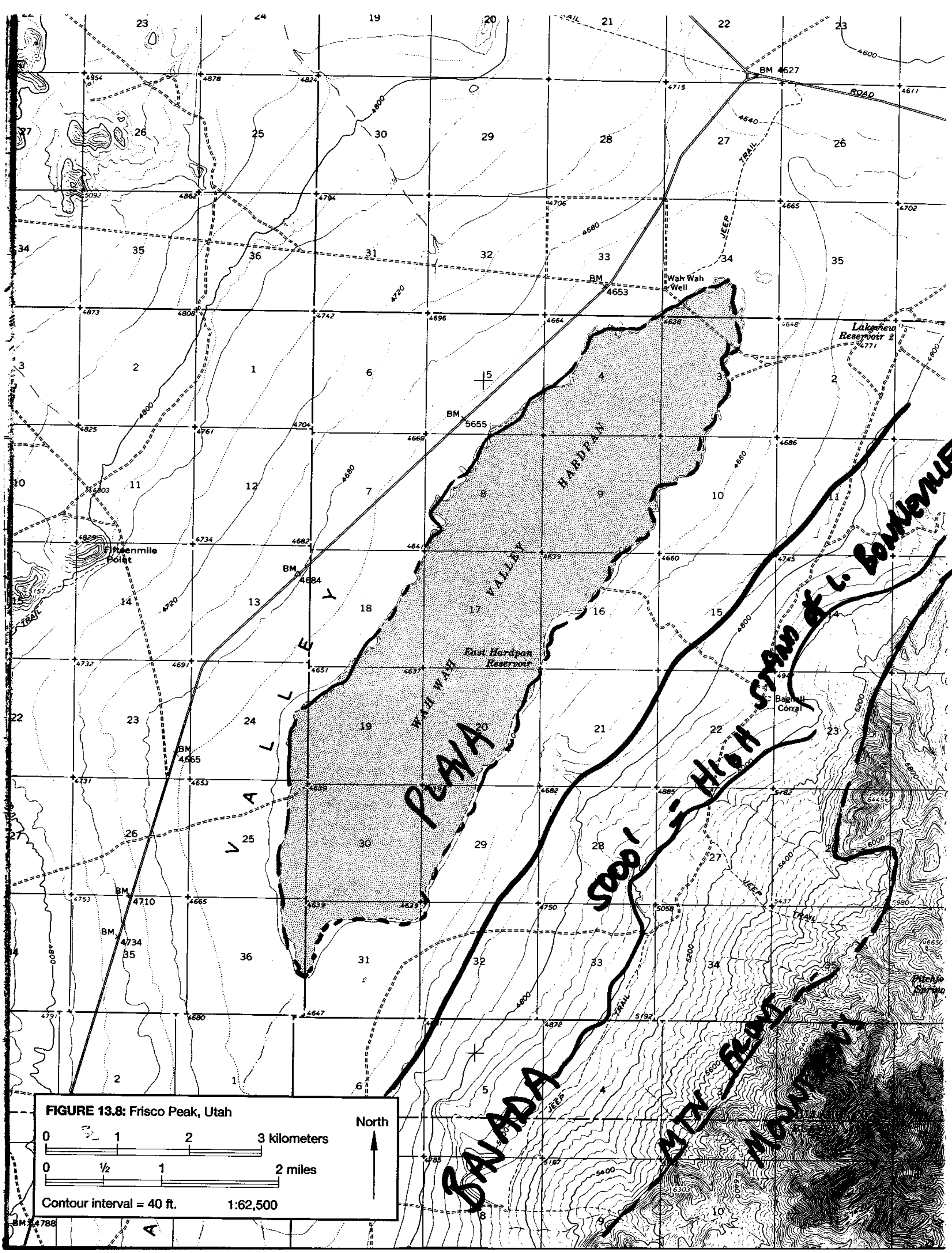


FIGURE 13.8: Frisco Peak, Utah

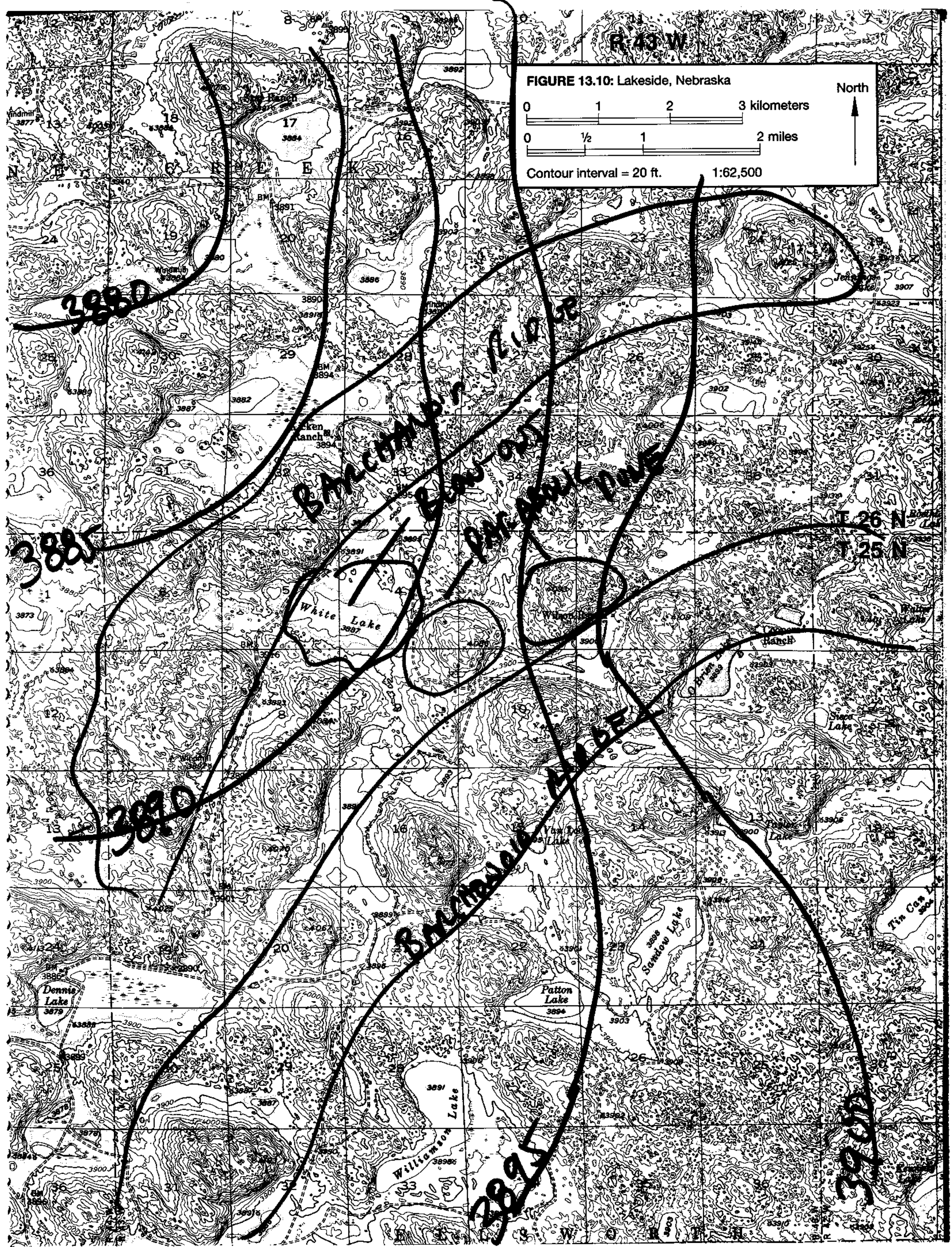


FIGURE 13.10: Lakeside, Nebraska