Technical Memorandum NESDIS 7

SURFACE SOIL MOISTURE MEASUREMENTS OF THE WHITE SANDS, NEW MEXICO

Washington, D.C.
September 1984

U.S. DEPARTMENT OF COMMERCE / National Oceanic and Atmospheric Administration / National Environmental Satellite, Data, and Information Service

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NESS 118 Satellite Observation of Great Lakes Ice - Winter 1979-80. Sharolyn Reed Young, July 1983, 47 pp. (PB84 101054)

NESS 119 Satellite Observations of Great Lakes Ice: 1980-81. A.L. Bell, December 1982, 36 pp. (PB83 156877)

NESDIS 1 Publications and Final Reports on Contracts and Grants, 1982. N. Everson, March 1983. (PB83 252528)

NESDIS 2 The Geostationary Operational Environmental Satellite Data Collection System. D.H. MacCallum and M.J. Nestlebush, June 1983. (PB83 257634)

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NESDIS 6 The Advantages of Sounding with the Smaller Detectors of the VISSR Atmospheric Sounder. W. Paul Menzel, Thomas H. Achtor, Christopher M. Hayden and William L. Smith, July 1984, 22 pp.

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UNITED STATES DEPARTMENT OF COMMERCE
Malcolm Baldrige, Secretary

National Oceanic and Atmospheric Administration
John V. Byrne, Administrator

National Environmental Satellite, Data, and Information Service
John H. McElroy, Assistant Administrator

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SURFACE SOIL MOISTURE MEASUREMENTS OF THE WHITE SANDS, NEW MEXICO

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ABSTRACT. Surface soil free moisture measurements of the White Sands gypsum dunes and flats have been made over five-day periods during the solstice and equinox. The percent by weight/bake-out method of moisture determination was used. The results of several periods of measurement have been compiled and presented. The surface moisture content is a function of the season or amount of rainfall; the flats appear more moist than the dunes.

I. INTRODUCTION

White Sands surface soil moisture content measurements were made as a part of the ground parameter measurements in support of the NOAA-NESDIS clear sky high altitude aircraft measurements of the visible wavelength radiance of White Sands. NOAA instrumentation[1] was flown aboard the NASA Lewis Lear jet [1] at an altitude of 41,000 feet in the time frame of the solstice and equinox. Soil moisture samples were gathered concurrently with the aircraft overflights. In addition, concurrent White Sands satellite radiance data was archived.

Area Description

The New Mexico White Sands is composed of gypsum which is hydrous calcium sulfate ($CaSO_4 \cdot H_2O$). The gypsum exists as flat crystals rather than irregular grains, such as normal beach sand. The flat crystalline nature of the individual gypsum flake is evident if a handful of the sands is examined closely by eye in the sunlight. The White Sands occupies an area in the western part of the Tularosa Valley (figure 1) at the foothills of the San Andres Mountains. It extends approximately 30 km to the east and 45 km in the north-south direction. The eastern area is comprised of dunes and the western area is the flats.

An overview of the geological origin[2] of the White Sands is a requisite to an understanding of the present nature of the dunes and flats. The present day Lake Lucero (figure 1) is a remnant of an earlier and much larger body of water which geologists call Lake Otero. Lake Otero probably occupied the area which now includes the flats. Ancient rains washed gypsum from the exposed sedimentary rocks of the eastern slopes of the San Andres mountains. Gypsum in solution both entered the ground water table and filled the bed of Lake Otero. In the ancient past and at present, the Tularosa Basin has no outlet for surface water, precipitation in the valley does not run into rivers, but remains, and adds to the water table and creates seasonal lakes. Climatic changes caused Lake Otero to dry up. The dunefield was built from the old lake bed's dry gypsum deposits via the prevailing winds. Present day gypsum is suppled mostly from ground water which seeps upward to the surface, carrying water table gypsum with it, and a smaller amount from new deposits running down from the mountains after heavy rains.

Dunes-building begins when the dry lake bed surface of selenite (gypsum in its crystalline cleavable mass) is blown away as dust. The brown tinted selenite flakes collide with each other in the wind and turn white at each point of impact. As a result of this tumbling-collision process, the selenite particles become pure white and are added to the dunes. Gypsum is heavier than silt and other foreign particles. The wind thereby filters out all but the heavier gypsum, which settles to the ground in the dunes area.

The flats area is composed of salt compounds, silt and gypsum, hence this area is referred to as the alkali flats. There is a random area-wise distribution of these three elements. After a heavy rainfall, the flats exhibit a darker color with patches of brown which identify heavy silt concentration areas (e.g., June 1981). As a result of an extended drought, the flats become "super dry" and exhibit the same brightness as the dunes as observed by eye at ground level. Aircraft and satellite observations, however, still indicate a lower brightness for the flats under these conditions.

The southern half section of the dunes and flats is the White Sands National Park public area, under the jurisdiction of the U.S. Department of the Interior. This area is off limits to the military and civilian research sector and is not accessible for science. The northern area is under the jurisdiction of the White Sands Missile Range of the Department of Defense. The NASA White Sands Test Facility (WSTF) is responsible for the operation and maintenance of the "Northrup" air strip (recently renamed "Space Harbor"), which consists of two crossing runways (figure 2), each seven miles long, located in the northern flats area, and generated specifically as a shuttle landing strip. These strips are not paved runways, they are areas of the flats designated as runways which have been graded and cleared of shrubs and are maintained as such. Formal aircraft runway markers and lighting are provided.

The barren nature of the terrain would require that soil sample gathering station locations be marked with a rather substantial structure in order to be seen or located on a regular basis. For this reason, the sand samples were gathered in the area around the easily identified air strips.

Measurement Description

Surface soil moisture is the only meaningful moisture measurement with respect to the radiance of the sands. Moisture content in the levels below 2 to 3 mm depth are much higher than that of the surface. The lower level moisture has no relation to the condition of the observed surface of the sand.

Samples were taken at seventeen locations in the northern area, as outlined in figure 2. Sample locations, 4, 5, 6 and 7 are in dunes, the others are in the flats, adjacent to the Northrup runways. The sample gathering activity was centered about solar noon and required more than an hour to complete, using a standard pickup truck as the vehicle.

Surface sand samples of 1-2 mm depth were swept with a clean and dry brush into a small dust pan and placed in small, clean and dry glass jars with covers. These samples were taken to the laboratory within three hours of gathering. The covers were then removed, the samples precision weighed and placed in an air oven at 45°C for 16 hours. Following bake-out, the samples were removed to a clean environment and allowed to cool to room temperature. Then the samples were re-weighed, the weight reduction recorded and the percent weight loss tabulated as the free moisture content. Bake-out at temperatures above 45°C would introduce the risk of not only removing the free moisture, but removing the combined moisture of the $CaSO_4 \cdot H_2O$ bond. Laboratory procedures for the above were required to conform with document ASTM-D-2216-71, "Standard Method of Laboratory Determination of Moisture Content of Soil."

Figure 3 shows the soil moisture percent of each sample station for December 16, 17, 18 and 19, 1980. The dunes samples (stations 4, 5, 6 and 7) were usually near 0% water content. The surface of the flats maintains a higher level of moisture, up to 18%, as indicated.

Figure 4 presents the soil moisture for June 17, 20, 21 and 22, 1981. A period of unusually heavy rainfall had preceded these measurements, even the dunes were moist.

Figure 5 illustrates the soil moisture for September 19, 20, 21, 23 and 25, 1981. These results parallel those of Figure 2, December 1980, except that September 1981 was lower in moisture.

Soil moisture samples were taken for five days in August 1982, all in the dunes area adjacent to range road 10 (figure 1). Moisture content of all samples for this period were less than 0.5%. Soil moisture was also measured on March 21, 1984, near the equinox, and the results are shown on figure 6. In March there were no aircraft flights, but satellite data has been archived for this day.

Conclusion

White Sands surface soil moisture samples will continue to be gathered in concurrence with NOAA aircraft overflights and the collection of satellite data. Many years of seasonal data would be required to establish a statistical data base upon which some conclusion concerning the relationship of sand radiance and soil moisture might be possible.

Acknowledgments

The author wishes to thank Alexander Paczynski and John Nelson of the NASA White Sands Test Facility and the Lockheed contractor personnel who gathered the soil samples, performed the bake-out and tabulated the results.

References

1. NESDIS Technical Report, 9, June 1984, by G. R. Smith et al., The NESDIS-SEL Lear Aircraft Instruments and Data Recording System.
2. The Natural History Story of White Sands National Monument, 1971, by Natt Dodge, pub. Southwest Parks and Monuments Association.

White Sands

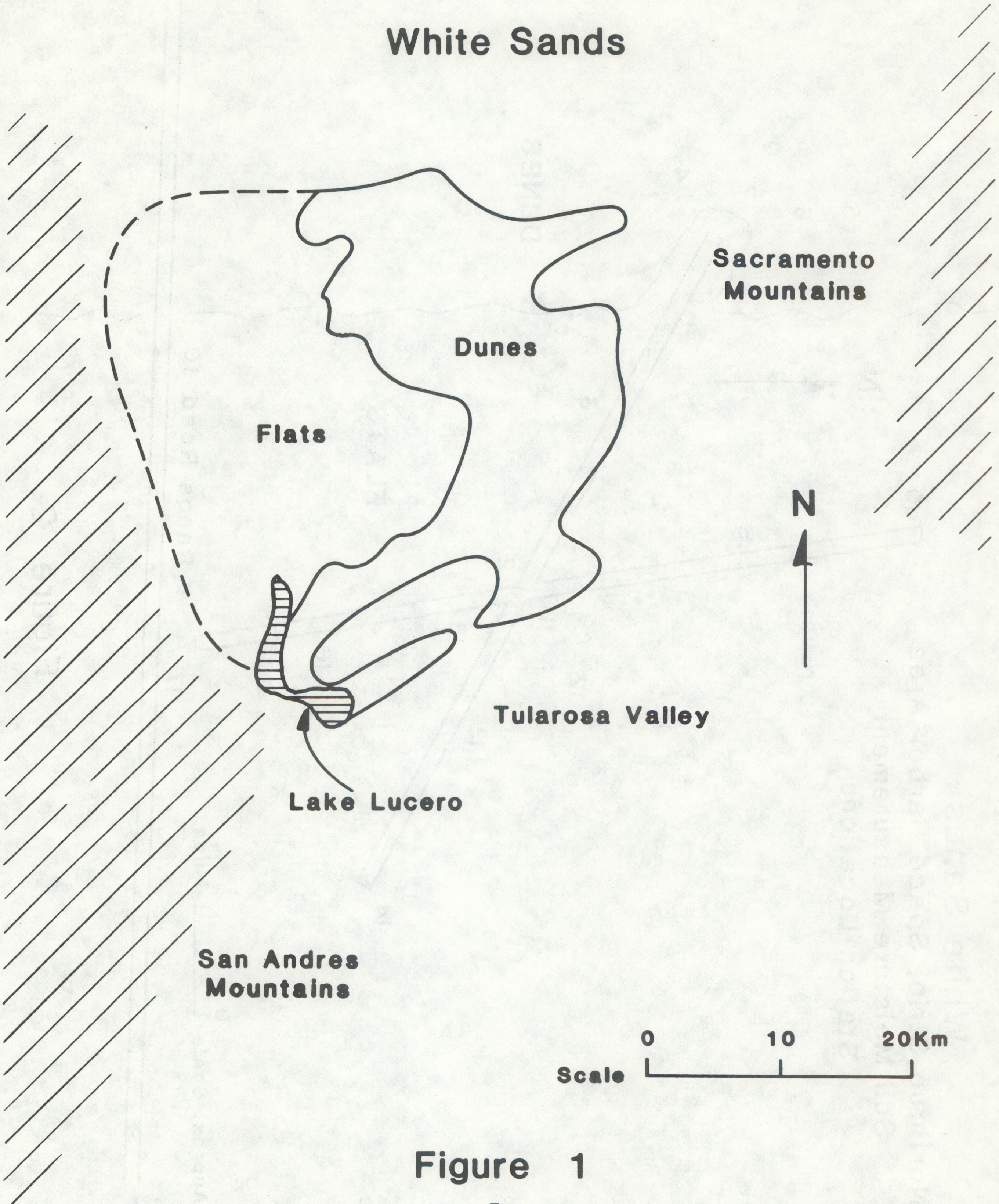


Figure 1

White Sands
Northrup Strip, Space Harbor Area Soil Moisture Measurement Station Locations

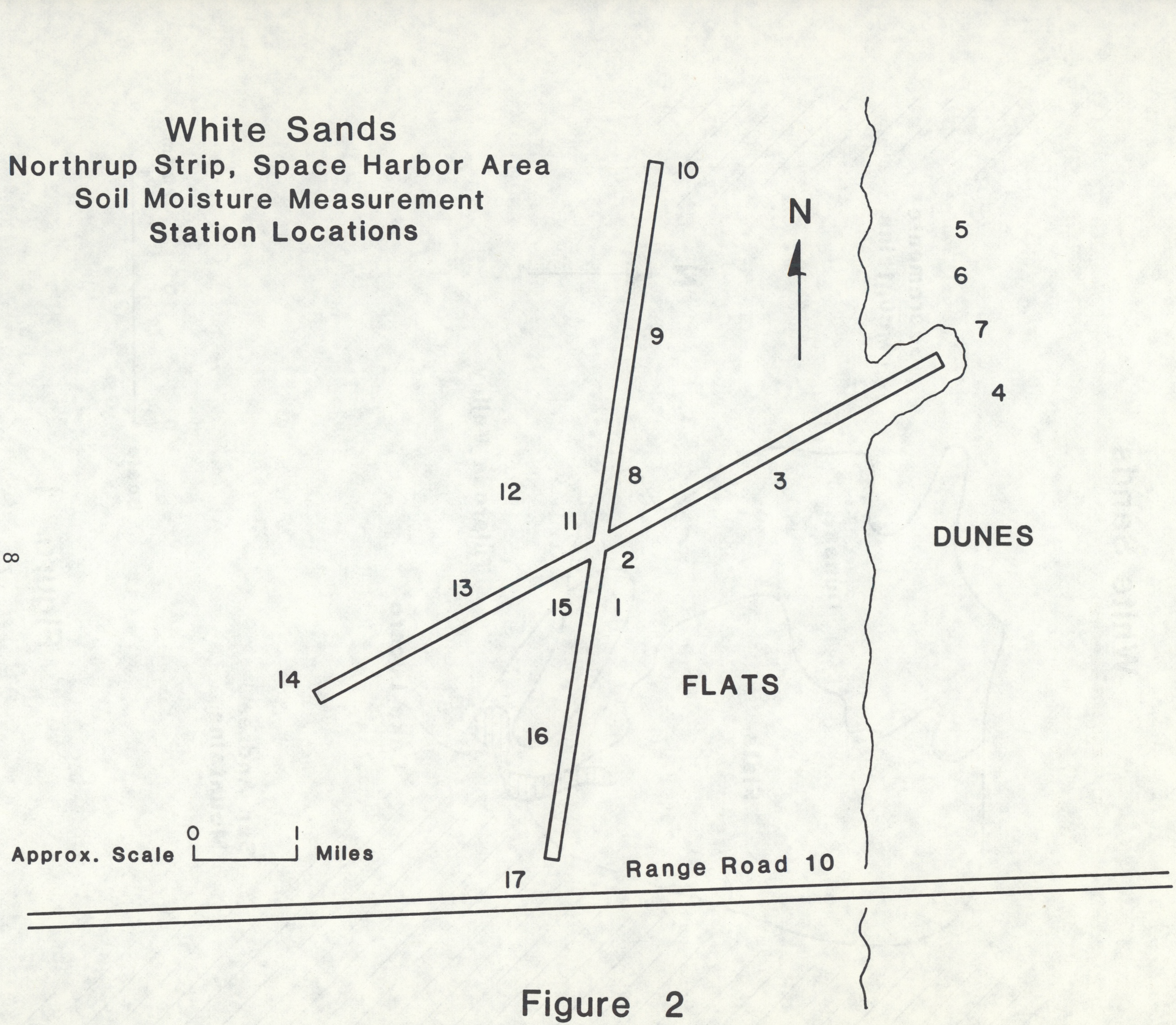


Figure 2

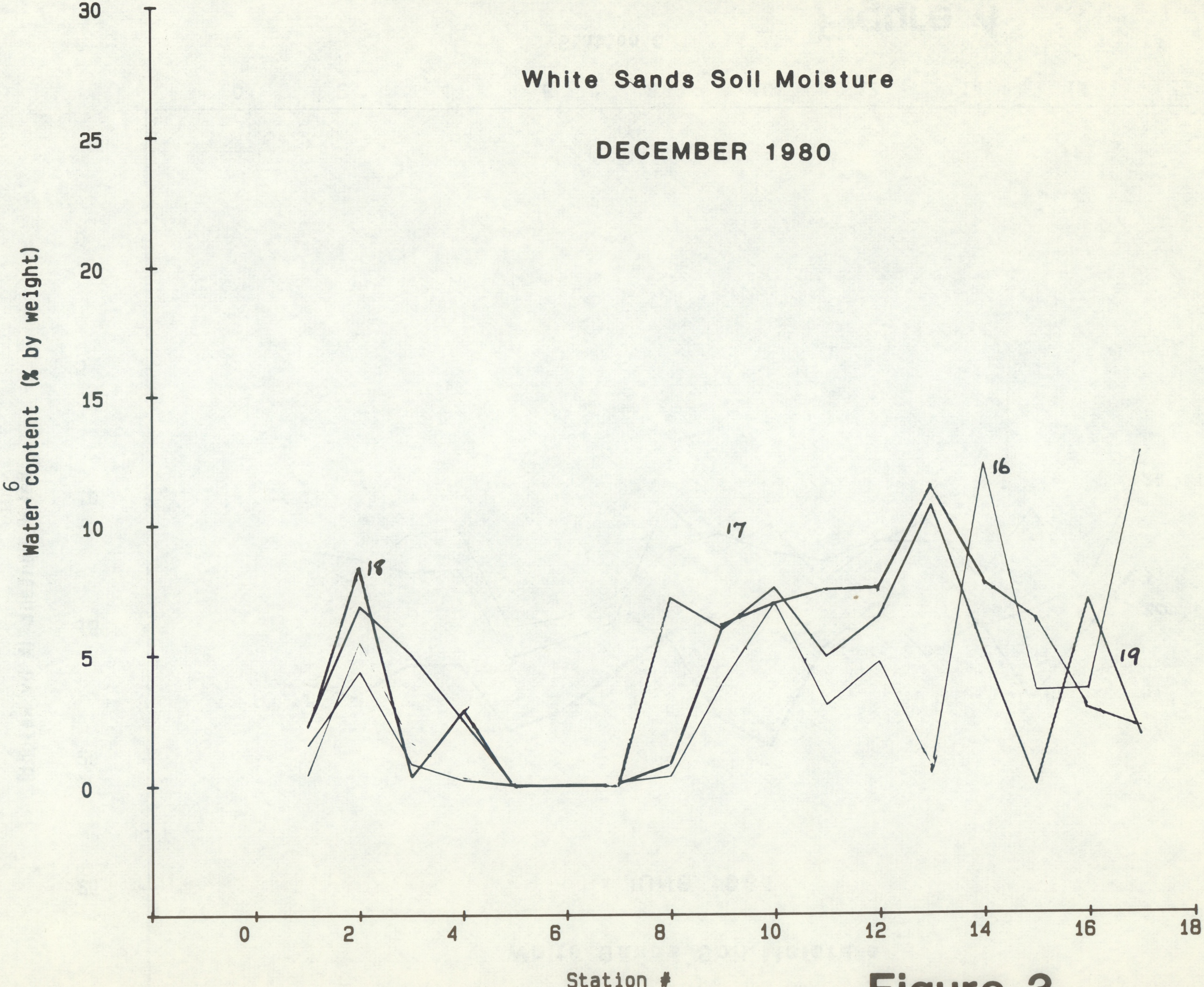


Figure 3

DEC 80 DATA

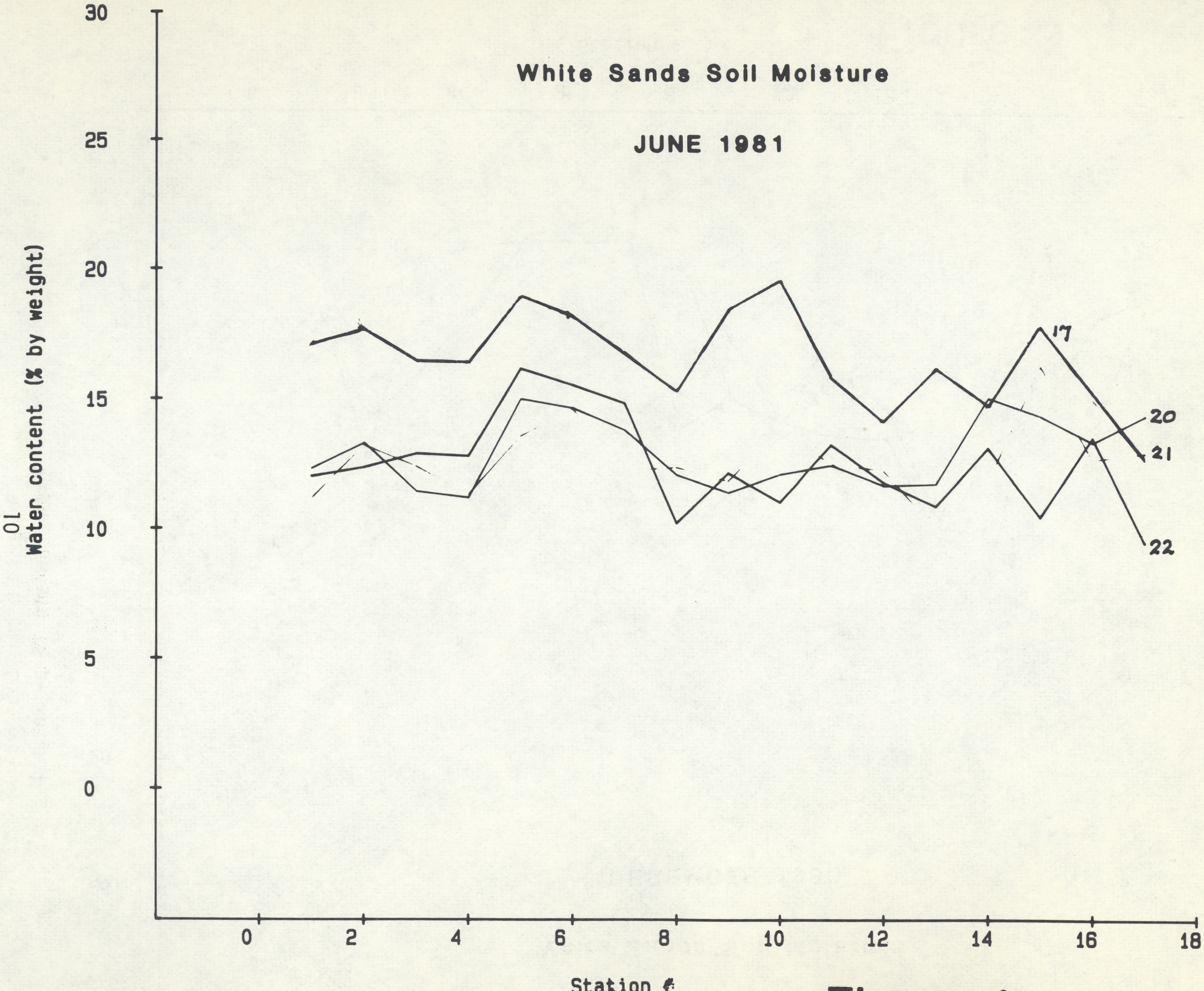
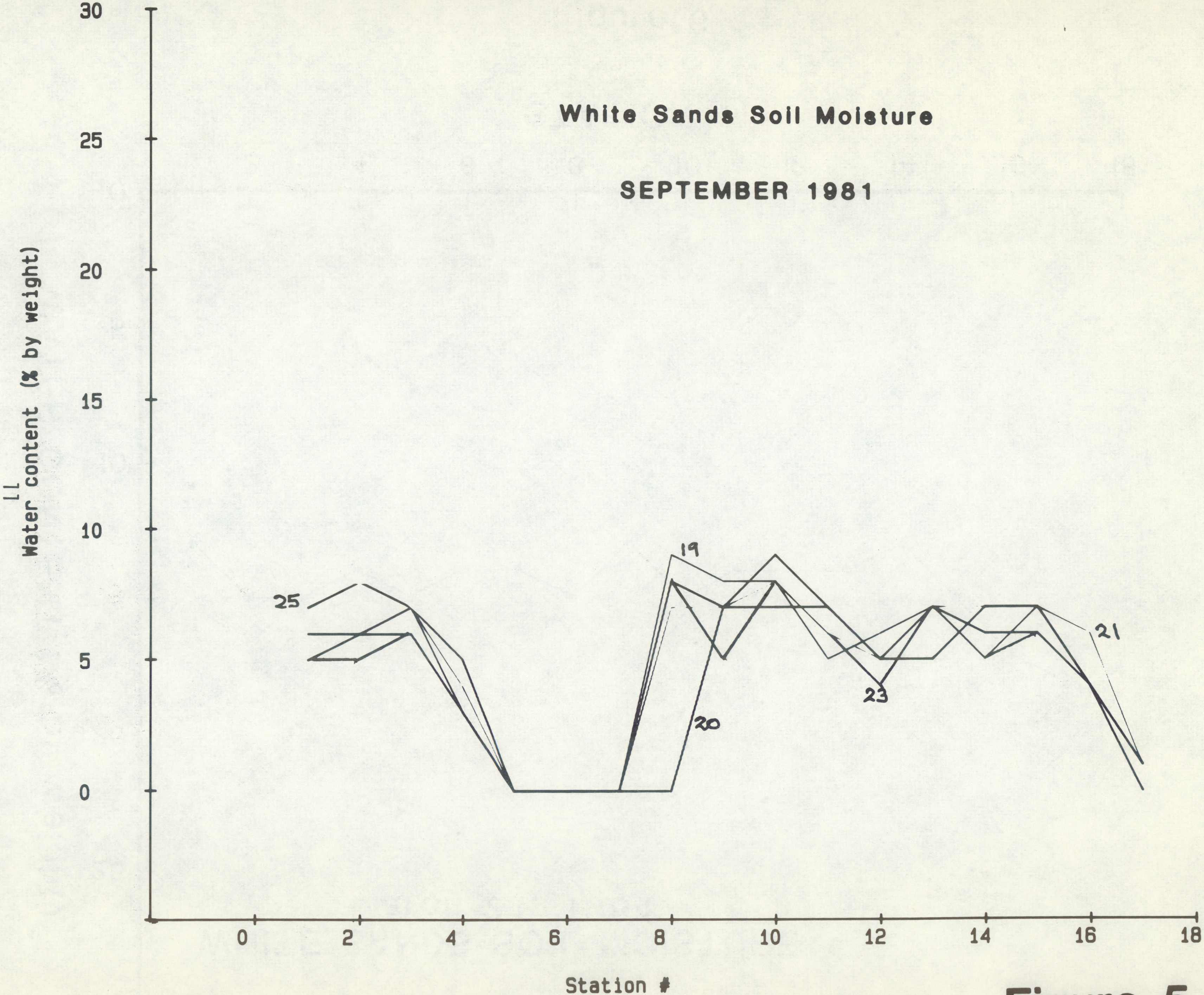


Figure 4

JUN 81 DATA



SEPT 81 DATA

Figure 5

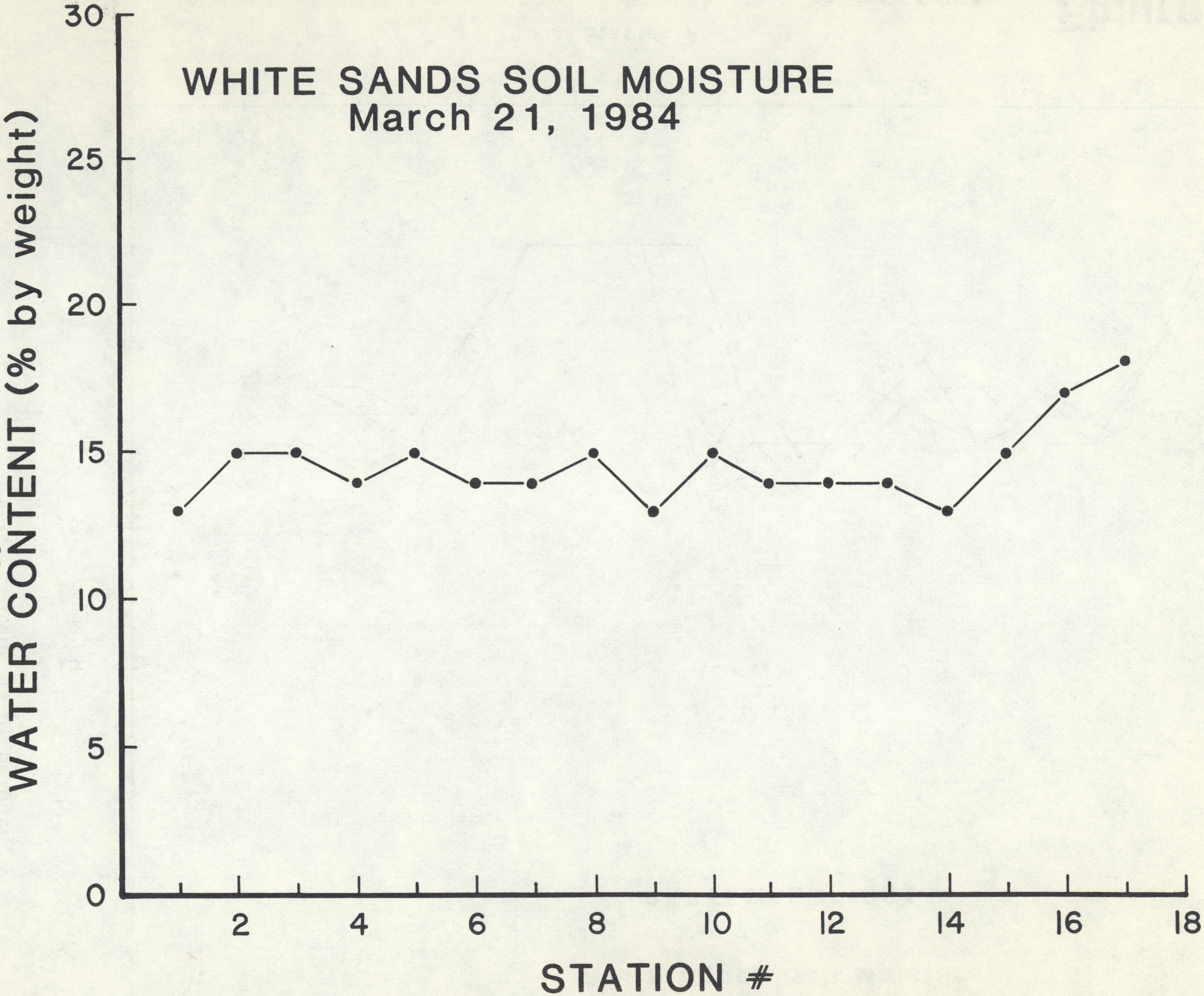

WHITE SANDS SOIL MOISTURE
March 21, 1984
WATER CONTENT (% by weight)
30
25
20
15
10
5
0
2
4
6
8
10
12
14
16
18
STATION #

Figure 6

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