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WATERSHED HYDROLOGY

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Spring and Seep Investigation
of Wupatki National Monument

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FLAGSTAFF AREA NATIONAL MONUMENTS
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Wupatki National Monument was established to preserve prehistoric ruins from a civilization--the ancestors of the Hopi or "people of peace." The major attraction of the monument, Wupatki Ruin, is located on the edge of Dead-man Wash--an ephemeral drainage for approximately 50 square miles of the San Francisco region.

As many visitors view the ruins, the most frequent question relates to the water source for former inhabitants (ca 1100-1250 A.D.). There is no obvious evidence for the visitor as to water source and the rhetorical answer is "from nearby seeps and springs."

When the monument was established in 1924, Wupatki Spring was active and providing a substantial flow. The original Civilian Conservation Corps/Work Progress Administration Crew, hired to excavate and stabilize the ruins under the direction of the Museum of Northern Arizona in 1924-33, had "piped" water from the spring to camp location 500 yards northeast (personal observation). The park staff increased and by 1950, a visitor center and residence also used spring water which was stored in a holding tank and then pumped to the house 400+ yards east (R. Euler, personal communication). No photograph or reports are on file to aid in determining where above developments were located.

Former park personnel had some foresight to monitor spring flow and track the output with local precipitation and snow course readings from the inner basin of San Francisco Peaks. From as early as 1938, former park ranger-in-charge, David J. Jones, was monitoring Wupatki and Heiser Springs. During his tenure, he recorded Wupatki Spring to have flows from 178-1122 gallons per day. (Although Heiser Spring is active, no output is available.) ^{2000+ gallons/day} *sc* Custodian Jones commented on Wupatki's Spring response, to local precipitation, 3-5 days later (Jones, 1945). In 1948, the Superintendent's Monthly Report relates efforts taken to clean 12 cubic yards of clay, sandstone and shale from the spring and installing perforated pipe to aid in capturing the flow (Jones, 1948). Although the monitoring was intermittent for ten years, it provided impetus for this project. In the mid-1950s, various superintendents were submitting comments to superiors regarding the diminishing flow of the spring and the effort being expended to haul water from nearby Heiser Spring (Superintendent's Monthly Reports, 1956-59). In 1959, a 900' well was drilled near the current headquarters area. The pump and house equipment were removed from the spring, and regard for the native water source diminished (C. Crane, D. Morris, personal communication).

Wupatki Spring is only one of three known natural water sources on the north and east edges of Woodhouse Mesa which could be available for wildlife. Heiser Spring was tapped for human consumption and removed as a wildlife source in the 1950s. Cottonwood (Peshlaki) Spring is still available and has a flow of 12-15 gallons per hour. The reason for loss of Wupatki's Spring is still in question but it is no longer available for wildlife (See Map 1).

The purpose of the project was two fold: (1) provide data to determine the feasibility of developing Wupatki Spring, and (2) sample various locations to determine presence of water. The scope of this project was to relate the presence of water, whereas more expertise is required to determine geologic/hydrologic events taking place, i.e., source of the water.

METHODS AND MATERIALS

A piezometer was designed to collect water to a depth equal to that of excess moisture in the soil. In this study, the height of water in the tube is equivalent to amount of water in soil. Tubes were left in place for a minimum of one day, and sometimes longer (See Table 1). Holes of 1/8 inch in diameter were drilled around the circumference of the 3/4 inch inner diameter PVC tube. The holes were spaced at two-inch intervals for the first 12 inch length of pipe, then spaced at 4 inches for three more feet. A 1-1/2 inch inner diameter galvanized pipe, 6 feet in length, was driven into the substrate at locations around the mesita where Wupatki Spring is located, and numerous other sites within the monument. Once the metal tube was extracted, a 4-6 feet in length of piezometer tube was inserted into the hole. Water depth was determined by inserting a length of 3/8 inch wooden dowel into the piezometer and recorded as the height of water column on the dowel. The same dowel was used for all depth measurements. Sites were sampled over a three-week period, and no significant rainfall was received during that time.

SITE DESCRIPTION

The location of all "holes" were within an area known as Wupatki Basin (See Map 2). The site is an arid region supporting cold desert shrub vegetation: Fallugia paradoxa, Atriplex canescens, Chrysothamnus nauseosus, Juniperus monosperma, Artemesia filifolia, Ephedra torreyana, numerous bunch grasses and forbs. In recent field investigations, two plants species have been considered as potential indicators of available moisture. Foresteria neomexicana (a native

species-desert olive) and Tamarix pentandra (an exotic species-salt cedar) (personal observation). For purposes of this study, sites with desert olive were not "tested," but one with tamarisk was. The desert drainages will be studied at a later date.

The main area of interest, Wupatki Spring, is located on a small extension of Moenkopi sandstone in Deadman Wash, approximately 250 yards west of Wupatki Ruin (See Map 2.). Woodhouse Mesa, a basalt formation (ca 800,000-3 million years old), (Moore and Wolfe, 1976) overlies the Moenkopi sandstone. A solid cap of Moenkopi sandstone, 3-4 feet thick, overlies older pervious Moenkopi shales, clay and mudstone. Judging from the amount of alkali deposits on the surface, it is surmised that the spring flows (Heiser, Cottonwood and Wupatki) are associated with these strata. The alkali is a residue of mineral as water evaporates. Inspection of the outcrop revealed several gullies of various depths and erosional stages, which indicate substantial runoff. Old 4 inch clay tile, iron pipe and two cement foundations were found near the top of the formations and are evidence of previous work. Along the east edge of the Moenkopi, were remains of a prehistoric dwelling, with an associated structure on the slope formed from vertical slabs. No investigation was made of the structure. Across one of the arroyos was a weathered "check dam," 5-6 rock courses high. The catchment was filled in with sediment and supported dense stand of vegetation. For that reason, one of the sites (#11) was placed in the catchment. Five other drainage locations were chosen around the mesita, two on the west and three on the east. None of the locations were around exposed rusted pipe or tile from the previous development.

Another location of interest was a site in Section 29, T25NR10E. The area is an obscure drainage between ridges of Moenkopi sandstone. During 1983 field surveys for exotic species, 100 clumps of "young" tamarisk (5-7 feet in height) were found growing in this drainage. The site was selected for testing because of the knowledge that tamarisk requires surface moisture, and the lack of evidence of above-ground flow. The area is characterized as cinder upland (Soil Conservation Service, 1971), with cinder depth ranged from 30 to 42 inches for sites 1, 1a, 1b.

The final area of testing was near a large gravel bank in Section T25NR10E. This site was also surveyed for exotic species in the summer of 1983. A few mature desert olive plants (6-10 feet) were found growing in the area. Also during December, 1983 and following January, the site was found to be "active",

in that water was dripping from ledges and had formed a considerable amount of ice. This was thought to be quite unusual, as no precipitation had been received since the previous September. This "seep" was one of several exposed on the west face of the gravel bank. Examination of the arroyos revealed seeps at various elevations, which may be active with respective amounts of soil moisture. The seeps at higher locations would be dripping first with higher soil moisture and also cease activity as the water table drops. The lower seeps are active longer and support more vegetation. A similar arroyo (south) was sampled as well as a site in the bottom of Deadman Wash. The site uphill from the active seep was in similar strata, but none of the ledges had evidence of active seepage at times. The core was composed of alluvial material (sand) and a dozen pebbles 8-10mm in diameter.

RESULTS

The process of sinking tubes was as follows: drill a hole by driving with a larger pipe (1-1/2 inch diameter), examine the contents of core, set the piezometer tube (3/4 inch in diameter), and record water initially 24 hours later. In some cases, water was present in that short of time, whereas in others, tubes were left in place for one week without significant results. Because only three tubes were used, longer recording times were not possible.

The Wupatki Spring area, the focus of the study, provided some valuable data. Strata was impervious after 16-18 inches for sites 6 and 7. The core content revealed some wet cinder and clay, but little or no water was recorded (See Table 1). Secondary results of the sampling were the discovery of the check dam (Site 11) and other prehistoric features (Sites NA 2785&2786). The piezometer at Site 11 was monitored for a week with final result of recording 2-1/2 inches of water. As a result of this finding, more intensive effort will be made during the summer of 1984 to ring the Moenkopi sandstone outcrop with similar tubes to prove or disprove other water locations. Each site (Wupatki Spring, 1-6, will have a separate tube for monitoring purposes. Archeologists for Southwest Regional Office will record the archeological features found as part of the ongoing Wupatki Archeological Survey. Pending authorization, an archeologist will assist in excavating the reservoir and stabilize the check dam to restore the "catchment" device to a near original form. The result will be valuable for the interpretation of the ruins and for native wildlife species. The presence of the check dam and reservoir will reconfirm the ingenuity of the former Sinagua residents and their ability to cope with the desert environment.

The sites along the gravel bench, where an active seep was observed, provided insight as to the holding capacity of the gravel and the substantial amount of water beneath the surface at the seep: site 2, 6 inches of water, 17 inches in depth of tube. The difference in water between two drainages (Sites 2 and 3) was deduced to be the result of elevation and tilt of gravel bed with water coming out a lower elevation.

The obscure site (#1, 1a, 1b) with growth of tamarisk proved to be the most interesting. The site was sampled initially due to presence of tamarisk, and continued due to the fact water was present. As sites were chosen for "sinking tubes," another prehistoric feature, a potential check dam and water catchment was found (Site 1a) at the west end of the drainage. Heavy growth of bunch grass and alkali deposits were present at the site. During examination of the soil conditions, two sections of fallen wall, nearly covered with blown cinders were observed nearby were two pieces of vertically placed sandstone, evidence of stone work. As the upper one half to 1 inch crust of cinder and deposit were scraped away, very moist clay was found. The third sampling point (Site 1b) in this drainage was 100 yards downhill from the initial site, amongst tamarisk and in the above-ground "channel" (See Map 3). There were small, 2-4 square ^{meter} ~~feet~~ exposures of the white alkali deposit, but not mud as found at the previous site (1a). As the pipe was driven into place, it slipped 4-6 inches as it neared the bottom, having either gone through dissolved layers of sandstone or a site of previous excavation. The extracted core revealed dripping mud from a depth of 33 inches.

Table 1 lists the sites, depths and water column height. In all cases, excluding Deadman Wash, cinder material of various depths (1 inch - 55 inches) was above the Moenkopi shale and clay material. The column of Deadman Wash was cinder mixed with alluvial material (sand size grains).

DISCUSSION

Further investigation will be necessary around the periphery of mesita near Wupatki Spring site to ascertain existence of water. If water is found at a substantial, yet reasonable depth, further monitoring with piezometer should be conducted to correlate spring flow with local or regional precipitation or snow melt. Should considerable water be found behind the check dam, Site 11, an archeologist and hydrologist will cooperate in exposing the flow and reestablishing the water catchment device. It would be feasible to clean out the basin behind the check dam to "recreate" a vital part of the prehistoric Sinagua culture for interpretive purposes and provide a permanent water source for wildlife.

Other locations (Sites 2 and 4) in addition to unsampled remote drainages supporting growth of desert olive, will be monitored for water presence and fluctuation with snow melt or precipitation. The drainage supporting tamarisk will be monitored and investigated with the feasibility of excavating the pre-historic site and reestablishing its nature as a water catchment, primarily for wildlife.

The three springs on the edge of Woodhouse Mesa are at the following elevations: Cottonwood (Peshlaki)-4920 feet; Heiser-4860 feet; and Wupatki-4950 feet (NAU Natural Resource Survey, 1976; United States Geological Survey 1:24000 scale maps; Wupatki SE, Roden Crater, Wupatki Quadrangle). Since Wupatki Spring is at a higher elevation, the cessation of flow can be explained as follows: As the water level supplying the Moenkopi sandstone dropped, the ample water source was removed. This would account for the spring's lower elevations to remain active. Another theory is that a shift may have occurred due to the regional volcanic or tectonic action and shifting of formations. This seems unlikely due to the continuing flow from the other springs. A third reason could be man's historic (1930-50) but unsuccessful attempts to increase the flow from Wupatki Spring.

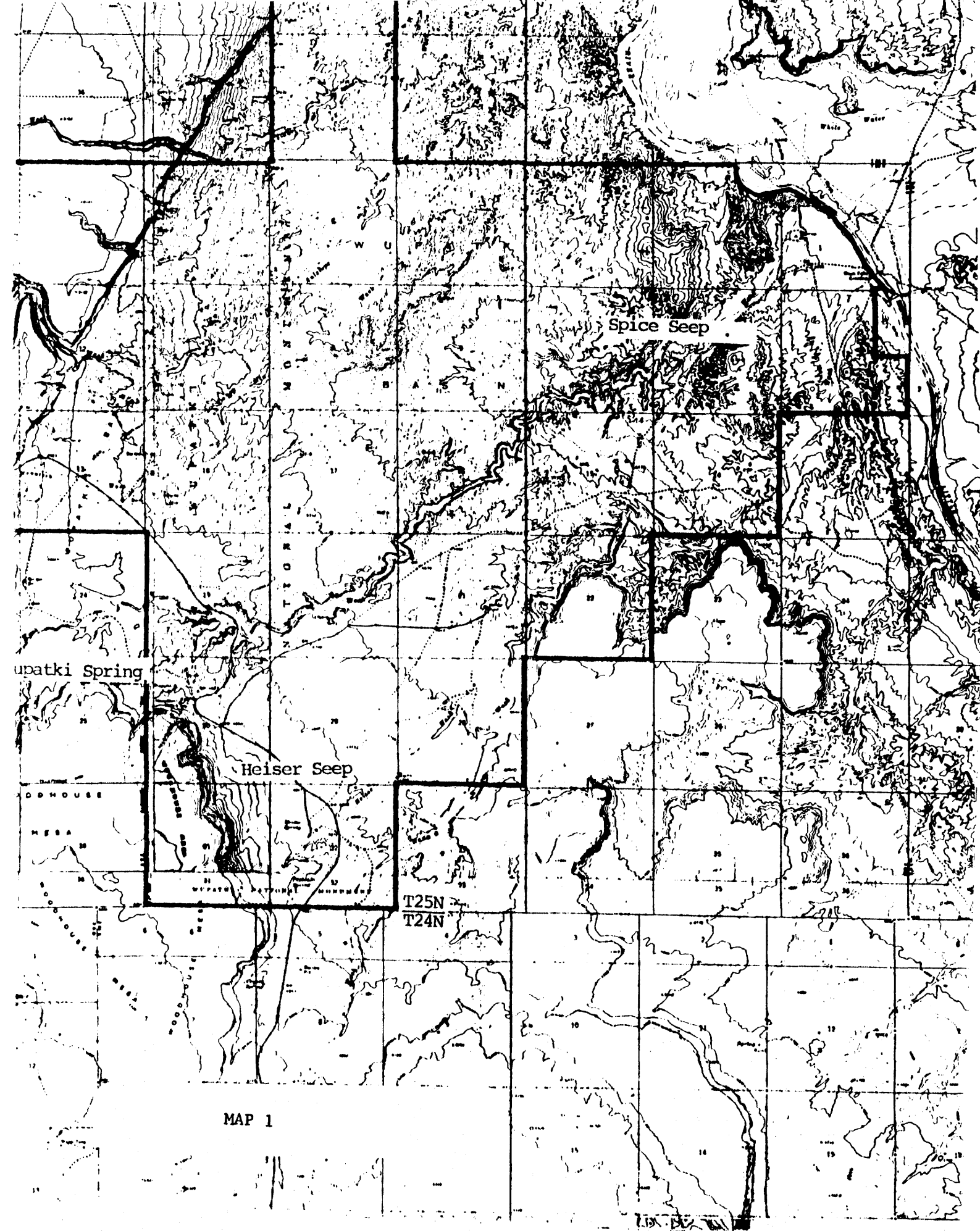
Whatever the reason for the disappearance of the flow, the same thing may have occurred when the Sinagua occupied the area, thus causing their departure. The presence of water assured life and without the basic necessity, survival was even more precarious. This may be a feasible assumption--a volcanic tremor and lava flows continued for nearly 200 years following Sunset Crater's eruption in 1064 A.D. and may have caused shifting of sediments and water source elsewhere.

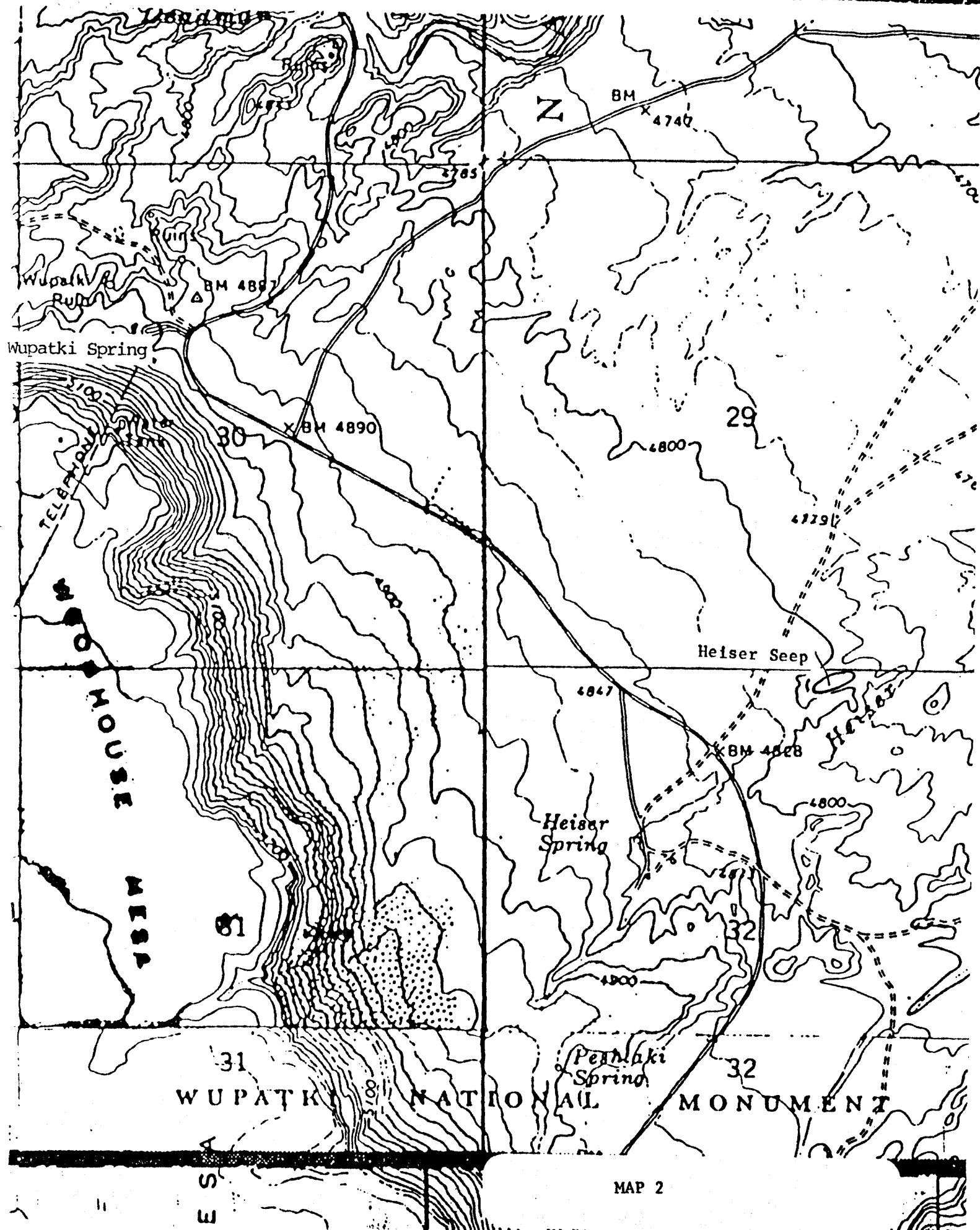
The monitoring process initiated in 1948-54 by Jones will be pursued to determine the correlation of spring flow to snow melt in the inner basin of the San Francisco mountains or the seasonal precipitation as a project statement in Wupatki-Sunset Crater Resource Management Plan.

TABLE 1. SUMMARY OF PIEZOMETER TUBE LOCATIONS, DEPTHS, FINDINGS AND SEDIMENTS

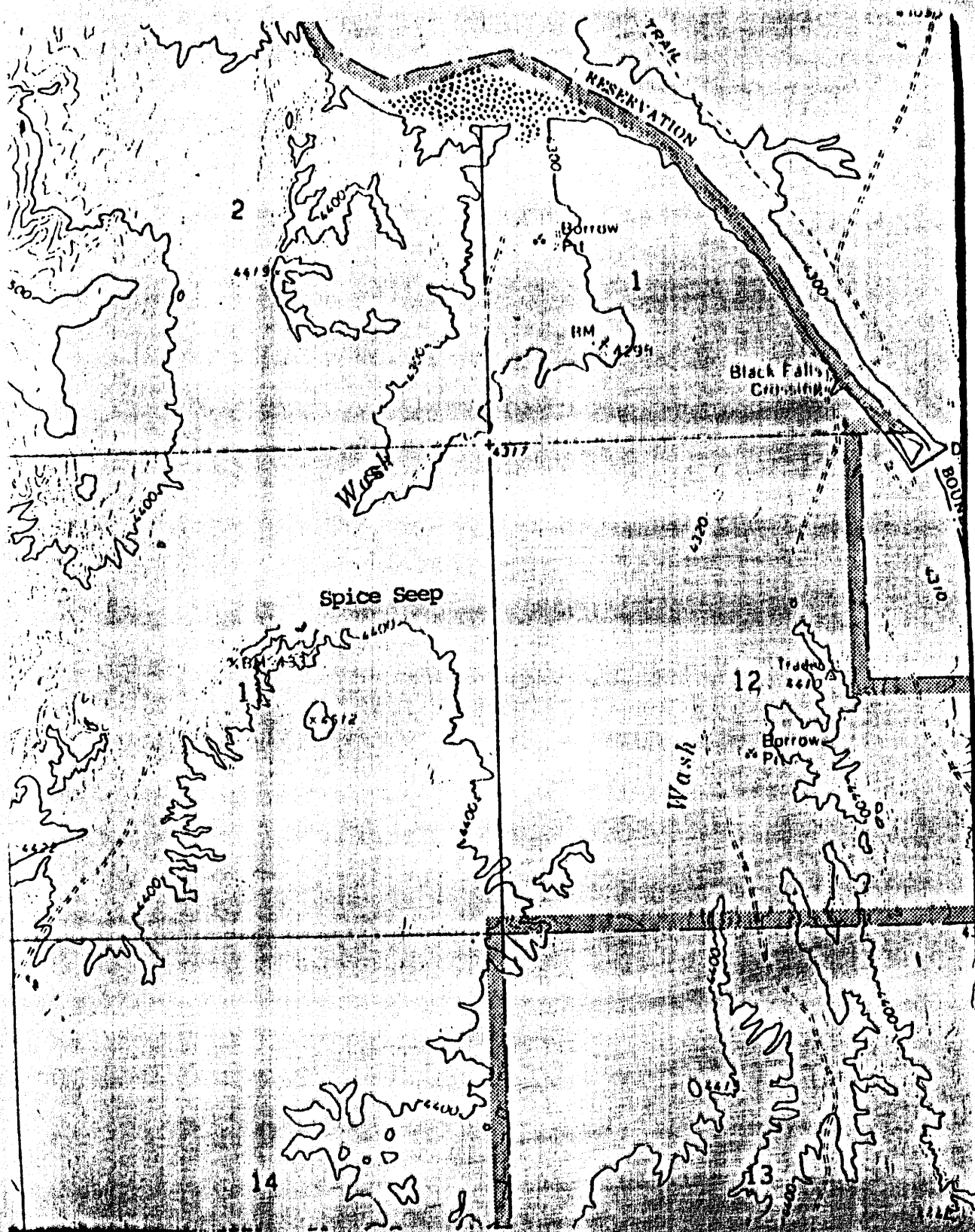
SITE NUMBER	LOCATION	DEPTH (INCHES)	TUBE INSERTED	TUBE CHECKED	WATER DEPTH (INCHES)	SUBSTRATE CHARACTERISTICS
1	Heiser Ruin ; NE ⁴ NW ⁴ NE ⁴ Sec 32 T25NR10E	36	March 28	March 29	1.5	34" cinders overlying sandstone shale
1a	Heiser Ruin ;	45	April 21 April 23	April 22 April 27	.5 1.5	43" cinders overlying sandstone shale clay
1b	Heiser Ruin ;	45	April 23 April 24	April 27 April 25	1.5 6	28" cinders overlying sandstone shale
2	Spice Seep* ;	17	March 30	March 31	6.5	Moenkopi shale to bedrock
3	Fork Seep ;	40.5	March 31	April 1	Dry	Moenkopi shale to bedrock
4	Deadman Wash ;	65	April 1	April 2	7/8	Sand, cinder, pebbles (.5" diameter at 30")
5	Wupatki Ruin ;	57	April 9	April 10 April 20	Dry .5	54" cinder Moenkopi clay. Bees and water; condensation on 36" of tube.
6	Wupatki Spring-1	16	April 9	April 10	.25	1" cinder Moenkopi shale, bedrock (tube wet at 11-13")
7	Wupatki Spring-2 ;	27	April 9	April 10	.25	2-3" cinder, Moenkopi clay and shale bedrock
8	Wupatki Spring-3 ;	46	April 15	April 16	.1	43" cinder, Moenkopi clay
9	Wupatki Spring-4 ;	32	April 15	April 16	Dry	Moenkopi shale, bedrock
10	Wupatki Spring-5 ;	26	April 20	April 21	Dry	Moenkopi shale and cinder, clay
11	Check Dam ;	49	April 20	April 22 April 26	.35 2.5	Moenkopi shale and cinder, clay

*Named after author





MAP 2



MAP 3