

June 13, 2003

L54(2380)
MEVE/General

Memorandum

To: Superintendent, Mesa Verde National Park

Through: Chief, Water Operations Branch, Water Resources Division (WRD)

From: Larry Martin, Hydrogeologist, Water Operations Branch, WRD

Subject: Trip Report for travel to Mesa Verde National Park on June 4, 2003

Summary: I traveled to Spring House in Mesa Verde National Park to provide assistance to park staff in evaluating the hydrology of the site and identifying potential actions to reduce the amount of moisture adjacent to the walls of Spring House. It is thought that moist soil conditions adjacent to the walls accelerate the decay of stones and mortar forming the walls of the cliff dwellings. Removal of soil moisture from the vicinity of the walls may help in the long-term preservation of the cliff dwellings. It is interesting to note however, most of the cliff dwellings further away from the spring have already collapsed.

There is a population of the rare Trailing Four O'Clock (a locally rare wildflower) on the slope below the cliff dwellings. The relationship or dependence of the wildflower and flow from the seep at Spring House is unknown. Any actions that are taken to remove water from the vicinity of the cliff dwellings should include plans for returning the water to the soil in the area below the cliff dwellings but upslope from the wildflowers so as to not disrupt the water supply for the wildflowers.

I will work with park staff to identify potential remedial actions to stabilize the walls of the cliff dwellings while insuring that any flow of water from the seep to the wildflowers will not be disrupted.

Discussion: Spring House is located on a west facing cliff of Long Mesa, approximately two miles east of park headquarters. Spring House is reached by following a four-wheel drive road approximately 5 miles south from the Wetherill Mesa Road.

Spring House is in an alcove at the base of the Upper Cliff House Sandstone. In this area, the Cliff House Formation is informally divided into three units; the Upper Cliff House Sandstone,

the Middle Sandy Shale Unit, and the Lower Cliff House Sandstone (Griffits, 2002). The Upper Cliff House Sandstone is quartz sandstone that is resistant to erosion and forms massive cliffs. The Middle Sandy Shale Unit is composed of alternating layers of shale and poorly cemented sandstone. It is easily eroded and forms an unstable slope between the two massive sandstone units. The Lower Cliff House Sandstone is similar to the upper unit, but is not as well-cemented and contains a few irregular shale layers. The most important geologic features at Spring House are the shale layers in the upper part of the Middle Sandy Shale Unit and a large vertical crack in the upper sandstone unit. The crack probably acts as a collector and conduit for groundwater flowing through the sandstone. Some surface water from the top of the mesa probably infiltrates and follows the cracks and fractures in the sandstone to the base of the upper sandstone unit, where it encounters the shale layers and flows horizontally to the canyon walls. The shale layers can easily be seen on the cliff face just north of the cliff dwellings. They act as an impermeable boundary for groundwater in the Upper Cliff House Sandstone, forcing groundwater to seep out of the sandstone immediately above the shale. This seepage dissolves the cement in the sandstone, weakening it and allowing formation of the alcove where the cliff dwellings were built.

At Spring House, the combination of water availability from the fractures and cracks in the upper sandstone and the impermeable shale layer resulted in formation of a large alcove. The presence of a small spring made the area desirable for construction of cliff dwellings. Adjacent areas along the canyon walls do not have cliff dwellings because there are no fracture systems funneling a sufficient quantity of water to allow formation of large alcoves. In areas where the upper sandstone unit is not fractured, the permeability of the sandstone is too low to allow very much groundwater to flow through the sandstone and alcove formation does not occur.

The large vertical fracture in the upper sandstone behind Spring House provides a pathway for groundwater and surface water to migrate through the sandstone. When the water encounters the impermeable shale layers, it is forced to flow horizontally resulting in a small spring or seep area near the intersection of the vertical fracture and the horizontal shale layers. I did not measure the flow rate, but estimate it was in the range of a few gallons per hour. Flow from the seep creates a small pool of water (approximately two feet across and 6 inches deep at the time of our site visit) in a small depression at the base of the cliff. This pool is behind some of the few remaining intact walls at the site. Water infiltrates into the underlying sandy sediments, creating a constant source of moisture in the soil and fill material in the cliff dwellings. This water may, or may not, be an important source of water for the population of Trailing Four O'Clock wildflowers that are present on the slope below the cliff dwellings.

Preston Fisher, the park's structural engineer, is concerned that moisture in the soil is being drawn into the walls of the cliff dwellings by capillary action, causing erosion and weakening of the rocks and mortar at the base of the walls. His analysis of the situation is probably correct. Therefore, the goal is to remove enough water from the soil in the vicinity of the walls to create drier conditions, while at the same time continuing to supply water to the rare wildflowers in the area.

Because there is only a small amount of water flowing out of the seep, it is highly unlikely that there is enough water infiltrating into the ground to create saturated soils. Soils in the area are

predominantly sand from erosion of the Upper Cliff House Sandstone and therefore are fairly permeable. Because water can flow freely through the soil and the slopes are steep at the site, it is improbable that the groundwater would pool in any area to create a water table. Without saturated soil conditions, conventional dewatering techniques such as a french drain or dewatering wells will not accomplish anything. I have asked Preston Fisher to construct a couple of “monitoring wells” in the area to determine whether there might be saturated soil and a water table. That information will determine whether we should further investigate any type of dewatering alternative.

If we are dealing with moist, but not saturated, soil conditions then our options are limited to; 1) reducing infiltration from the spring pool, 2) attempting to dry the soil in the vicinity of the walls, 3) reinforcing foundation of the walls, and 4) do nothing. There may be additional alternatives available that I have not thought of.

Infiltration from the bottom of the spring pool might be reduced by first excavating the pool and adjacent areas along the base of the cliff to direct all of the seepage into the pool. The pool would then be lined with either a rubber or clay liner to reduce infiltration. An overflow pipe would be required to carry water away from the cliff dwellings. The water should be allowed to infiltrate into the talus debris below the cliff dwellings but above the Trailing Four O’Clock so the hydrologic regime for the wildflowers is not disrupted.

It may be possible to dry the soils in the immediate vicinity of the wall by constructing a ditch adjacent to the wall, placing a perforated pipe in the ditch on a bed of pea gravel next to the wall. Warm, dry air would then be forced into the pipe to dry the soils next to the wall. This action would cause evaporation and might reduce the availability of soil moisture for the wildflowers down the slope from the site.

The foundation of the remaining walls could be reinforced by excavating a trench adjacent to the walls and constructing a concrete wall to provide additional support. Perhaps a concrete support wall could be constructed on both sides of the cliff dwelling wall. Additional support could be provided by installing a horizontal rod below grade from the concrete support wall to an anchor in the sandstone cliff face.

A final option is to do nothing and allow natural processes to occur. The spring and seep areas existed in this area long before there were cliff dwellings at the site. The cliff dwellings have survived under the existing conditions for at least 700-800 years. If we do nothing, the remaining walls will undoubtedly collapse at some time in the future, but it’s impossible to say if they will survive 1, 10, 100 or more years. It is rather interesting to note that most of the surviving walls are adjacent to the spring. Most of the cliff dwellings further from the spring have already collapsed.

If there are any questions regarding this trip report, please call me at (970)-225-3515.

References

Griffits, Mary O., 1990, Guide to the Geology of Mesa Verde National Park, Mesa Verde Museum Association, 88 pp.

Griffits, Mary O., 2002, Spring House Visit 2002, unpublished report, 4 pp.

Harris, Ann G., Esther Tuttle, and Sherwood D. Tuttle, 1997, Geology of National Parks, pp. 92-101

PMIS Statements No. 71981-A, 72596-A, 85960-A, 85960-B

cc:

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1211 – Reber

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Southern part of Spring House. The spring area is to the right of this photo.



Shale layers at the bottom of the Upper Cliff House Sandstone.
Photo location is a few tens of feet north of the cliff dwellings.



Photo of the northern part of Spring House. The spring is at the intersection of the vertical crack and the base of the cliff, behind the wall in the center of the photo.