



United States Department of the Interior

NATIONAL PARK SERVICE
Water Resources Division
1201 Oak Ridge Drive, Suite 250
Fort Collins, CO 80525

May 25, 2012

IN REPLY REFER TO:

L54(2380)
JECA/General

Memorandum

To: Mike Wiles, Cave Management Specialist, Jewel Cave National Monument

From: Larry Martin, Hydrogeologist, Water Resources Division (WRD)
Dale Pate, Physical Scientist, Carlsbad Caverns National Park (CAVE)

Subject: Technical Assistance Request Report to Jewel Cave National Monument
Site Visit - May 16, 2012

Summary

A visit was made to Jewel Cave National Monument (JECA) May 16, 2012 to address a FY 2012 Technical Assistance Request (TAR) submitted by park resource staff. The technical assistance request was based on water infiltrating into the park's elevator shaft causing damage to electrical and other components of the elevator equipment and leaving pools of water in two in-cave lobbys at 211 and 287 feet below the surface.

This report summarizes the site visit and discussions with JECA staff, provides a discussion of the geology and hydrology of the bedrock within the area of the elevator shaft, and concludes with the following recommendations:

- Construct weepholes at the most prominent seepage areas. These will likely coincide with the horizontal seams in the concrete wall. Insert PVC pipe into the holes and seal them in place with waterproof, expanding epoxy to prevent water from leaking around the outside of the pipes. Convey the flow from the weepholes to the existing system of gutters and downspouts.
- Seal the openings at the headers above the elevator doorways at the cave lobby entrances. This will require some type of waterproof, expanding foam or epoxy. Drill a series of weepholes above and alongside the doors to drain water and reduce the hydrostatic pressure at the newly sealed areas above the doorways.
- After the major leakage areas have been controlled, coat the entire inside of the elevator shaft, including behind the panels, with a waterproof epoxy coating to reduce diffuse seepage through the concrete wall.
- Ventilate the shaft by pumping warm, dry air to the bottom of the shaft and allow it to rise to an exhaust at the top of the shaft. There is presently no air circulation in the

elevator shaft, and so no evaporation occurs, making even minor seepage a major problem.

Discussion:

The 300-foot deep elevator shaft at Jewel Cave penetrates several units of the lower part of the Minnelusa Formation and the Madison Formation. The elevator provides access to two levels of the cave at 211 and 287 feet below ground surface. Water infiltrates from the surface and flows down along the outside of the elevator shaft. Water seeps and flows into the elevator shaft at many locations where the concrete walls lining the elevator shaft are not watertight. This water wreaks havoc with the electrical and mechanical controls and operation of the elevators.

Hydrogeology – Figure 1 shows a conceptual geologic cross-section in the vicinity of the elevator shaft. The elevator can be thought of as occurring in the general location to the right of the center, and shown by the blue arrows indicating downward percolation of water and the red lines indicating fractures in the bedrock. We don't know that the bedrock in the vicinity of the elevator is fractured, but the figure provides an otherwise reasonable depiction of the geology.

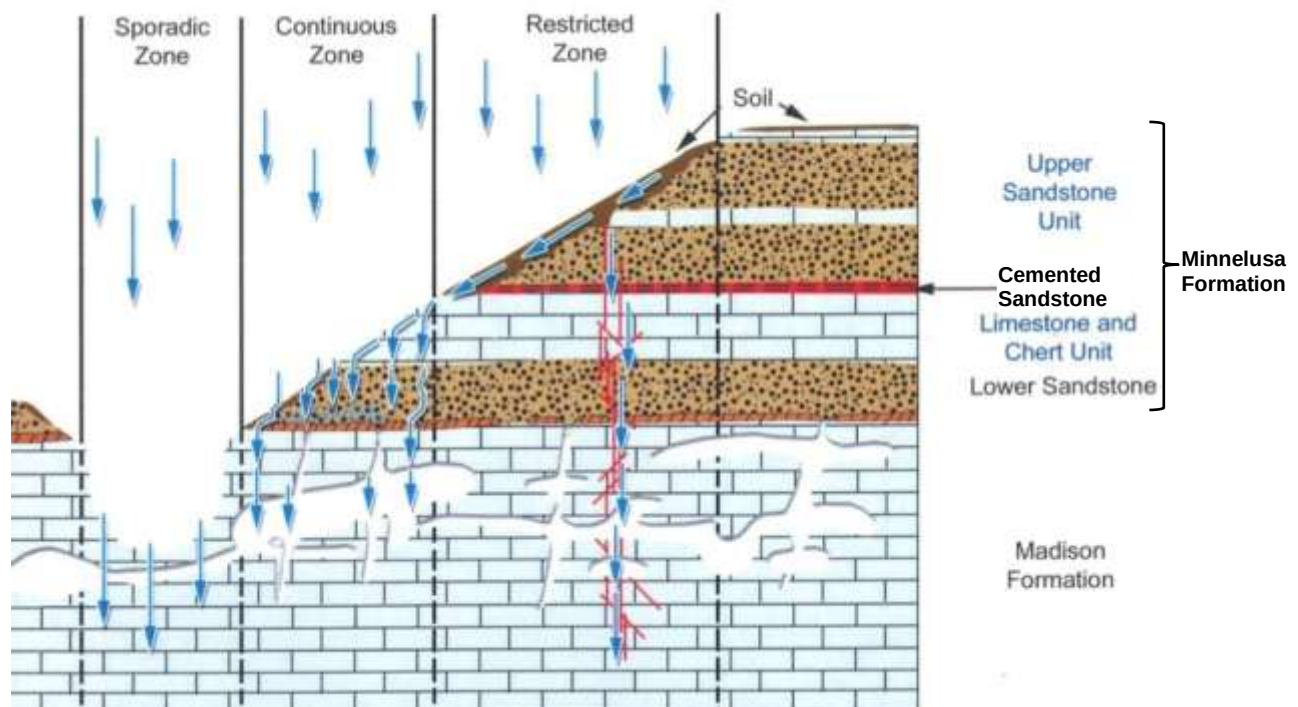


Figure 1. Conceptual geologic cross-section in the vicinity of the Jewel Cave elevator shaft.

Cemented sandstone in the upper part of the Minnelusa Formation is thought to act as an impermeable layer over much of the cave area. The cemented sandstone is above a limestone and chert unit and a sandstone unit at the base of the Minnelusa Formation. The cave below is dry wherever the cemented sandstone layer is present above. The impermeable layer was penetrated during construction of the elevator shaft. The impermeable seal was not recreated during construction of the shaft. It's likely that the occurrence and significance of the impermeable layer were not recognized at that time.

Water infiltrating into the ground in the vicinity of the elevator will percolate downward until it reaches the impermeable layer (the cemented sandstone shown as a thin red layer on the cross-section). Water will then flow laterally until it finds an opening where it can percolate down through the cemented sandstone. That might be the elevator shaft, or it could be naturally occurring fractures in the bedrock. However, it is generally thought that the cemented sandstone provides an effective impermeable barrier to downward percolation because the cave is generally dry below wherever the cemented sandstone is present above.

The elevator shaft was constructed incrementally from the top down. Excavation would proceed for about 10 feet. Then forms would be constructed and concrete poured for the wall. Excavation would then proceed for another 10 feet, forms would be placed, and concrete poured into openings at the top of the forms. Construction in this manner would not allow a watertight seal between the bottom of the previous pour and the top of the new pour. The seam in the concrete is an obvious weak point, as that is where much of the seepage was observed to occur. While the inside surface of the elevator shaft appears continuous, it is likely that there are gaps in the concrete toward the outside of the walls. The situation is illustrated in Figure 2. The blue arrows represent probable groundwater flow paths on the outside of the concrete wall.

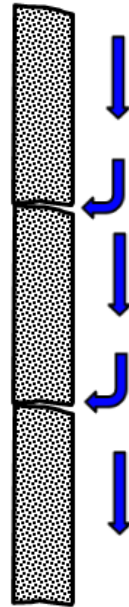


Figure 2. Schematic of elevator shaft wall

It might be possible to drill holes at each seam in the concrete and inject some type of waterproof, expanding sealant to fill any voids toward the outside of the elevator shaft. However, that would likely require drilling hundreds of holes, perhaps at one foot intervals along each seam. Sealing in this manner, even if successful, would do nothing to alleviate the pressure of water outside the concrete wall. It's likely that eventually water would find a new pathway through the concrete wall, such as along a previously dry crack. Park staff could be faced with a perpetual job of drilling holes and injecting sealant.

We think it will be more effective to capture, collect, and redirect the flow of water to the existing system of gutters and downspouts in the elevator shaft. Gutters and downspouts already exist on three sides of the interior of the elevator shaft. They seem to be effective in capturing water and directing it to a sump at the bottom of the elevator shaft. Water is then pumped from the sump to disposal in the cave. It seems that the gutters were not installed on the door side of the shaft because there is not as much clearance between the wall and the elevator.

Weep holes should be drilled in the areas where the most seepage occurs. Insert short pieces of PVC pipe into the hole, seal the annular space with waterproof, expanding epoxy to prevent leakage around the outside of the PVC, and attach a piece of flexible tubing to collect water and route it to the existing gutters and downspouts.

It might be possible to seal the inside of the concrete wall to further reduce the diffuse seepage through the concrete after weepholes and drains have been installed to capture most of the water from outside the concrete wall (and thereby reducing the hydrostatic pressure). A variety of products are available. A couple examples are;

<http://www.emecole.com/products/emecole-pene-seal-crete-5-gallon-bucket-concentrate.html>

http://www.thoroproducts.com/products_waterproofing.htm

We have no experience with these products. We present them only as examples of products that are available and advertise themselves as being applicable for this type of use.

Headers above the elevator doorways at the cave levels are another area where water seeps in from behind the concrete walls. Figure 3 shows a schematic cross-section of a typical construction of the elevator doorway opening at the cave lobby. A steel I-beam is laid on its side as a header. Under the I-beam is a course or two of concrete blocks and then a piece of channel iron to frame the opening. There are a lot of gaps between steel, concrete, and bedrock in this area. Water seeps and drips into the elevator doorway, wreaking havoc with the steel components of the door and frame and eventually finding its way into the electrical components. The openings could be filled with some type of waterproof, expanding foam or epoxy materials. An example is found at this website <http://www.epoxy.com/420.htm>. Other materials are undoubtedly available and further research should be conducted to select an appropriate product. A series of weepholes should be drilled above and alongside the doorways to drain the water that will build up after sealing the openings at the top of the doorways. Otherwise the water will eventually develop enough hydrostatic pressure to leak in around the new seal. Water from the weepholes should be drained to the gutters and downspouts via flexible tubing, as with the other weepholes throughout the shaft.

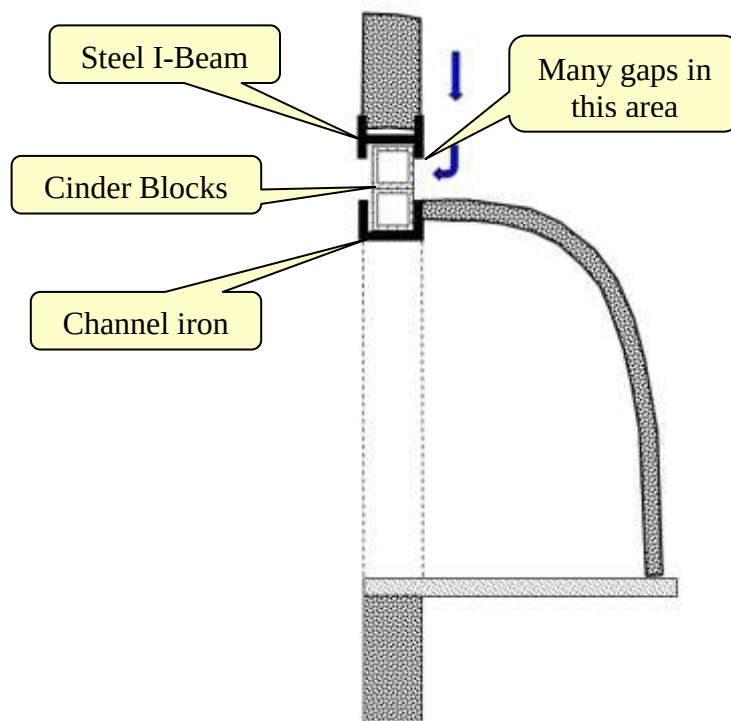


Figure 3. Schematic cross-section of the elevator doorway at the cave lobby.
Blue arrows indicate pathways for water seeping into the doorway openings.

Summary:

We recommend a series of actions to control the seepage into the elevator shaft at Jewel Cave. These actions might be conducted sequentially, with an assessment period after each step to determine when the seepage has been adequately controlled.

1. Construct weepholes at the most prominent seepage areas. These will likely coincide with the horizontal seams in the concrete wall. Insert PVC pipe into the holes and seal them in place with waterproof, expanding epoxy to prevent water from leaking around the outside of the pipes. Convey the flow from the weepholes to the existing system of gutters and downspouts.
2. Seal the openings at the headers above the elevator doorways at the cave lobby entrances. This will require some type of waterproof, expanding foam or epoxy. Drill a series of weepholes above and alongside the doors to drain water and reduce the hydrostatic pressure at the newly sealed areas above the doorways.
3. After the major leakage areas have been controlled, coat the entire inside of the elevator shaft, including behind the panels, with a waterproof epoxy coating to reduce diffuse seepage through the concrete wall.
4. Ventilate the shaft by pumping warm, dry air to the bottom of the shaft and allow it to rise to an exhaust at the top of the shaft. There is presently no air circulation in the elevator shaft, and so no evaporation occurs, making even minor seepage a major problem.

If there are any questions regarding this trip report, please call Larry Martin at (970)-225-3515 or Dale Pate at (575)-785-3107

cc:

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WRD – Gary Rosenlieb
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