Using Science to Change Management Perspectives at Carlsbad Caverns National Park

By Paul A. Burger[1] and Dale L. Pate[1]
[1] Carlsbad Caverns National Park, 3225 National Parks Highway, Carlsbad, NM 88220

Abstract

Research at Carlsbad Caverns National Park (CCNP) has led to dramatic changes in the management of cave and karst resources in the park. Surface contaminants found in the pools of Carlsbad Cavern have led to a re-evaluation of the infrastructure above the cave and could lead to the removal of buildings, parking lots, and utility lines above the cave. The discovery of cave-adapted microbes in remote areas of some caves has changed how exploration and mapping is conducted. Lint accumulation in Carlsbad Cavern has been found to harm speleothems and may support a thriving non-native microbial population.

Multidisciplinary research has revealed many unforeseen human impacts on the cave resources of the park. The park is changing its management practices to protect these resources while still providing a quality experience for the half-million people who visit the park each year.

INTRODUCTION

One of the goals of the Cave Resources Office of Carlsbad Caverns National Park is to protect the caves and cave resources of the park (Figure 1). The park must balance this goal with the need to provide over a half-million visitors per year with a memorable and safe experience in the park. In addition to visitation to Carlsbad Cavern, the park provides access to some caves for recreation and for scientific research. The management of the park caves must weigh the impacts of these activities against their benefits.

Cave management throughout the National Park Service (NPS) has traditionally focused on highly visible and easy to measure impacts such as broken speleothems, high-traffic areas, and litter. In karst areas characterized by sinkholes, springs, and sinking streams, the NPS has managed the surface to prevent impacts from fuel spills, industrial waste, and sewage leakage into the ground above the caves.

Recent research at CCNP has identified other issues that the park needs to manage. A study of the hydrology and hydrochemistry of Carlsbad Cavern has identified sources of contamination originating from the park facilities above the cave. Carlsbad Cavern is seen by more than 500,000 visitors a year, by far the most visited feature in the park. Park manangers have found that visitors leave behind tens of kilograms of lint in Carlsbad Cavern every year. These discoveries have changed the way the park manages the cave resources of Carlsbad Caverns National Park.

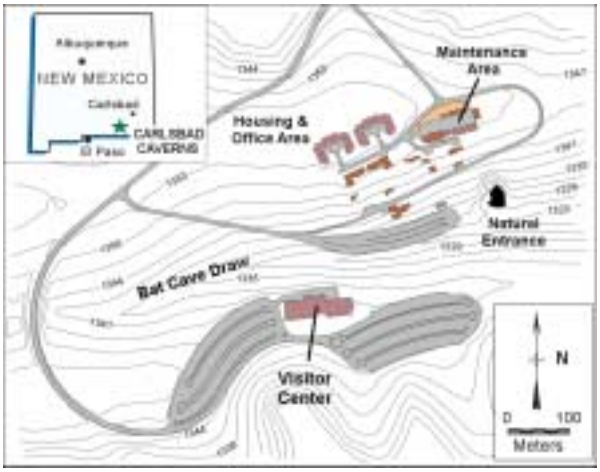

Figure 1—Location of Carlsbad Caverns National Park and major features of the developed area above the cave

Microbiological investigations in Lechuguilla Cave and Spider Cave have led to the discovery of previously unknown bacteria which may lead to cures for some human diseases, but which can be decimated by just a few contacts with people.

INFILTRATION STUDY

An infiltration study was performed in the area around Carlsbad Cavern (Figure 2) as part of a Colorado School of Mines master's thesis (Brooke, 1996) and an investigation by the International Ground Water Modeling Center (van der Heijde et. al., 1997). This study identified areas in the cave threatened or already affected by contamination due to surface facilities, as well as probable pollution sources. The most affected

In Eve L. Kuniansky, editor, 2001, U.S. Geological Survey Karst Interest Group Proceedings, Water-Resources Investigations Report 01-4011, p. 47-51

areas of Carlsbad Cavern are: 1) Left Hand Tunnel, 2) Main Corridor and New Section, and 3) locations from the New Mexico Room to the Big Room. The study reported:

> Most of the unnaturally high concentrations of aluminum, zinc, total organic carbon, and nitrate... can be related to rather chronic, relatively low-level, releases at specific locations at the surface.. .A variety of accident, spill and leakage scenarios can threaten the water quality in the cavern, and even public health. Major potential sources identified in this study are: 1) leaks in the sewer lines; 2) spills and vehicle fires with subsequent contaminated runoff from the public parking lots and road segments in the western part of the [developed] area; and 3) spills, leaking tanks, fires and other accidental releases from the maintenance yard.

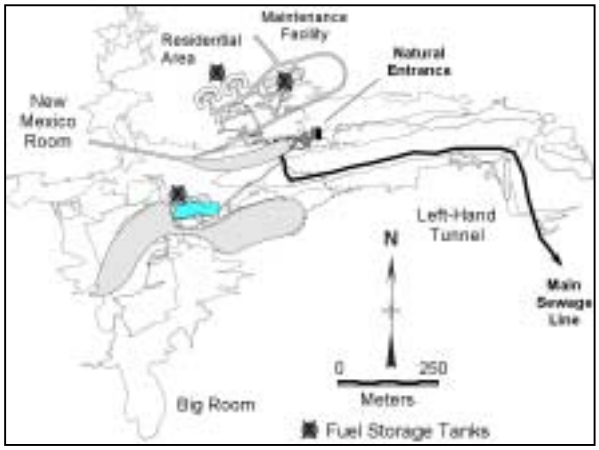

Figure 2—Location of surface features to Carlsbad Cavern.

Spills of hazardous materials, including oil and gasoline, into the subsurface could pose a potential threat to visitors. Such a danger could cause the cave to be closed to visitation until the danger was eliminated. It could also severely damage or destroy cave biota and associated ecosystems.

Total wastewater generated by visitors and staff in the park is 38 million liters per year. The sewer lines in the park vary in size, material, and condition. Some pipes are more than 65 years old and leak to a great extent. The collection system carries raw sewage from the residential and maintenance areas to a small lift station located in Bat Cave Draw near the natural entrance to Carlsbad Cavern. The lift station forces the sewage up to the ridge of the escarpment. Sewage flows by gravity from the visitor center along the escarpment ridge and drops off the ridge to sewage lagoons at the base of the escarpment. When the system backs up, sewage flows out of manholes and onto the ground. These leaks and spills supply raw sewage to the groundwater system and pose a threat to human health and water quality.

The main parking lots have the capacity for over 900 cars, 63 recreational vehicles, and approximately 152 meters of unmarked space that can be used for either recreational vehicles or cars. There is also an average of 25 cars parked in the residential housing area on the north side of Bat Cave Draw. These cars are generally parked all day and not for just the 4 hours a day the average visitor is parked. The remaining cars, however produce an effective visitation of 72 cars per day or 26,026 cars per year (Bremer 1988). This means that resident parking accounts for almost 14% of the parks yearly vehicle use.

The parking lots not only alter natural infiltration patterns, they collect and store hazardous materials generated by automobiles, maintenance operations, and residential activities. Between rainstorms, oil, fuel, antifreeze, and other contaminants accumulate on the pavement. A trash vehicle is usually parked behind the visitor center to collect waste for the concessionaire. Fluids from the waste leak and collect on the pavement. Kitchen floor mats and other items from the concessionaire restaurant kitchen are washed daily behind the visitor center. This contaminated water is allowed to drain into Bat Cave Draw. The maintenance facility makes wide use of solvents and other materials required for vehicle maintenance that may be spilled on the ground.

Rainwater carries contaminants off the pavement and into the fractured limestone above the cave. Most of the contaminants are carried by the first 13 mm of rainfall. The parking lots collect rainwater from a total of 42,550 m^2. This results in 540,000 liters of contaminated water entering the groundwater system in every 13 mm storm. There is an average of 10 storms per year that produce more than 13 mm of rain (Bremer 1998), making a total of 5.3 million liters of contaminated water entering the groundwater system every year. Some of the contaminants are absorbed by the thin soil and the rock, but unmitigated exposure to these materials will lead to contamination of the groundwater and the cave (Bremer 1998). Leaks from sewage lines and potential leaks from fuel storage tanks add to the amount of contaminants that may enter the cave from the developments above.

In Eve L. Kuniansky, editor, 2001, U.S. Geological Survey Karst Interest Group Proceedings, Water-Resources Investigations Report 01-4011, p. 47-51

The park has proposed modification of the developed area above Carlsbad Cavern. The purpose of this is to: 1) protect the groundwater and cave resources from continuing chronic exposure to contamination; 2) protect the cave resources from potential catastrophic contamination; and 3) protect visitors to Carlsbad Cavern from potential hazardous conditions due to contamination. To achieve these goals, the park is preparing an Environmental Assessment (EA) with alternatives to reduce the impacts from the park facilities on the cave.

To address parking lot runoff issues, the park is planning on treating some of the runoff and eliminating some paved areas altogether. The parking lots near the visitor center will be resurfaced to drain southward, away from the cave. The park will install oil-grit separators at the drainage points for these parking lots to treat the water before it enters the ground. The large parking lot in Bat Cave Draw has been closed to visitors in order to reduce the amount of vehicle fluid buildup. The EA proposes removing most of this parking lot and replacing it with a bus turnaround area and handicapped access path to the natural entrance. The turnaround would be more than 300 meters further west than it is now. The majority of the paved surface will be removed and replaced with natural vegetation to help restore natural drainage and infiltration conditions.

The sewage collection system in the housing and office area north of Bat Cave Draw is going to be replaced with new lines that will not be as prone to leaks. One option of the EA proposes that the main sewage line be rerouted southward to minimize the exposure of the caves to sewage leaks from this line.

The park has made important management decisions to protect the cave by placing funding priorities on sewage line repair and restructuring of the parking lots. Park residents are restricted from using pesticides, and other household chemicals which may be harmful to the cave. Residents are also restricted from maintaining vehicles and other activities which could spill hazardous materials on the ground. The park has developed a space allocation plan which will remove most of the residents from above the cave. This will reduce the amount of sewage in the system and will effectively reduce the number of vehicles parked above the cave on the north side of Bat Cave Draw. The park has also used this study as a springboard to make significant changes to park facilities through the Environmental Assessment.

Lint Accumulation in Carlsbad Cavern

For many years, people have noticed a gradual discoloration of speleothems in Carlsbad Cavern. Close examination has revealed large accumulations of lint, clothing fibers, skin, and hair left behind by the thousands of cave visitors each year. This lint builds up on cave walls and speleothems and makes them appear dull and gray with obvious lumps of material. Organized efforts to clean up these deposits of lint since 1988 has removed over 70 kg of lint and more than 100 kg of other litter (Jablonski, et al., 1993).

During a lint cleanup in 1991, volunteers noticed that the calcite beneath the lint was pitted and had started to deteriorate (Jablonski, et al., 1993). Further investigations showed that the lint was a very good source of organic material for microbes, mites, and spiders. Microbiologists have suggested that the breakdown of the lint was probably generating organic acids that dissolved the calcite. The large amount of organic material may support a large population of microbes that thrive in a high-organic-energy environment. These microbes can out compete the native, low-organic-energy microbes and decimate their population.

Several different methods of reducing or controlling lint accumulations were investigated both at Carlsbad Caverns and at Wind Cave National Park in South Dakota. Researchers tried applying a vacuum to visitors to quantify lint deposition and to determine the effectiveness of lint removal using flowing air. Most methods for cleaning lint from visitors would require careful control of air circulation which is not possible in either Carlsbad or Wind Cave, so ways to reduce the migration of lint were examined.

Researchers looked at how lint migrated along the trail and onto the cave walls. They found that short rock walls along the sides of the trail contained much of the lint. In these areas, trail cleaning prevented the lint from breaking down into small enough particles to be carried into the air and deposited higher on the walls.

Based on the results and recommendations of these studies, Carlsbad Caverns is in the process of constructing rock walls along most of the five-kilometer-long trail. Twice a year, this trail is vaccumed with a HEPA vacuum to remove any lint that may have accumulated within the walls. In addition to these measures, a volunteer group works in the cave during a week-long “Lint Camp” to remove lint and other litter from throughout the visitor trail system. In places where there is a problem with visitors urinating in the cave and other places where the trail may become

In Eve L. Kuniansky, editor, 2001, U.S. Geological Survey Karst Interest Group Proceedings, Water-Resources Investigations Report 01-4011, p. 47-51

slick, water is used to clean the floor. In the past, this water was allowed to run off the trail, but the park is now studying methods to collect and remove this waste water from the cave. With these measures, the park hopes to significantly reduce the impacts from lint on the cave.

MICROBIOLOGICAL RESEARCH IN LECHUGUILLA CAVE

Researchers from NASA have been looking at extreme environments across the planet that may be analogs for life on other planets. A team of scientists, primarily from the University of New Mexico and Biomes, Inc., have found previously unknown bacteria living on the rock and in the pools of Lechuguilla Cave. These bacteria survive hundreds of meters below the ground with no light and no organic input from the surface.

Some bacteria exist in thick mats of corrosion residue that line the walls, ceiling, and floors of many places in Lechuguilla Cave (Northup et al., 1994). These bacteria utilize small amounts of iron and manganese in the limestone bedrock to derive their energy (Northup et al., 1997). The researchers have found that almost one-third of the cells in the cave are actively respiring and that the process of microbial corrosion is still going on.

The pools in Lechuguilla Cave are also teeming with life (Northup et al., 1999). The bacteria in these pools have to compete fiercely with each other for the few nutrients that exist. To do this, they release enzymes that kill the competition. Some of these enzymes have been tested under laboratory conditions and have been found to attack leukemia cells. Much more testing needs to be done, but these bacteria may lead to a cure for some human diseases.

People carry foreign bacteria into caves on skin, hair, and clothing fibers. When they are shed into the caves, these bacteria out compete native microbes for food and destroy their populations. The magnitude of human impact was not known until some of the pools in Lechuguilla Cave were discovered. In some pools, the native microbe populations have been decimated by only a handful of contacts with cave explorers.

The park has changed it policy to require that everyone who enters Lechuguilla Cave has clean clothes and equipment to prevent microbes from other caves from being introduced into the Lechuguilla. Cave explorers and scientists often camp in the cave for several days. To minimize their impact, they are now required to eat and sleep on drop cloths to catch food, skin, and hair. Cave explorers and researchers are also encouraged to wear bandanas to contain hair and are required to eat their food over plastic bags to catch fallen crumbs. Some areas where there has already been contamination have been closed off to determine if, and how long it takes the native microbes to recover.

Cavers are restricted from getting near any pools found during exploration. When a pool is discovered, explorers report it to the park and to scientists studying the microbes. Scientists approach the pools wearing Tyvek clean suits and set up slides that sit in the cave for up to five years. The slides are collected later and the bacteria cultured in a lab where scientists hope to study them further.

SUMMARY

Research in the fields of geology, hydrology, hydrochemistry, microbiology, and cave restoration have revealed negative impacts on the cave resources of Carlsbad Caverns National Park. The park has changed the way it manages both the surface and subsurface to mitigate these impacts. The park has used this research to engineer solutions to some of the problems of infiltration and contamination. Scientific research has changed and will continue to change the way the park manages both the caves and the surface around them.

REFERENCES

Bremer, Mark, 1998, Preliminary assessment of environmentally-sound methods for treating and or diverting rainwater run-off from parking lots and roads in the vicinity of Carlsbad Cavern: Carlsbad, New Mexico, National Park Service draft report 62 p.

Brooke, Mark, 1996, Infiltration pathways at Carlsbad Caverns National Park determined by hydrogeologic and hydrochemical characterization and analysis: Golden, Colorado, Colorado School of Mines, Master's Thesis, 182p.

Jablonski, P., Kraemer, S., and Yett, W., 1993, Lint in Caves, *in* Pate, D.L. (ed), National Cave Mangement Symposium, 9th, Carlsbad, New Mexico, 1993, Proceedings: Carlsbad, New Mexico, National Cave Mangement Symposium Steering Committee, p. 73-81.

Northup, D.B., Spilde, M.N, and Boston, P.J., 1999, Microbial interactions with the limestone walls of Lechuguilla Cave, Carlsbad Caverns National

Park, New Mexico, USA *in* Journal of Conference Abstracts, 11th Bathurst Meeting, 1999: Cambridge, UK, p. 951.

Northup, D.B., Lavoie, K., and Mallory, L., 1997, Microbes in Caves: NSS News, volume 55 number 4, p. 111.

Northup, D.B., Carr, D.L., Crocker, M.T., Cunningham, K.I., Hawkins, L.K., Leonard, P., and Welbourn, W. C., 1994, Biological Investigations in Lechuguilla Cave: NSS Bulletin volume 56 number 4, p. 54-63.

van der Heijde, Paul K.M., Kolm, Kenneth B., Dawson, Helen, and Brooke, Mark, 1997, Determining water infiltration routes from buildings located above Carlsbad Cavern, Carlsbad Caverns National Park, Carlsbad, New Mexico: Golden, Colorado, International Groundwater Modeling Center report IGWMC-GWMJ 97-01, 88 p.