DEVELOPING AND MANAGING AN ENVIRONMENTALLY RESPONSIBLE TOURIST CAVE

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Abstract

In November 1999, Kartchner Caverns in Arizona, USA was opened to the public. Arizona State Parks took 11 years and spent $30 million preparing the cave for viewing while protecting it from the impacts that the tourists would have on the resource. Because the cave is a wet cave (99% humidity) just below the arid Arizona desert, extreme precautions were necessary to ensure that the cave would not dry out when opened to the public.

This paper will explore the sciences used in the planning of the development, the techniques used to protect the cave during development and to mitigate anticipated tourist impacts, and the management constraints imposed in the operation. It will also highlight the eco-tourism niche that was developed due to the extreme care given to this resource.

Sciences

Before any excavation for entrances or even the design of a tourist trail was attempted, an extensive scientific study of Kartchner Caverns was initiated. Because the cave is a wet cave just below the Arizona desert, any interference with the natural phenomena of the resource could have devastating impacts.

The discoverers had already recruited a cadre of cave scientists prior to the state purchase in 1988, and although much work had begun, it was constrained by the fact that the existence of the cave was a tightly-guarded secret. While there is no science known as "secretology", it can not be overstated that this secrecy (from 1974 to 1988) was perhaps the most important tool employed to protect the cave in that it prevented vandalism and inadvertent damage from recreational cavers. Moreover, it set the tone that Kartchner Caverns was a special place and needed to be treated with extraordinary care.

After the secret was lifted, Arizona State Parks spent the next four years continuing baseline studies on humidity, temperature, evaporation rates, rainfall, and a small colony of bats. In addition scientists were employed to study the geology, hydrology, sedimentology, mineralogy, vertebrates, invertebrates, speleothem dating, and geophysics among others. The discovery of bones from a ground sloth (~80 Ka) and a horse and bear (~20 Ka) required the services of a paleontologist.

The results of many of these scientific studies can be obtained through the National Speleological Society. They have been published in the *Journal of Cave and Karst Studies*, August 1999. Taken as a whole, the studies reveal a complicated system where geology, hydrology and biology intersect interplay creating a sophisticated and intriguing cave resource.

This last statement could be made of any cave in the world. The challenge comes with the knowledge that the cave will be opened to tourists and the application of those sciences in the development and management of the resources in such a way that they will remain unimpaired for future generations . . . a difficult task in any case . . . particularly so in a wet cave just underneath the desert.

Development Protection Techniques

Masterplanning

The first step in the development of the cave was to create a generalized master plan for the above-ground development. The visitor center, Park Manager housing, campground, restrooms, sewage treatment plant, utilities and roads were all located to prevent inadvertent contamination of the cave system and to avoid interference with the hydrological systems that provide water to the resource. With that plan in place, excavation sites (tunnels) were selected that met a variety of the same criteria.

Workforce Training

Over 90% of the cave floor were never touched by the explorers. Trails were marked and followed carefully. If this was to be maintained, the workers would have to go through rigorous orientation and training. Personnel were trained outside of the cave in trail construction that did not allow them to get off of the trail they were working on. All off-trail steps required approval by the supervisor. Gloves were mandatory to prevent the transfer of skin oils. Each worker signed an agreement that they would not touch any of the features unless it was necessary for the work at hand and approved. Over the course of construction of five years by more than 100 workers, only one worker deliberately disobeyed those rules. He was not only fired for breaking a stalactite, he was prosecuted successfully in the local courts. Newspapers around the state carried the story showing everyone how seriously we were taking this issue.

Materials, Tools and Techniques

The cave environment dictated that particular thought had to be given to the materials, tools and techniques used in the development. During the tunneling, for instance, standard mining techniques (blasting) were used. Extensiometers were placed in the cave to measure the acceleration of the shock wave for each blast to determine the charge for the next round. The final 1.8 m to 2.4 m of each tunnel was removed through hydraulic splitters and manual labor.

Hydraulic, electrical, and muscle-powered equipment were the only tools allowed inside the cave because they did not emit fumes. The most sophisticated tools used were electric drills, hydraulic drills and splitters, a hydraulic diamond bit chainsaw, and a welder adapted with a charcoal-filtered vacuum. Beyond that, rock was moved by bucket or wheelbarrow. (see Fig. 1)

Fig. 1 - Cave worker is using a hydraulic chainsaw and water to keep dust to a minimum while calcite is trimmed along the trail.

Cement was mixed with an electric mixer in the tunnel to prevent dust from entering the cave. All handrails are stainless steel to avoid corrosion, and all of the re-bar used in construction was epoxy coated to prevent oxidation and eventual contamination by rust.

A special caution regarding materials is in order. State Parks had purchased some large rolls of black opaque plastic sheeting in order to seal off a part of the cave during the tunneling process. Park personnel were fearful that a sudden entrance to the cave without a temporary way to seal the airflow could quickly dry out that chamber. Three or four days after erection of these walls, large (15 cm. dia.) mold blooms had begun to grow in the dark. The process for making these sheets includes a micro-thin layer of oil to allow the sheets to unroll. The plastic was replaced with another type of sheeting, and from that point forward materials such as plastic, wood, and rubber were cleaned prior to being brought into the cave.

Dust Control

Cave development inevitably involves dust, and the more that dust is controlled or contained, the less clean-up is needed at the end of construction. Less contamination means less disturbance of cave features.

Development personnel used two techniques to help control dust. would soak an ordinary paint brush with water and apply it to the drill bit during operation. This would prevent much of the dust from occurring.

On larger scale projects, and eventually throughout the development, large walls were created on either side of the trail to contain the dust on the trail (see Fig. 2).

Fig. 2 - Note the plastic sheeting along the trail to protect area from exposure to dust, debris or human touch.

As soon as possible these walls were erected and maintained throughout the development process. Not only was post development clean-up minimal but the walls had the added effect of concentrating the focus of the work at hand and also provided a visual (and physical) barrier to cave features within arm's length. It should be noted here that the cave trails was designed to keep people far enough away from the features that they could not be reached, but that it was not always possible.

There were times when construction required overhead protection from contamination. When the ceiling drew close or when using a hydraulic tool such as the chainsaw which could spew water, the plastic wall technique discussed previously included a tent-like plastic ceiling (see Fig. 3).

Moisture and Algae Control

Overarching issues in the development process included ways to keep the moisture in the cave and algae out of the cave. Fig. 4-6 show a variety of techniques. Airlock doors (Fig. 4) were installed in a series to minimize air exchange and a misting system was installed to add moisture (Fig. 5).

In order to control algae, the trail was designed to catch most of the lint from the visitor (Fig. 6) and the lights (computer-controlled) are only on when being viewed by the visitor. Each evening the trail is washed down to low points and the dirty water is pumped out of the cave.

Fig. 3 - Plastic sheeting is used to protect the entire area, including the ceiling, from dust and debris.

***Fig. 4 - Freezer doors create airlocks (conservation chambers) which minimize air exchange to the outside environment. Even tunnel trails are washed daily*.**

Fig. 5 - The misting system was installed during construction to minimize dust in the air as well as add moisture.)

Fig. 6 - Cave trails were designed with 18" high sidewalls which contain the water and debris. Trails are washed down daily.

Management Constraints

There are several aspects of management to be considered. Setting a carrying capacity is perhaps the most critical. Management direction not to exceed that capacity under any circumstances is critical. All tours should have a lead guide to interpret and a tailing guide to add security.

Under the current management at Kartchner Caverns, the reservation system was set up with a limit of 20 people per tour, with the additional limit of 25 tours per day. This limit was created not only to control the number of people also to ensure a quality experience for each visitor. The cave size and developed visitor trail also provide constraints to group size. These are important factors that will keep future managers of the resources from increasing these numbers. The park has operated at capacity since opening day in November 1999.

Management includes perpetual monitoring of the cave conditions by the Cave Management Unit. This group of employees monitors temperature, humidity, evaporation and air chemistry. This data is interpreted to determine if management can adjust operational factors to counteract the changes. As an example managers have the ability to lower lighting levels reducing the amount of heat generated in any specific area.

Guides are trained to not only give tours but also to respond to a variety of emergencies. Cave guides are trained to respond to inadvertent or flagrant touching of cave formations. Guides mark formations touched and the cave unit cleans the area after tours are finished for the day. At that time all cave trails are washed down and the wash water is pumped out of the cave and released away form the cave.

The Eco-Tourism Niche

There is a definite eco-tourism niche for caves that are developed and managed with care. Reservations at Kartchner Caverns have consistently been full three months in advance. Tour group operators purchase $40,000 of tickets at a time. It is not uncommon for people to be at the park entrance 3 hours prior to opening seeking the daily issue of unreserved tickets.

This also has an economic benefit to the surrounding community. The Arizona State Parks Research and Marketing section randomly surveys park visitors for feedback regarding their experience at all of our parks. It has been determined that each group visiting a park spends $150-$200 at local shops and restaurants. Visitation in the first year at Kartchner Caverns State Park was held to the cap of 180,000.

While the financial success is remarkable, perhaps a greater indication of the niche is the feedback we are getting from the visitors. They indicate that they are glad we took the time to do it right, that the care we displayed in the development and management is obvious, and, because of that, they feel a visit is a privilege.

Finally the environmental stewardship message has generated by far the most publicity for Kartchner Caverns State Park. Media around the world have headlined this environmentally-responsible tourist cave. Through these media, the nature resource stewardship message has been received by more than 100 million people.