

## **APPENDIX F: CAVE SURVEY STANDARDS FOR CARLSBAD CAVERNS NATIONAL PARK**

“Modern day” cave exploration and surveying began in Carlsbad Caverns National Park (CCNP) in the 1960’s with the advent of the Guadalupe Cave Survey. Carlsbad Cavern, many back-country caves, and more recently, Lechuguilla Cave have seen large numbers of teams surveying and resurveying many miles of cave passages and rooms. Though all surveyors have had good intentions, there have been extreme variations in the quality and accuracy of field notes and survey methodologies. Recent management of the caves of CCNP have increasingly relied on more accurate and complete survey and inventory notes.

In order to impact the caves as little as possible while gathering a maximum of information from each survey trip, we have developed a set of survey standards that must be adhered to by all parties interested in surveying in the caves of CCNP. The Cave Resources Office will work with each group to help bring everyone up to these standards. The main objective of surveying teams should be the gathering of quality data.

A survey team may not have more than 4 individuals per team. Teams may be given permission to have more than 4 individuals if they can show a specific need. In addition, no one may enter unexplored or unsurveyed passages without surveying as they go. There are many passages in Lechuguilla Cave and Carlsbad Cavern that have been “scooped”, but not surveyed. In order to avoid further abuse by relatively few individuals, everyone must adhere to this policy.

All original notes will be kept in the park unless a written formal agreement, such as a Memorandum Of Understanding, specifically states that original notes will be kept by the originating party. The notes should be turned into the Cave Resources Office before leaving the park. Copies of notes will be provided to those doing the work upon request.

### **THE SKETCHER**

The sketcher is the most important person on the survey team and has the most responsibilities regarding the survey trip. He or she is responsible for the team. The sketcher must ensure that any unsurveyed passage seen by any member of the team is surveyed on that trip. He or she must also ensure that backsights are read and recorded.

Once the team begins to survey, the sketcher is the leader of the team and controls the speed and ultimate direction the team takes. All other team positions should work with the sketcher to help accurately survey the cave passage.

Park provided cover sheets and data sheets should be used unless specifically stated in a written formal agreement that the originating party can use their own sheets. This is to help bring consistency to the various surveys being performed in the park. All surveys should have a cover sheet and should be filled out completely. When filling out the cover sheet, be sure to record the name of the cave, the general area of the cave, and the more specific area if possible. Also record the full name of those individuals participating in the survey.

Data sheets are straight forward and should make note-taking easier. Enter one station per box with the distance, azimuth, vertical angle, and passage dimensions in the corresponding boxes. DO NOT write two station numbers per box. This is confusing when it comes to data entry. Also, record all numbers using decimal points, not fractions. This makes it much easier for data entry.

Sketchers should have designated letters to use for new stations before entering the cave. These will be provided by the expedition cartographer or the Cave Resources Office.

The sketchers goal is to produce a quality sketch that accurately depicts the passage that has been surveyed and to record all necessary notes, numbers, etc. that accompany the sketch. The sketcher is responsible for making sure that all needed items are done correctly. There are three types of drawings that must be produced for all surveys. These are the plan, profile, and cross-sectional views. All drawings must be drawn to scale, on graph paper, and should have a north arrow and a distance scale on each page. The sketcher should use an appropriate scale for the passage being sketched. The sketch should not be so small that it is impossible to show any detail, but it should also not be so large as to not fit well on the page. If the passage is small to medium in size, then 20 or 30 feet to the inch would work well. If the passage is large to extremely large, then 50 feet to the inch is appropriate.

Heavy dots or small triangles can be used to denote survey stations. Make sure the stations are marked accurately and labeled clearly on the sketch. If during the course of the survey, you change scales on your notes, be sure to clearly indicate that a scale change has taken place.

The sketcher should also strive to take legible notes that are clean and neat.

PLAN VIEW - This drawing should be done with a protractor and ruler, to scale on graph paper. The plan view should concentrate mostly on floor detail. Cave walls, boulders, columns, flowstone, drops in the passage, etc. should be drawn in their proper positions and orientations. Smaller features should be added with general symbols such as gravels, sand, mud, dirt, etc. The use of floor-sloping symbols are OK and necessary in places, but the composition of the floor should also be apparent from your sketches. Writing a general statement such as “All floor detail is gypsum” is not an acceptable practice for most situations. Sketchers should take the time to fill all floor detail in on the plan view with the proper symbols.

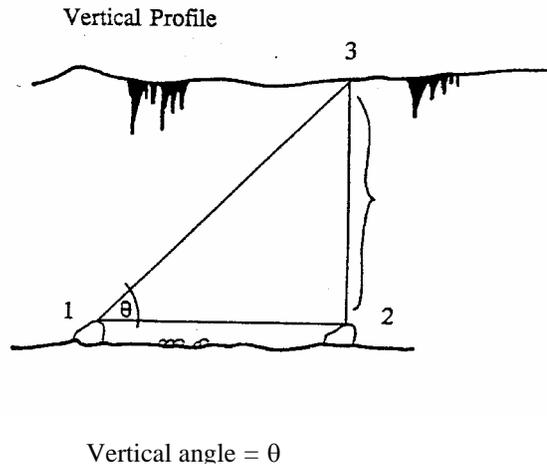
If you have plotted stations accurately, any major survey errors should show up in your sketch.

**PROFILE VIEW** - A running profile, taken from survey point to survey point, should accurately depict ceiling height changes, floor changes, height of station above the floor, formations such as stalagmites, stalactites, soda straw areas, rocks, boulders, bedrock, and other important features that help relay more information about that particular passage. Be sure to include ceiling leads on the profile as well. The profile should also be plotted accurately. It can be located next to the plan sketch or done on a separate sheet of graph paper. Label the survey points with heavy dots or small triangles and the station name.

**CROSS-SECTIONS** - Cross-sections are an important part of the sketch and should be done whenever there is a significant change in the character of the passage or every 100 feet or so. You can never have too many cross-sections. Make sure the cross-section and the view direction is clearly marked on your sketches. Like the profile view, they should depict all important features that are found when looking in cross-section at that particular point in the passage. Obviously, this should include the general shape of the passage. When surveying a large room, cross-sections as well as a running-profile down the middle of the room are very helpful.

Figure 1. GRAPHICAL SOLUTION FOR DETERMINING CEILING HEIGHTS

1. Using graph paper, pick a point on the ceiling to be measured. Establish station 2 directly under this point.
2. Measure the distance between station 1 and station 2 (Vertical angle MUST be 0).
3. Take the inclination between station 1 and the point on the ceiling directly above station 2 (3 on the illustration).
4. Plot this data in the survey book. Drop a perpendicular line from the point on the ceiling to station 2. This is the ceiling height which can be measured directly from the graph paper.



## PASSAGE DIMENSIONS

Passage dimensions are most accurately being recorded on the plan, profile, and cross-sectional sketches. However, it is very time consuming for someone to go back over all sketches to retrieve needed data. It is much easier to record passage dimensions as the stations are being established. The goal is to record numbers for left-wall, right-wall, ceiling, and floor that best represent the actual passage dimensions at that point. Sometimes a station will be located in a position that is not indicative of the passage itself and it will be necessary to assume that the station is in the middle of the passage. In most cases, the distance from the floor and ceiling as well as left and right wall will be an estimate. For left and right wall try to estimate the distance across the passage from the station. Measure across if this is feasible and more helpful. If the ceiling height is very high, try to triangulate to a point on the ceiling and a point of the floor. Fig. 1 shows a graphical way for determining ceiling heights.

## MAPPING ROOMS AND LARGE PASSAGES

When mapping a large room, you can either pick a spot in the middle of the room and do a series of spray shots to determine wall locations or do a perimeter survey around the room. Figs. 2 and 3 are graphical representations of these two methods of surveying large rooms. Spray shots or perimeter surveys do not contribute to the caves total length. These extra survey shots are used to firmly establish shapes and sizes of the larger rooms and passages.

Just remember, the goal of each survey is to produce a quality set of notes with minimal impact on the cave features.

Figure 2. SPRAY SHOTS

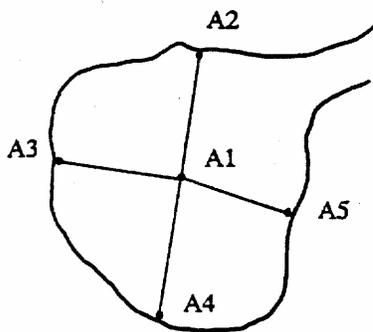
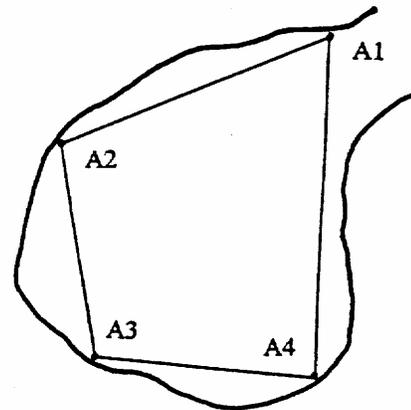


Figure 3. PERIMETER SURVEY



## **INSTRUMENT PERSON**

The instrument person is a very important position and requires diligence and care. This person is responsible for **making** sure the instruments are in good working order and have been run through the test course near the CRF huts before using.

Several different types of instruments may be used; however, they must all be in degrees and must be oriented to magnetic north. Instruments utilizing quadrants or degrees and minutes may not be used. Readings should be to at least .5 degrees, i.e. 105.5 degrees. If the instrument reader can comfortably read to the nearest .25 degrees, then that is acceptable also.

In order to prevent resurveys because of loop closure errors, BACKSIGHTS as well as FORESIGHTS must be read whenever possible. When compared, the resultant readings should be no more than 2 degrees different. If a discrepancy of larger than 2 degrees occurs, then the readings should be redone. REMEMBER, the goal is to produce a QUALITY SURVEY. This is not a race. Sometimes, because of the difficulty of reading instruments between two particular stations, no amount of rechecking will provide agreement between the foresight and backsight. Usually, the instrument reader will have more confidence in either the foresight or backsight. He or she should communicate to the notekeeper which one is thought to be more accurate. The notekeeper will then circle the better reading. Certainly, this will not be the case at all stations, but should help when looking at loop closure errors. Loop closure errors of greater than 2% are considered unacceptable and may show the need for resurveying a portion of that loop. In order to avoid resurvey, it is very important that the instrument person be experienced and careful.

Every effort to read backsights should be made; however, sometimes this is impossible. Tight crawlways and other hard-to-get-to positions are examples of impossible conditions. This does not relieve the team of the responsibility to get backsight readings whenever possible. Once again, the real push is to produce a quality survey and as such it takes time.

For those using a Suuntos compass and inclinometer, be sure to use just ONE eye and move the instrument back and forth or move your eye up and down to accurately line up the station point and the line in the instrument. Using the two-eyed method often introduces errors in your readings because the eye looking through the instrument and the eye looking at the station point are in two different locations.

## **LEAD TAPE POSITION**

This position on the survey team is as important as the sketch and the instrument reader. The lead tape determines the route to take unless the sketcher overrides his decision. (Remember the sketcher controls the survey team at all times.) It is the responsibility of the lead tape to locate survey stations an optimum distance from the previous station while planning ahead to the next station. A station should also be set at any leads that will be surveyed at a later date. While setting stations, the lead tape must set them with the idea that the instrument person has to be able to read the instruments from that point.

## **SURVEY MARKERS**

At this time, we have not established any one method for marking stations. Presently in use are hard plastic pieces with the station number written on them in permanent ink or blue flagging tape that have the station numbers written on them. Neither are ideal for every site, but work adequately. Station sites must be recoverable and well-marked. In addition, stations should not be located on extremely fragile formations. The tape to be used should be in feet and tenths/hundredths of feet or meters and tenths/hundredths of meters. Tapes in feet and inches are not acceptable.

The lead tape position is also responsible for flagging the trail as it is being surveyed so as to minimize the impact of future visitors to these areas. Other members of the team should help in this endeavor also.

## **INVENTORY POSITION**

The fourth person on a team inventories the features found near every station. If there are less than 4 people on the survey team, then one of the others can produce the general inventory of the areas being mapped. Recognizing cave features are essential for whoever does the inventory process. Novices should not be doing the inventory.

The mineral inventory process being accomplished in Lechuguilla Cave is a more complex inventory that requires specialized training. The contract leader for the mineral survey has the final say over who may participate in that inventory.

## **DESIGNATED SURVEYORS**

In order to ensure that quality information is gathered on surveying trips, only approved sketchers will be allowed to sketch in the caves of CCNP.

## **SKETCHERS**

The Cave Specialist or the Assistant Cave Specialist will work with each group to help bring and keep sketchers up to approved standards, but will have the final say on each individual. Any group or expedition to survey in caves of the park should submit names of individuals that they would like to be sketchers to the Cave Resources Office. This should be done well before any expedition begins. Copies of notes taken on other cave trips by individuals unknown to our Cave Resources personnel should be included if they wish to be sketchers. Our cave specialists will then work with the Chief Cartographer or Expedition Leader of each group to establish the designated sketchers for that expedition. Constructive criticism will be provided to each sketcher after each expedition.

For those who have not sketched in caves of the park, to become a designated sketcher you must submit copies of sketches you have produced on trips outside the park.

**SPECIAL NOTE: SURVEY TEAMS NOT HAVING A DESIGNATED SKETCHER MAY NOT ENTER ANY CAVE IN THE PARK**

INSTRUMENTS READERS who consistently show unacceptable loop closure errors will not be allowed to read instruments in the caves of CCNP.

## **EXPLORATION**

Please remember that caves in CCNP are contained within a National Park and, as such, there are strong conservation mandates that relate to the caves. It is essential that everyone do whatever possible to minimize their impacts to the caves of CCNP.

**NO ONE HAS PERMISSION** to explore virgin or unsurveyed passages in any of the caves of CCNP. Survey is a required activity that must be done in conjunction with exploration. Looking at (SCOOPING) passages without surveying them is totally unacceptable and will not be tolerated.

The caves of CCNP contain very fragile, very sensitive areas. Digging, breaking or altering formations, or enlarging any passages requires permission from the Superintendent or his designated representative. Breaking a trail through ultra-sensitive areas, such as aragonite bushes is strictly prohibited. You are required to notify the Cave Resources Office so that the NPS can be involved in making a decision of such magnitude. This also includes wading in, swimming through, or disturbing any newly found pools. **FAILURE TO COMPLY WITH THESE CONDITIONS MAY THREATEN YOUR FUTURE ACCESS TO THE CAVES OF CCNP.**

# CAVE MAP SYMBOLS FOR CARLSBAD CAVERNS NATIONAL PARK

## PASSAGE SYMBOLS

	Passage Walls
	Lower level passage
	Unsurveyed or indefinite walls
	Breakdown walls
	Passage too low
	Flowstone choke
	Breakdown choke
	Breakdown walls
	Flowstone walls
	Bedrock pillar
	Unexplored lead (Describe on lead list)
	Survey station

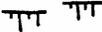
## FLOOR SYMBOLS

	Bedrock
	Sand or silt
	Mud or clay
	Gravel or cobbles
	Small breakdown or talus
	Large breakdown drawn to scale
	Gypsum
	Spar
	Guano
	Paleontological material
	Archeological material
	Paved trail
	Trail
	Sharp drop in floor, down in hatched direction
	Slope
	Pit; entrance pit if so indicated
	Ledge or drop in passage
	Canyon in floor
	Natural bridge

## CEILING AND WALL FEATURES

	Ceiling height
	Ceiling channel
	Ceiling lowers (hatch points to low side)
	Dripline

## SPELEOTHEMS

	Stalactites
	Stalagmites
	Soda straws
	Columns
	Helictites
	Flowstone on floor (bulged side downslope)
	Flowstone mound or large stalagmite
	Rimstone dams (drawn to shape and scale when possible)
	Flowstone on walls
	Drapery, bacon
	Popcorn
	Chandeliers
	Rafts
	Raft cones (hoodoos)
	Aragonite
	Gypsum flowers
	Boxwork
	Shields
	Moonmilk

## WATER SYMBOLS, ETC.

	Stream
	Intermittent stream
	Lake or pool with depth
	Sumped passage
	Air direction
	Scallop direction
	Strike and dip
	Fault, D side moved down relative to U side

**CARLSBAD CAVERNS NATIONAL PARK  
SKETCHER EVALUATION SHEET**

<b>SKETCHER:</b>			
<b>DATE:</b>			
<b>SURVEY:</b>			
<b>COVER SHEETS &amp; DATA PAGES</b>	<b>YES</b>	<b>PARTIAL</b>	<b>NO</b>
Is there a cover sheet and is it completely filled out?			
Is the data legible?			
Have the passage dimensions been recorded?			
<b>SKETCH</b>	<b>YES</b>	<b>PARTIAL</b>	<b>NO</b>
Is there a North arrow and scale on every sketch page?			
Is the passage drawn to scale and plotted at the measured orientation (plan & profile)			
Is the sketch drawn at a scale that shows adequate passage detail?			
Is the sketch legible?			
Is there adequate floor detail?			
Does the sketch contain cross sections?			
Is there a running vertical profile?			
Are the stations clearly labeled on the plan and profile?			
<b>OTHER</b>	<b>YES</b>	<b>PARTIAL</b>	<b>NO</b>
Have all the pages been numbered and labeled with the sketches name & date?			
Is there a lead list?			

**COMMENTS:**