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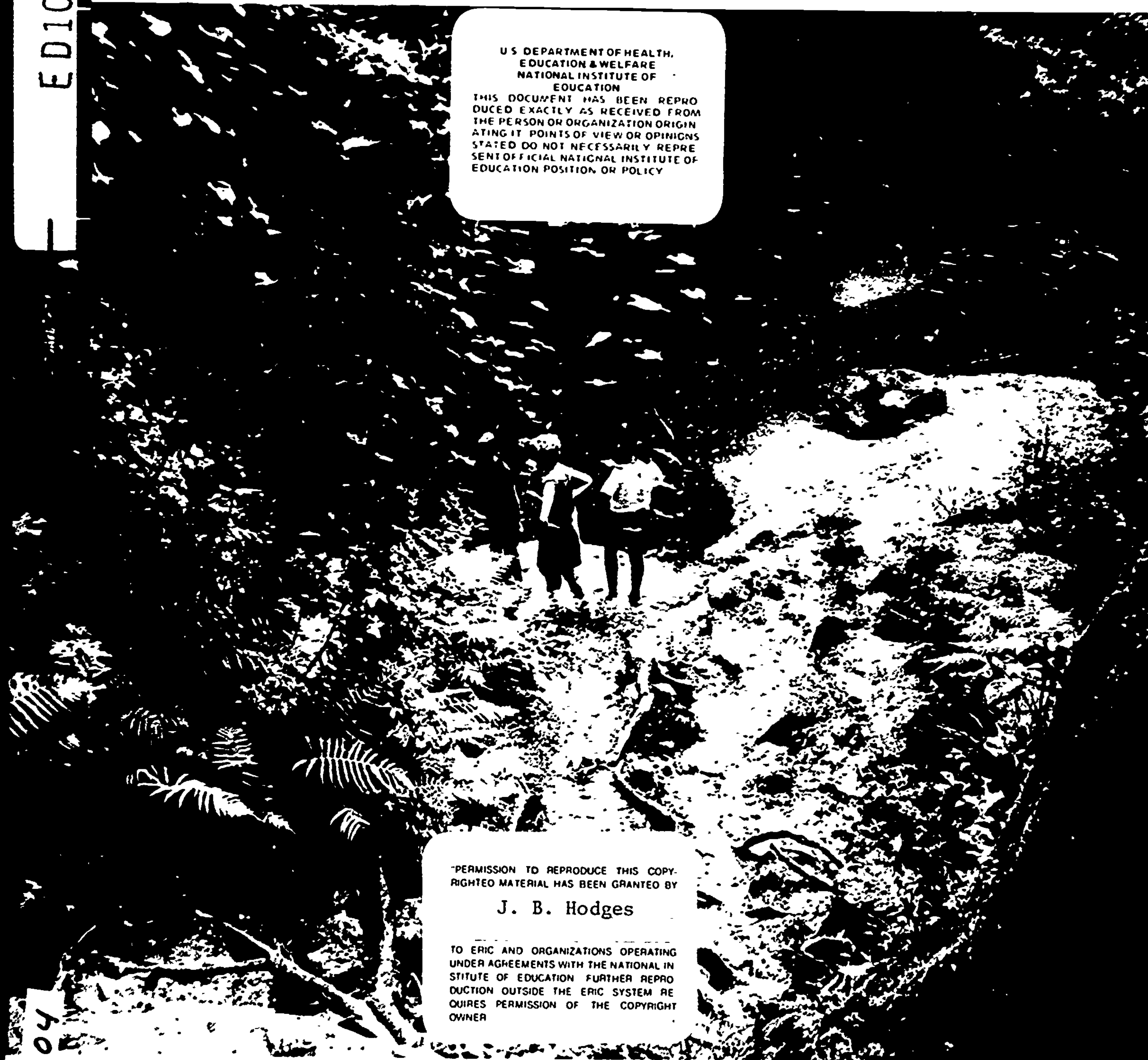
ABSTRACT

This resource monograph is one of a series designed as a teaching guide for field studies. Each guide centers around the exploration, observation, and interpretation of a field site in one of the four geological areas of Florida. Incorporated into the guides are many of the subject-matter schemes of the Earth Science Curriculum Program (ESCP) and three major process schemes: science as inquiry, comprehension of scale, and prediction. These guides also give the teacher information on the planning and execution of the field trip, as well as educational objectives, learning activities, and teaching materials available. The primary site for field study in this guide is the Devil's Millhopper, a collapse sink near Gainesville. Incorporated into the investigation of the area are activities in geology, history, mathematics, art, language arts, and environmental studies. The major theme for all these is change. Also included in this field trip is a stream study of Hogtown Creek. This guide contains directions for the activities, data sheets, and evaluation sheets. With some modification, these activities can be used at primary or secondary grade levels. (MA)

THE DEVIL'S MILLHOPPER: A RESOURCE FOR DEVELOPING FIELD STUDIES

BY DR. FELICIA E. WEST



RESOURCE MONOGRAPH NUMBER 2

P. K. YONGE LABORATORY SCHOOL
DR. J. B. HODGES, DIRECTOR

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Dr. Felicia E. West

PREFACE

As one becomes more and more aware of the need to understand the earth and its forces and processes responsible for changes associated with the earth as well as its water and its ai· . a concomitant need develops to encourage teachers and students to study these forces and processes firsthand through the use of field studies. It is believed that in-service teachers need encouragement and assistance as they become involved in the use of this teaching technique and in the use of their communities' resources. With this need in mind, a series of monographs has been prepared by Dr. Felicia E. West at P.K. Yonge Laboratory School. The series presents a case study and resource guides to sites characteristic of four geological areas in the State of Florida.

The case study presents the methods and techniques of planning which include familiarization with the area by the teacher, development of goals and objectives for the study, pre-trip classroom activities, field-trip activities, follow-up activities, and evaluation by the students and teachers involved. In addition, administrative details and the logistics of planning are treated.

Field resource guides have also been developed for Little Talbot Island State Park on Florida's northeast coast; for the Devil's Millhopper, a large "collapse sink" near Gainesville; for the Cedar Keys area on Florida's west coast; and for the Flagler Beach area on the Florida east coast. Material which relates to the area between Gainesville and the east and west coasts is included in the guides for the coastal areas. Each of these guides presents geological background information on the area, suggested activities for study in several curriculum areas, safety factors to be considered, and maps and routes. Information which is considered beneficial to teachers as they plan to visit these areas is also included.

The subject of this monograph is the Devil's Millhopper. It is a sinkhole, a very common feature in a karst region. However, the Millhopper is unique in several respects. Perhaps the most obvious is that it is not full of water. Up to 14 water falls may be observed emptying into the sink; yet, it stays fairly well drained. Thus, a new cave and potential

Because of its depth, the Millhopper provides an excellent opportunity to examine the underlying strata of this part of Florida. Subtle environmental changes may be detected by studying the various layers. Fossils may also be found in the streams on the Millhopper floor, indicating much about the pre-history of Florida.

The botany of the Millhopper is also of interest in that it is a mesophitic area in the midst of a dry, well drained area. The floor is rich in liverworts and mosses. Many of the herbaceous plants found here are not found elsewhere in North Central Florida but are common in North Carolina.

It is hoped that the information included in this monograph will provide some stimulus, assistance, and encouragement to classroom teachers as they plan field studies to this highly interesting site. Your reactions to these materials will be appreciated and aid us in preparing similar materials in the future.

Additional copies of this monograph and others in the series may be had by contacting P.K. Yonge Laboratory School.

J. B. Hodges, Director
P.K. Yonge Laboratory School and
Professor of Education

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INTRODUCTION

This document discusses educational purposes, age levels, teaching units, and activities to which the site is best adapted; teaching aids available; safety factors to be considered; times available for visitation; and number restrictions on visitors. It is suggested that the teaching style strive to sustain inquiry by encouraging questions, explanations, extrapolations, and speculations based upon the problems themselves.

In developing field guides for the study of the site within the framework of earth science, many of the subject matter schemes around which the Earth Science Curriculum Program (ESCP) is built should be kept in mind and these schemes encompass:

- universality of change
- flow of energy in the universe
- adaptation to environmental change
- conservation of mass and energy in the universe
- earth system in space and time
- uniformitarianism, a key to interpreting the past

The three major process schemes which are to be woven throughout the program are:

1. Science as Inquiry: a search for accurate knowledge and a recognition of the incompleteness and uncertainty of present knowledge; unsolved problems; logical and systematic developments of conclusions from accurate observations and well-chosen hypotheses.

2. Comprehension of Scale: using scales of measurement or units appropriate to the problem; the use of models for the enlarge-

ment or reduction of a scale; skill in devising and using models; and an intuitive feeling for scale in the real world and in models.

3. Prediction: extrapolation from the known to the unknown in either space or time; making logical interpretations of past events from fragmentary records; interpreting past events on the basis of given data.

The survey to select sites for the development of the field guide included exploration, observation, and interpretation of each site. Sites which showed only a few processes or features, but showed them at their best, were not eliminated. Some of the following evidences of dynamic changes on the earth's surface are illustrated by the sites reported in this series of monographs.

a. Stream evolution

b. Beach erosion and deposition

  (1) Atlantic Coast - relatively high energy

  (2) Gulf Coast - relatively low energy

c. Dune formation and evolution

d. Coastal features and their formation

  (1) Barrier bars

  (2) Lagoons

  (3) Islands

  (4) Spits and others

e. Relic terraces as evidence of glacial-eustatic fluctuations of sea level

f. Karst topography and its development in the lime-sink area

g. Geologic histroy of Florida from fossil records

h. Economic geology

  (1) Lime rock quarries

(2) Phosphate mines

(3) Heavy mineral mines

The exact sites and routes were selected in order that as many concepts and principles as possible could be developed. Worthwhile student activities are suggested; sets of slides, for which representative prints are included in the monograph, were produced to aid in the teacher's pre-planning and post-discussion of the trip; a bibliography of literature available for the area is included for the teacher's use; and any additional information considered useful to the teacher making the trip is made available.

Two means of assessing field trip experiences were developed in conjunction with The Case Study of Hogtown Creek. These are included as appendices. Appendix A is for the teacher; Appendix B is for the student. Included also from the case study are models for a student field guide (Appendix C) and for development of behaviorial objectives and activities for field trips (Appendix D).

A list of sites for which additional trips have been developed, subjects of other monographs, is given below.

a. Little Talbot Island State Park - Coastal features and their formation. (Resource Monograph #3)

b. Atlantic Coast from St. Augustine to Flagler Beach - Coastal features and their formation. (Resource Monograph #4)

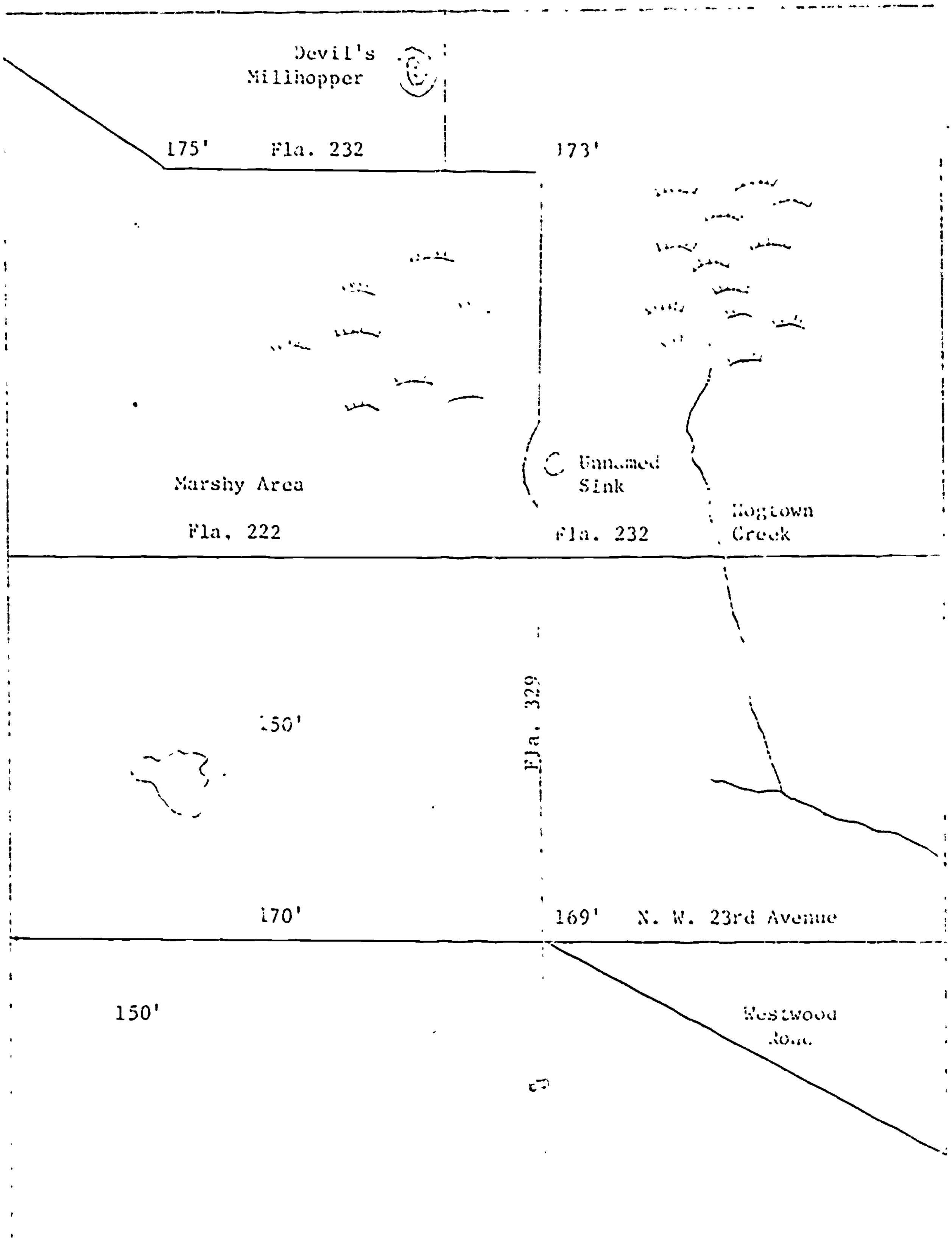
c. Cedar Keys area on the Gulf Coast - Coastal features and their formation. (Resource Monograph #5)

RESOURCE GUIDE FOR FIELD STUDY AT DEVIL'S MILLHOPPER

Background and Location

Alachua County, lying on the eastern flank of the Ocala Arch, has been divided into three physiographic regions: (1) the High Plateau with elevations ranging from about 175 feet a.s.l. (above sea level) to about 200 feet a.s.l.; (2) the Transition Region which encompasses about two thirds of the northwestern portion of the County; and (3) the Limestone Plain with elevations ranging from about 57 to 100 feet a.s.l. Sink holes are not common on the High Plateau; the Devil's Millhopper occurs in the marginal zone between the High Plateau and the Transitional Zone. Elevations range from about 55 feet a.s.l. at the bottom of the Devil's Millhopper to about 195 feet a.s.l. on erosional remnants of the high plateau. The Millhopper, then, with its creeks and slumping sides, becomes one of the erosional mechanisms currently lowering the High Plateau.

The Devil's Millhopper is located about three miles west of Paradise (Dub's Steer Lounge) and about six miles northwest of Gainesville. It is readily accessible from I-75 (west), from the south or from the east. From the south, approach by Florida 329 and Florida 26 which intersects with Florida 232. From the west, leave I-75 on the northernmost Gainesville exit at Florida 222 and move east to Florida 232. Proceed north on Florida 232. About four-tenths of a mile after turning north, the road bends around a small pond, turn sharply west. About two-tenths of a mile beyond this bend, turn right on a paved road which deadends at a radio tower. Two-tenths of a mile off Florida 232, turn left (west) on a dirt road and park at the railing. Any through road north of University



Map of Devil's Millhopper Area

Avenue such as 39th Avenue, N.W. 23rd Boulevard, and Westwood Road intersects with Florida 329. The area north of the Millhopper is void of any roads; consequently direct entrance from the north is impossible by car.

The area in which the Millhooper is located is slightly undulating with a few marsh lands in the vicinity. The sink is surrounded by level flatwoods which are higher than the adjacent hammock belt which slopes westward toward the Gulf. Surface drainage in this area produces minimal erosional effects. No rivers are indicated on the Gainesville West quadrangle, and the creeks represent surface drainage terminating in sink holes. Of the three creeks shown on the map, Turkey Creek is the only one which flows into a river. Hogtown Creek flows into a sink; Blue Creek rises at the 175-foot contour and empties into a marshy area at the 125-foot contour.

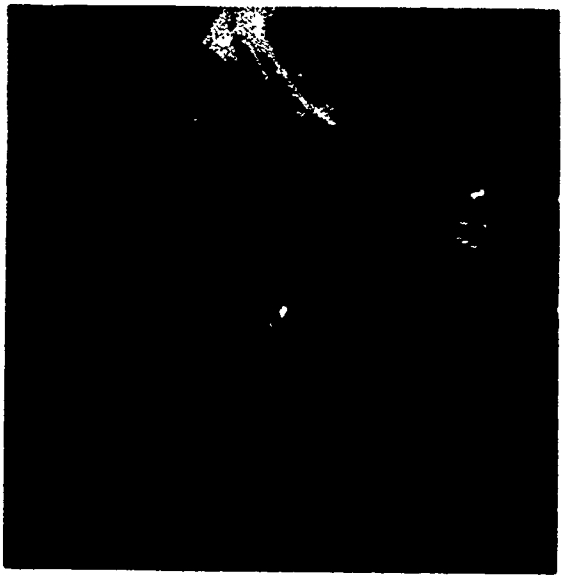
Both the vegetation and the subsurface drainage are determined by the sediments underlying this area. Although the clays of the Hawthorne Formation are present in certain localities, they have been eroded over much of the area. Where these clays have been eroded extensively, subsurface drainage has increased.

The water percolating downward through decayed vegetation and other organic material becomes slightly acidic. Since calcium carbonate (limestone) is soluble in acids, it is slowly dissolved away. As this solution occurs, a void is created beneath the surface. As this void or cavern increases in size, a point is reached at which the roof of the cavern is no longer capable of self-support. Any further increase in size or the lowering of the water level, creating a dry cave, will signal the collapsing of the roof--the result of which is a "collapse sink." The Devil's Millhopper is such a sink. It is approximately 125 feet deep and has resulted from the solution in the underlying Ocala Limestone.

Southward from the Millhopper is the Western Limestone Plains region. Here the sinks become quite numerous as the Ocala Limestone is overlain by a thin covering of loose sand. The sinks may be identified easily by their circular pattern and the clumps of trees surrounding them; occasionally roads have to veer around them. Plate 1 illustrates the clarity with which these can be viewed from the air. Plate 2 is a view of the Millhopper from the air; Plate 3, Ichetucknee Springs, illustrates water issuing from crevices in the limestones.

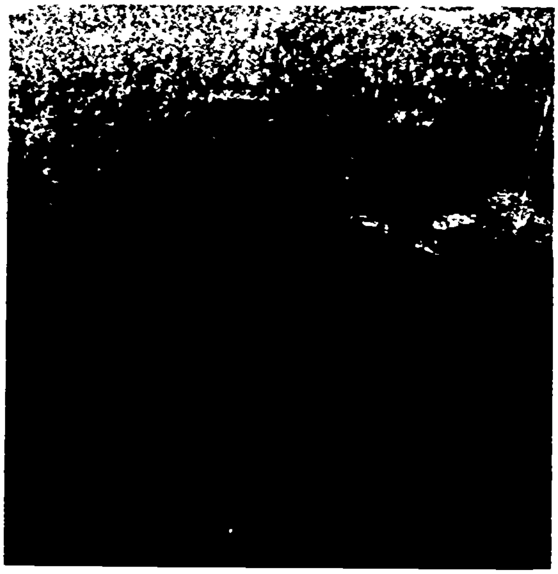
The stratigraphic section used was prepared by Pirkle, Pirkle, and Yoho. They indicate that there are about 117 feet of sediments exposed in the sides of the Millhopper. The underlying Ocala Limestone is beneath the surface of the water in the sink and is difficult to reach. This unit, and that representing the surface materials, are relatively easy for the student to find since they represent the top and the bottom of the exposure. A third unit, unit four of the section, is more distinctive by its olive green color and serves to orient students as they attempt to locate the lower units in the section. Marine mollusks' borings occur in the dolomitic limestone of unit 14. This is found just above the spring line and forms a ledge along the side of the sink. Resting in places on unit 14 is a group of sediments considered Pliocene by Dr. H. K. Brooks. Since Pliocene land vertebrate fossils have been found in these sediments, students should be given the opportunity

PLATE 1



Aerial View of a Sink

PLATE 2



Aerial View of Devil's Millhopper

PLATE 3

Water Issuing from Crevices in Limestones

PLATE 4

Students Collecting Fossils in Millhopper to examine these deposits and to find evidence which indicates an environmental situation other than the marine conditions of the other units. Students may find casts of phosphatized mollusks in these sediments not indigenous to these sediments. The student should be introduced here to the idea of sediments and fossil evidence being reworked or recycled and to the dangers of misinterpretations based on such evidence. Plates 4 and 5 show students working on the bottom and on the sides of the sink.

Because of the slumpage that has occurred, it is very difficult to locate certain of these units. For high school students the exact location of each of the units must not be emphasized to the extent that students become frustrated, consequently losing interest and giving up. It seems more important to stress the relationships between the various units on the basis of environmental changes which may have occurred and the ways in which geologists use the rocks and sediments to understand these relationships. Fossils are found in some of the units while other evidences, such as mollusk borings in the limestone where it is exposed at the spring line, are more subtle.

Several small creeks cascade down the sides of the sink. Their descent is controlled by the sediments over which they are flowing. A perched water table is indicated by the spring line just above the impermeable clays. Observation of all of these features as well as a period of time for fossil collecting provide worthwhile experiences for the students as they participate in studies related to historical geology or karst topography.

PLATE 5

Students Examining Sediments in Sides of Millhopper

Educational Purposes Possible to Achieve *

Opportunities for achieving educational purposes are many. The teacher, however, must determine his general purposes for visiting, express them in behavioral terms, and then investigate the Millhopper himself with the objectives in mind. This must be done prior to the visit with the students. The Millhopper is not a place to take a class for fun and games or because it is there. Rather, the Millhopper is a place which provides opportunities for educational experiences which students cannot have in the classroom or elsewhere.

Teaching Units to Which the Site is Best Adapted

A study of the Millhopper may be used in several ways. A few are listed below:

1. Interpretation of the geology of the general area may be accomplished here. Many of the children around the Gainesville area have visited the Millhopper many times but know little or nothing about its origin or its significance.

2. Students may be introduced to a study of exposed rocks as a basis for geological interpretation of the historical geology of the area. The rocks and sediments exposed in the sides of the Millhopper take the students on the journey through time as they move up the sides from the Eocene limestone to the Recent sands. The Law of Superposition may be illustrated here as they move up in time.

* See Appendix D. This appendix appears as Chapter III in Resource Monograph #2, A Case Study of Hogtown Creek, P.K. Yonge Laboratory School, February, 1973. It is appended verbatim to each of the monographs in the series to serve as a model in the all important step of developing appropriate objectives.

3. The fossil remains may be studied and used as evidence for interpretation of the past environments and for correlation with sediments of other areas. The changing sediments suggest fluctuations of sea level over the last million years. As the student studies sea level changes in glaciation studies or oceanography, a visit here may prove useful.

4. Mathematics may be applied if students are asked to "measure the section." Graphic representations of the differences in temperature, humidity, soils, and water characteristics may involve mathematics.

5. A study at this site may span the curriculum on the basis of the few activities suggested below:

a. Art. Activities associated with art might include having students observe and sketch a natural scene. A story or documentary may be compiled back in the classroom based on the series of sketches, thus correlating art with language arts. Collages of various leaf specimens, rocks, fossils, etc. may be constructed. Web prints of spider webs will introduce the students to some of the intriguing designs of nature. Spore prints, leaf prints, leaf silhouettes, and sun prints may be used in much the same way. An activity which is always stimulating is to provide students with a piece of drawing paper and instruct them to paint a picture using only nature's materials. Soon the students will be crushing berries, squeezing leaves and flowers, using colored clays and dirts, and marking with soft rocks.

b. History. A resource person from the county or Florida Historical Society might provide background information on the early Indians who lived in the area. A search through historical publications will disclose the significance of the Millhopper in the growth and development of the City of Gainesville, particularly since the Millhopper has long been used as a recreational area by the citizenry of Gainesville. Projecting into the future ask students to write a possible history "story" for the Millhopper which would encompass the next 50-100 years. Students might also be asked for suggestions regarding the future use of the area and what might be done with it to preserve its natural state.

c. Language Arts. Reports from papers resulting from the study of the area may be made. Stories related to sketches done under the art activities might be a project for English class. Another popular activity is the writing of "haiku" poetry with reference to natural settings or phenomena observed at the sink. As a means of introducing students to new words, they might be asked to isolate themselves for a short period and describe the sounds they hear in a new way, using words which are new and strange to them.

d. Environmental Studies. Since this is a direct entrance way to the Floridan aquifer and since people throw everything from dead animals to beer cans over the side, students may, through the study of pollution problems here, begin to see the significance of using our aquifer as a garbage dump. Ecologically the Millhopper is a fascinating collection of mini-environments. Evidence is present for serving as a basis for hypothesizing on the characteristics of past environments and how the general environment has changed over the years. A study of the changing environmental factors as one moves from the rim to the bottom of the Millhopper is challenging and rewarding.

e. Chemistry. Analysis of the waters or a look at the phosphatic sands are just two ways chemistry study may be involved. A study of the waters, their content and pH, might be made. These are relatively the same kinds of fluids which caused the solution of limestone creating this huge hole. Realizing that the water is draining out of the Millhopper, students may be shown that solution is still going on, a new cavern is forming under the floor of the present Millhopper, and the High Plateau is still in the process of being lowered.

f. Physics. Temperature gradients made from the bottom of the sink to the rim might identify some mini-environments. This might prove to be an interesting study for most students, especially if they are asked to hypothesize about the temperature changes from top to bottom.

g. Botany. Because of the ranges in environments, a study of the changing plant life should prove of interest to students interested in botany. Many activities in this area may be correlated with studies in art.

h. Social Studies. Formally owned by the University, the area has been given to the state for the establishment of a park. Projects might initiate action for the preservation of its geological as well as aesthetic features.

The above list represents only a sampling of the possibilities for use. The unifying theme for activities might be CHANGE. There is evidence which indicates that CHANGE has occurred in the environment through time; there is evidence that CHANGE is occurring presently as the area continues to erode and wear down; there is every reason to believe that CHANGE will occur in the future.

Suggested Activities for Use at this Site

A list of several activities which have been used is presented to serve as a point of departure for teachers.

1. Field Activity - Students may be given a copy of the measured stratigraphic section having the determined thickness of each of the units omitted. In small groups, they may be asked to identify the units and, where possible, estimate their thickness. This is a difficult task, however, and must not be continued to the extent that complete frustration occurs. Class activity should prepare students for using such a "section" by studying a copy in the classroom and discussing the differences in the units and why they are separated.

2. Field Activity - Students may determine the depth of the Millhopper using basic instruments such as two meter sticks and two line levels. One meter stick is placed horizontally and a second one vertically. Levels are used to insure that the sticks are actually horizontal and vertical. Meter sticks are moved down the side of the sink in step fashion, and each new position is recorded and marked. The triangulation method may be used with students whose math background is sufficient.

Using a foot ruler, students may be introduced to this method of measurement by measuring the difference in elevation between two points on the chalk board. A line drawn on the chalk board representing a hill slope is used by students to determine the difference in elevation without measuring the direct vertical distance between the two points and the base of the chalk board (Plate 6).

3. Field Activity - Students may collect and identify fossils

found in the Millhopper. Creeks entering the sink erode and transport many fossils to the bottom. Consequently, students should be cautioned that fossils collected at the bottom are not "in place" since they have been reworked by the stream. Students should be asked to seek out the fossil bearing strata and do "in site" collection for correlation with the various units of the section. At this point, recording exactly where a fossil is found should be stressed. The fossil is a worthless piece of evidence if the location of collection is trusted to memory rather than recorded in writing.

Class activity to prepare students for this field activity may be minimal. Most students are masters at the art of fossil collecting. The idea of collecting fossils in small containers (cloth bags, jars, boxes), labeling them in the field, and recording data in field notebooks is stressed prior to the visit.

4. Field Activity - Students interested in botany may make comparisons of the plant communities on the rim with plants found on the bottom of the sink. Because of the changes in the environment as one moves down the sides of the sink, there are changes in plant populations.

If the teacher is not a botanist, the assistance of other faculty members or outside resource persons having a proficiency in this field of study, should be sought to aid students. In addition, a resource book which provides information needed to identify various plants should be made available.

5. Field Activity - Students collect samples of the various units for laboratory study. Since these students are not chemists,

analyses of the samples are generally limited to such things as density, moisture and nutrient content, microscopic study of the particles, and pH of the soils.

Class activity should involve instruction in the procedures for making such analyses, including the use of the microscope and the pH meter. Some students have learned the procedures in the eighth grade; some have not. It is advisable that students be prepared to move rapidly into making the analysis during the follow-up activities. Interest seems to decrease inversely as the square of the time which passes after the field trip. Efficient planning prior to the trip alleviates this problem.

6. Field Activity - Since the composition of the waters entering the Millhopper is basically the same as that which caused the Millhopper to form, an investigation of the water is significant. Students may collect samples of the water from different sources in the area, including the water disappearing down the sink, to determine some of the characteristics of the water. In addition, students observe the water disappearing down a hole in the limestone and can infer that solution is still going on and that these are the waters involved.

Class activity should include the preparation of any chemical solutions needed for the analysis and instruction in the use of the pH meter or methods for determing pH if a meter is not available. Students need not understand what is occurring chemically as they analyze the samples as long as they can interpret the results.

7. Field Activity - Since the environments at various places in the sink are different, some study should be made which correlates

the differences in plant communities with the changing environments. One group of activities might include the determination of differences in humidity and soil types (clay, sand, and limestone) at various levels in the sink. In addition, examination of the amount of moisture retained in each of the soil types and the pH of the soils may be made. The extent of soil analysis will be determined by the levels of students with whom the teacher is working. For most of the activities, care is essential in the selection of samples because much of the sides of the sink is covered with slumped materials.

Class activity prior to the field trip should include considerable preparation for the laboratory procedures necessary for the activities described above. To do so after the field trip is much less effective.

8. Field Activity - A small stream exists onto the floor of the sink. The stream is prepared in advance for use as a stream table would be prepared in the laboratory. By changing certain features of the stream, it is possible to simulate many different stream conditions. Slides of the variations were made for classroom use prior to the field trip. Students then were prepared to watch the effects of changes in stream profile, discharge rate, temporary base levels, and floods.

The list of activities is presented to serve as a point of departure for a teacher using this area. Many other activities could be designed, directed toward accomplishing the desired outcomes. The importance of determining specific objectives cannot be over emphasized. Without objectives for study, these activities become isolated tasks with no meaning, and evaluation is impossible.

Teaching Aids and Printed Materials Available

No teaching aids are available for this site. Slides used at the P.K. Yonge Laboratory School may be obtained through the School at cost. Plates 1 through 5 illustrate certain aspects of the Mill-hopper or related structures such as a view of the Ichetucknee Springs. Printed materials available to teachers are listed in the bibliography. Appendices include model trip evaluation forms for students and teachers and a model field guide, using Hogtown Creek as the subject, for use by students.

Age Levels to Which the Site is Best Adapted

Sink holes are dangerous. This particular sink, however, has a pathway constructed by Boy Scouts, which leads to the bottom of the sink. Small groups of relatively young children, properly supervised, may hike down this path, spend an enjoyable period of fossil collecting at the bottom, and exit safely. Any climbing on the slippery walls of the sink should be restricted to ninth graders and above.

Safety Factors, Hazards, or Special Conditions to Consider

Again, sink holes are dangerous! Listed below are the potential dangers one must consider when conducting a field study of the area:

1. Steep sides of slippery clay.
2. Overhanging rocks.
3. Caves which must be avoided by the children.
4. Falling material dislodged by other students.

The ies of the sink are sheer in certain places. Students must exercise extreme caution as they scale these steep sides to investigate the sediments and rocks. A misstep could result in a broken leg or arm; a dislodged rock or a dropped geopick could cause injury to those below. Precautions should include proper spacing of students while they work as well as limiting the size of groups working together. Other teachers or adults may be trained to move through the area with student groups. A final group meeting at the bottom with selected students strategically placed as guideposts on the sides may culminate the activity.

Students should be cautioned about overhanging rocks, particularly if there have been heavy rains previous to the visit. They should certainly not be asked to dig around the overhangs. A trip to the sink a day before the field trip should alert the teacher to the potential danger areas to be avoided.

Caves must always be avoided in this area. They are not large, but they have not been explored and are potentially dangerous for young children. If the students are well supervised and kept interested by their tasks, this poses no problem.

Days and Hours Available for Visiting

The area is "open" 24 hours each day. It is suggested that visits be limited to daylight hours and, if pictures are desired, to the brighter, lighter portions of the day. For safety's sake rainy days should be avoided since the combination of clayey sediments and rain make climbing hazardous. The Millhopper does occasionally begin to fill with water if input exceeds output, controlled by the opening at the bottom. The depth of the water must be considered and is more of a hazard to younger students. Other than these there are no restrictions on times for visiting.

Number Restrictions on Visitors

"The lower the age group, the fewer the number" is a sensible rule to follow. Seventeen ninth graders with two teachers proved very satisfactory. It is suggested that no more than fifteen students below the ninth grade age level, accompanied by two adults, should be taken at one time.

Accommodations

This undeveloped area has no accommodations. Consequently, for young children a rest stop at the last possible place before reaching the Millhopper is suggested. For older students a rest stop prior to leaving school suffices, as this visit can be made in about three or four hours. Snacks or cold drinks (preferably water) may be carried along if the class desires. All drinks except water should be discouraged because of the garbage disposal problem.

Admission Fees

There are no fees, and no contact needs to be made with any one for permission to visit.

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APPENDIX A

TRIP EVALUATION FORM (TEACHER)

ITEM	EVALUATION 1	2	3	4
1. Are the goals relevant, realistic and worthwhile?				
2. Do the objectives state clearly what effect the field study should have on the learner's behavior?				
3. Are the objectives relevant, realistic and worthwhile?				
4. Is the field guide well-organized and clearly understood?				
5. Are the guide questions for each stop relevant and significant?				
6. Are activities sufficiently varied to stimulate interest in a number of areas?				
7. Are the activities supplying relevant data?				
8. Do activities appear to be sufficiently sophisticated for this age group?				
9. Do the activities and observations warrant missing a day in the classroom?				
10. Was the time allotted for this trip adequate?				
11. Were the portions of the creek to be studied chosen to best advantage for this age group?				
12. Are the welfare and safety of the children adequately considered in the study and its activities?				

CODE FOR EVALUATION

1. Very good as described. 2. Satisfactory or acceptable. 3. Need revision. 4. See comments and suggestions on next page.

APPENDIX B

TRIP EVALUATION FORM (STUDENT)

Please answer the following questions. Do not identify yourself. You are being asked to convey your feelings and beliefs about the field trip to Hogtown Creek and to offer suggestions that will help make this a better field trip for future use. (Place your answers in the space following each question; if additional space is needed, use the back of the form.)

1. Do you believe that the field trip was successful in terms of the general goals as stated in your field guide? If not, please specify the goals you believe were not accomplished.

2. Please specify any mistakes you believe were made or any difficulties you may have encountered that were related to

   A. Resource sites used

   B. Guides (non-teacher)

   C. Teachers

   D. Other students

   E. Weather

   F. Transportation

   G. Size of group

   H. Activities

   I. Other

3. Do you believe that the conduct of the group was satisfactory? If not, what changes would you suggest?

4. Do you believe the trip was really worth the time and effort spent on it?

5. Do you believe the same educational results could have been obtained equally well through other methods such as the use of slides, movies, laboratory activities or reading assignments?

6. Which aspect of the trip might be improved?

   A. Pre-planning

   B. Size of groups

   C. Number of ideas presented

   D. Observations made

   E. Number of sites visited

   F. Length of the field trip

   G. Follow-up activities in the classroom

   H. Others

7. List the activities on the trip that you think were

   A. Most valuable

   B. Least valuable

8. Did you develop any new interests as a result of the trip? If so, what interests were they?

9. Did the trip make you change your attitude?

   A. Toward anyone in the room?

   B. Toward the teachers involved?

   C. Toward science?

10. Were your teachers "different" on the trip? How?

11. Did you learn anything on this trip about working with people? If so, what did you learn?

APPENDIX C

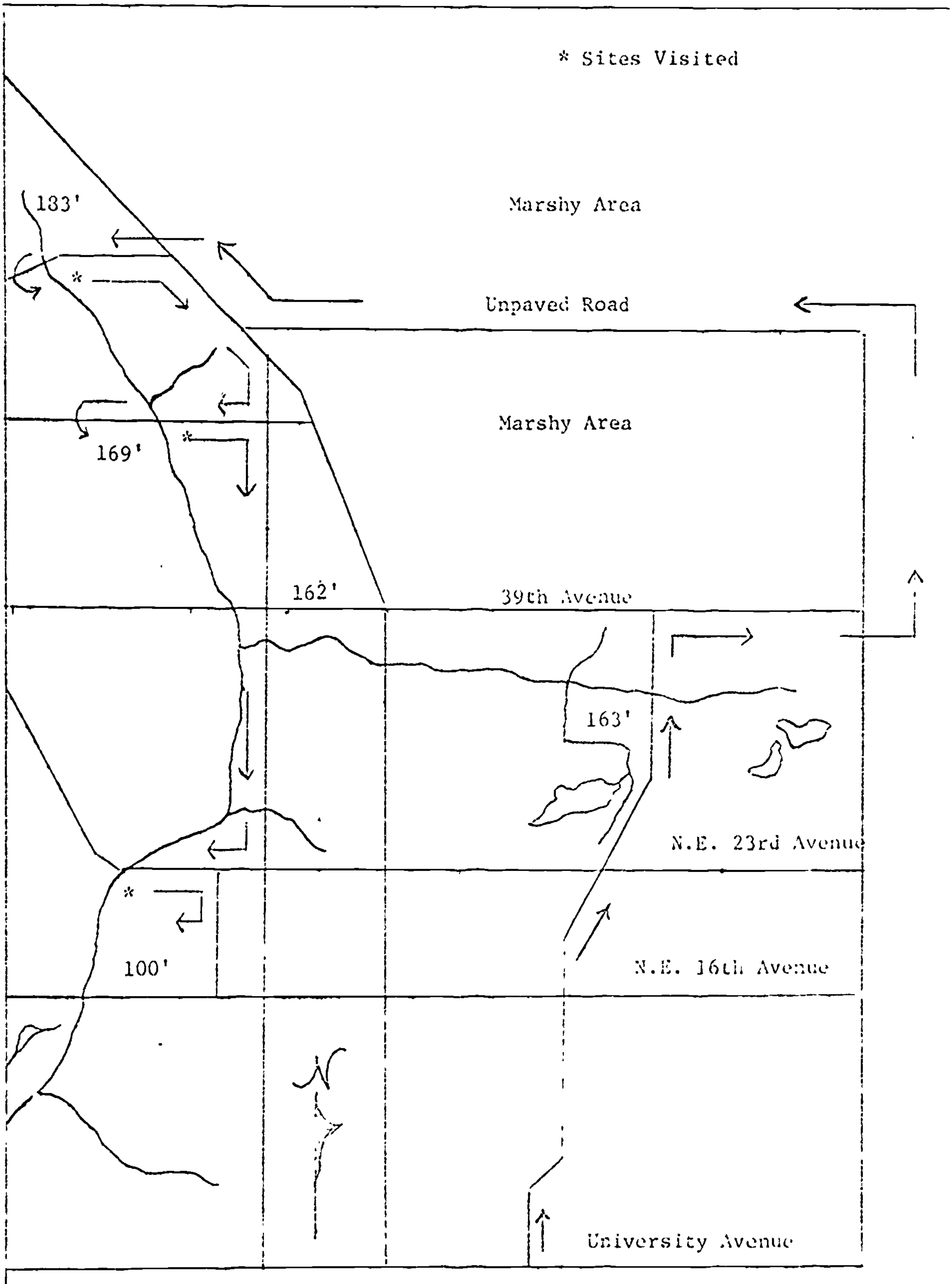
STUDENT FIELD GUIDE FOR AN INVESTIGATION OF HOGTOWN CREEK

INTRODUCTION

The revised form of the Student Field Guide is presented in the following pages. Since some of the activities have been revised after the students' participation, some of the activities and the associated instruments have been changed. The two instruments that have been revised are those used in the determination of gradient and cross-sectional area. In the Observational Record Guides space for student comments has not been allotted in this copy; in the students' working field guide, sufficient space is allowed for their comments.

The major change, as is evidenced by the map of the area under study, is the deletion of the visit to Hogtown Sink, the terminus of the Creek. This visit will be incorporated into a separate trip that will involve a study of karst topography. This change was based on the responses of the students who regarded the stop at the sink undesirable. These responses coupled with the necessity to shorten the trip resulted in the change.

STUDENT FIELD GUIDE FOR AN INVESTIGATION OF HOGTOWN CREEK



Route for Hogtown Creek Field Trip

Primary Goals

1. To develop in the student an awareness of the uniformitarianistic qualities and of the universality of the natural forces and processes through which the earth's topographic features have evolved.

2. To carry the student out of the confining classroom and into to direct empirical and quantitative observations of natural and physical phenomena at work in shaping the earth's surface.

3. To emphasize science as a process of inquiry by providing the opportunity for the student to observe, collect and process data, and make interpretations.

4. To develop an understanding and concern for our natural habitat in order to involve the student in the perpetuation of a quality environment.

Performance-Based Objectives

1. When the student completes his observations of the erosional and depositional features of Hogtown Creek, he will be able to identify similar features from slides with at least 70 per cent accuracy.

2. The student will view the processes, forces and related features involved in the evolution of Hogtown Creek and will view slides of the Colorado River and the Grand Canyon. The student will then be able to describe orally on tape or in essay form at least six of the similarities and/or differences between the processes and forces shaping these two great valleys with at least 70 per cent accuracy.

3. During the field trip the student will demonstrate at least

Once his ability to manipulate the various instruments by measuring gradient, velocity and cross-sectional area. His data will agree within a selected tolerance of the instructor's data for each activity (20 per cent tolerance for gradient, 10 per cent tolerance for cross-sectional area and 5 per cent tolerance for velocity).

4. The student will demonstrate his ability to interpret data on gradient, velocity, discharge rate, and cross-sectional area either in a taped oral discussion or by written assignment by correlating the quantitative measurements with the structural characteristics of the stream. He will do this with at least 70 per cent accuracy.

5. The student will demonstrate his ability to evaluate his observations and accumulated data by identifying at least two of the effects man has already had on the evolution of Hogtown Creek and by hypothesizing what one future effect of man's actions will be.

6. The student will be able to interpret the conditions under which the sediments were laid down after viewing depositional structures along the Creek. He will do this by examining a core sample of sediments in the laboratory and interpreting the relationships of the various types of sediments in the core in oral or written discussions.

7. The student will demonstrate a positive attitude by making positive vocal contributions in the form of questions or comments at least once during any discussion occurring during the field study. *

* This objective was not placed in the students' field guides. It is believed that the presence of this objective would in itself affect the students' behavior and therefore was omitted from all except the teacher's guide.

Summary of Activities

Stop no. 1:

Gradient determination and velocity of water.

Eighteen-inch core samples of sediments.

Surface samples of flat stream bed and of deep holes in stream bed.

Samples of sediments from slip-off slopes and cut banks.

Cross-sectional area.

Stop no 2:

Gradient determination and velocity of water.

Samples of resistant materials in stream bed - just above water level and just below water level.

Samples of materials associated with issue of springs in banks of the stream.

Samples of wet stream bed - flat portion, pot holes, slip-off slopes, and cut banks.

Cross-sectional area.

Stop no. 3:

Gradient determination and velocity of water.

Samples of wet stream bed - slip-off slopes, cut banks, terraces, and sand bars.

Collect samples from oxbow or old meander scars. (Scrape away organic trash on surface and collect 18 inches of sediments in 6-inch lengths.)

Cross-sectional area.

INTRODUCTION TO STOP NO. 1

Hogtown Creek drains part of an area lying between the high central plateau and the lime sink region. The drainage area has an elevation ranging from about 190 feet above sea level to about 60 feet above sea level. The elevation of the branch where you will begin your study is approcimately 175 feet above sea level. Your last stop will be near the 100 foot contour as you finish your observations. The terminus of the creek which will be visited at a later date lies at about the 60 foot level. The creek ultimately drains into Hogtown Sink in the southwest corner of the Prairie.

The branch of the creek that you will investigate first originates just southeast of Paradise. The upland area of this creek is typically one of lakes (ponds) and swamps. Because of man's interference, it is sometimes difficult to determine visually whether the land drains into Hogtown Creek or into one of the Hatchett Creeks, two additional streams draining this upland area.

As you leave P.K. Yonge campus and ride toward your first stop, please watch the landscape and plant cover with the following questions in mind:

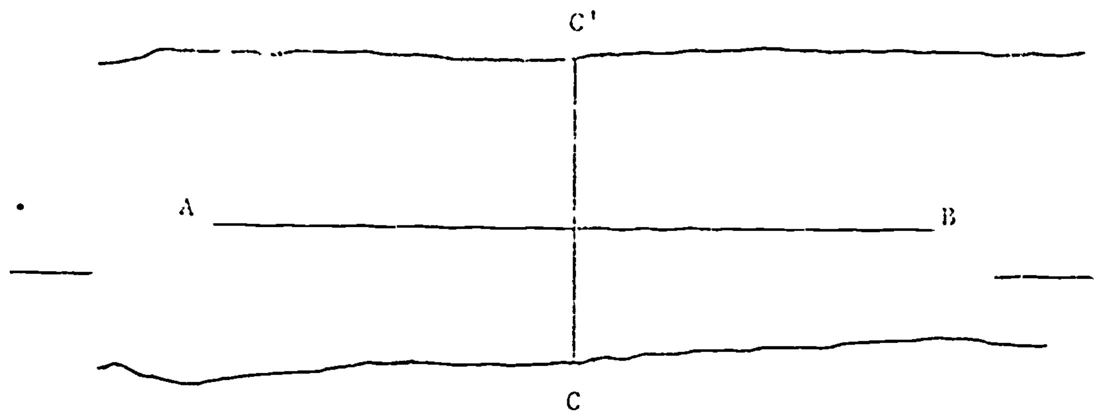
1. How have the topographic features changed as you moved from the campus to the upland area of the stream?

2. Are the shrubs and trees different from those which you find on the campus? How?

3. Is there any evidence along the way that might indicate a perched water table? What is your evidence?

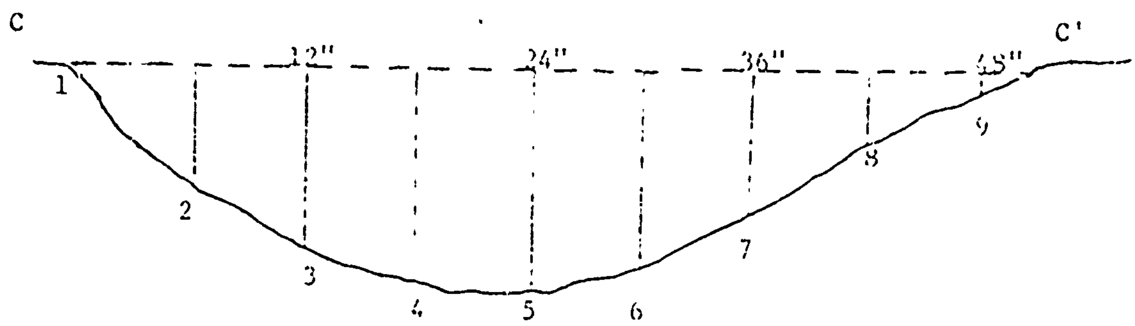
4. What effects do you think man's clearing of this land and developing a series of drainage ditches might have on the Creek itself?

5. From looking at the land surface can you tell anything about the sediments underneath the surface?



Distance from point A to B: 10 feet

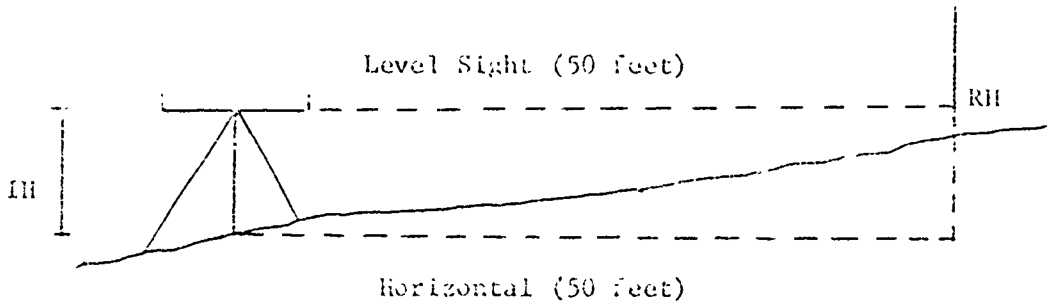
C - C' Midpoint between A and B (Cross-sectional data should be collected here.)



Depth of water is recorded every six inch interval. Tape stretched from C to C' must be right at water level. Depth is measured with a meter stick.

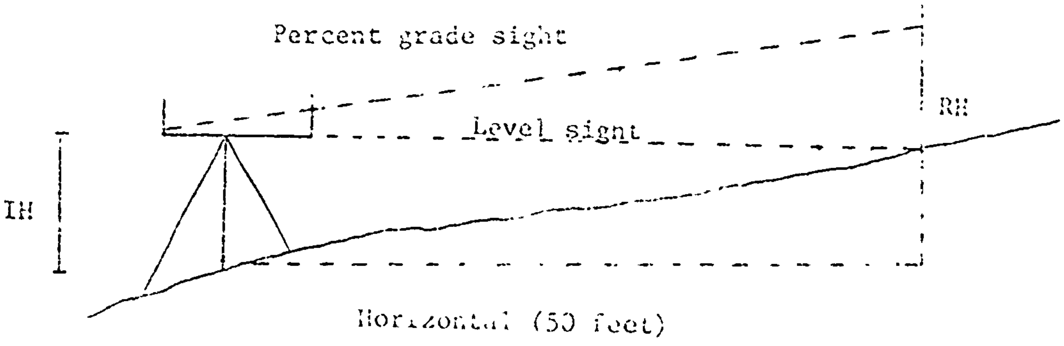
Figure 2: Velocity and Cross-Sectional Area

Sighting Level Method



Record IH (Instrument Height) and RH (Rod Height)

Percent of Grade Method



Record IH (Instrument Height) and RH (Rod Height)

Figure 1: Determination of Gradient

OBSERVATIONAL GUIDE

STOP NO. 1

FEATURES and COMMENTS:

1. Note the drainage of the area at this site.

2. Note the sediments through which the stream is cutting. Are they particularly resistant?

3. Can you find a section of the stream where it encounters more resistant sediments? Describe the area please.

4. Does this appear to be a typically youthful stream? Why or why not?

5. Can you account for the meanders that are present here?

6. Find and list as many erosional features in this section as you can.

7. Find and list as many depositional features in this section of the stream as you can.

8. Evidence of man's interference with this stream. Is there any? Describe your evidence for or against.

9. Other observations. Use back of page if necessary.

INTRODUCTION TO STOP NO. 2

You shall leave the first site and proceed down in elevation to the second site. The elevation here is about 150 feet above sea level, and is an interesting place to visit. The creek flows through a private yard and garden; the owner has given you permission to visit here. Please show him consideration by being careful with his trees and shrubs, and do not damage the creek banks so that erosion will become a problem for him. Because of the nearness of the residence to the creek, please keep your conversations at a reasonable level.

The small groups will gather their data and make their collection of samples. Following this the large group will assemble and everyone will look at the stream together, searching for, and discussing the features on the Observational Guide Sheet. Many other features may be noted that do not appear on this list. As you collect your data and make your observations, keep in mind the following questions.

1. What evidence is there here to indicate that this stream has undergone a setback in its progress toward maturity and old age?

2. Do you see any evidence of differential erosion?

3. How do you account for the presence of springs at the level at which they are found issuing from the banks?

4. How do the sediments through which the stream is cutting its way here differ from the sediments at the previous stop? Are there any similarities between these two groups of sediments?

5. The main source of water for Hogtown Creek is ground water. Through man's interference the rate of run-off has been increased and has been channelled into Hogtown Creek. Do you see any effects of this

periodic flooding during times of heavy rainfall? What effect does it have on the immediate terrain? Can you see any influence this periodic flushing might have on organisms living in the creek?

OBSERVATIONAL GUIDE

STOP NO. 2

FEATURES: COMMENTS:

1. Change in gradient.
2. Materials being added.
3. Meanders.
4. Rejuvenation.
5. Waterfalls and rapids.
6. Deep valley sides.
7. Higher stand of water level.
8. Hanging valleys.
9. Alluvial fans.
10. Potholes.
11. Abrasion.
12. Pollution.
13. Velocity in relationship to physical characteristics of the stream.
14. Stream competency.
15. Temporary base level.
16. Faunal evidence of past history.

INTRODUCTION TO STOP NO. 3

Your next site to visit is one located on the 100 foot contour behind the Gainesville Mall and Gainesville High School. Through the courtesy of the owner of the land, you have been given permission to investigate this portion of the stream.

This segment of the stream has some features that are better developed than what you have seen before. Please be alert to any changes in the physical appearance of the stream. As you proceed through your quantitative measurements and your collections, keep in mind the following questions.

1. Does any evidence show that the competency of the stream varied from time to time?

2. Is the stream here presently involved in down-cutting or lateral erosion?

3. How has man's interference affected the stream in this area?

4. Notice that the creek flows in a valley which is much wider and still has fairly steep banks. Does it follow that this stream once filled this entire valley and was much larger than it is now?

5. Are there any significant changes in the character of the sediments through which this creek is cutting its way at this point?

OBSERVATIONAL GUIDE

STOP NO. 3

FEATURES: COMMENTS:

1. Meanders.
2. Entrenched meanders.
3. Erosional features.
4. Depositional features.
5. Spring heads.
6. Intermittent streams.
7. Stream competency.
8. Stream load.
9. Cut banks.
10. Slip-off slopes.
11. Other observations.

VELOCITY DATA SHEET

STOP NO. 1: Team Leader ______________________

Team Members ______________________

Linear distance measured along center of creek

Length of time for object to cover distance: Trial 1 ________

Trial 2 ________

Trial 3 ________

Average Time ________

Velocity = Distance/Time (Avg.) Velocity ________

STOP NO. 2: Team Leader ______________________

Team Members ______________________

Linear distance measured along center of creek

Length of time for object to cover distance: Trial 1 ________

Trial 2 ________

Trial 3 ________

Average Time ________

Velocity = Distance/Time (Avg.) Velocity ________

STOP NO. 3: Team Leader ______________________

Team Members ______________________

Linear distance measured along center of creek

Length of time for object to cover distance: Trial 1 ________

Trial 2 ________

Trial 3 ________

Average Time ________

Velocity = Distance/Time (Avg.) Velocity ________

CROSS-SECTIONAL AREA DATA SHEET

STOP NO. 1: Team Leader ______________________________

Team Members ______________________________

Distance from right shore*	6"	12"	18"	24"	30"	36"	42"	43"
Depth of water	____	____	____	____	____	____	____	____

STOP NO. 2: Team Leader ______________________________

Team Members ______________________________

Distance from right shore*	6"	12"	18"	24"	30"	36"	42"	48"
Depth of water	____	____	____	____	____	____	____	____

STOP NO. 3: Team Leader ______________________________

Team Members ______________________________

Distance from right shore*	6"	12"	18"	24"	30"	36"	42"	48"
Depth of water	____	____	____	____	____	____	____	____

Distance from right shore*	54"	60"	66"	72"
Depth of water	____	____	____	____

*

Left bank

Direction of flow

Right bank

GRADIENT DATA SHEET

STOP NO. 1: Team Leader ______________________

Team Members ______________________

Instr. Height	Linear Distance	Flow Distance	Rod Height (level)	Percent Grade	Elev.* Change (level)	Elev.* Change (% Gr.)
______	50'	______	______	______	______	______

STOP NO. 2: Team Leader ______________________

Team Members ______________________

Instr. Height	Linear Distance	Flow Distance	Rod Height (level)	Percent Grade	Elev.* Change (level)	Elev.* Change (% Gr.)
______	50'	______	______	______	______	______

STOP NO. 3: Team Leader ______________________

Team Members ______________________

Instr. Height	Linear Distance	Flow Distance	Rod Height (level)	Percent Grade	Elev.* Change (level)	Elev.* Change (% Gr.)
______	50'	______	______	______	______	______

*The calculations for data for these columns may be made in the field or in the classroom.

Appendix D*

BEHAVIORAL OBJECTIVES AND ACTIVITIES

Development of the Objectives

The preliminary investigation of the study area suggested the educational potential of Hogtown Creek. The next task was to maximize the potential on the basis of general and performance-based objectives. The general objectives served as a logical point of departure in undertaking the development of the objectives for the field study.

Since two of the basic beliefs of earth science are uniformitarianism and universality of change through various processes and forces, students should be provided opportunities to develop awareness of these beliefs. Students' observations of the forces and processes at work in the Hogtown system and comparison of this system with similar systems in other areas could suggest the universality of the processes and forces. Further comparisons made with other stream systems should also suggest the concept of uniformitarianism. On this basis the first primary goal is stated as follows: "To develop in the student an awareness of the concepts of uniformitarianism and the universality of the natural forces and processes through which the earth's topographical features have evolved."

*Adapted from "Chapter III", A Case Study of Hogtown Creek, P.K. Yonge Laboratory School, Gainesville, Florida. January, 1973.

Field trips are believed to have an advantage as a teaching technique because the student can become actively involved. Some students will become involved from the planning stages to the final evaluation in a field study, but all students can be involved in making direct empirical and quantitative observations. Student's involvement emphasizes science inquiry: he observes, collects, and processes data and culminates his activities by making interpretations based on his data. From these basic beliefs and assumptions additional goals were developed: (1) To carry the student out of the confining classroom and into direct empirical and quantitative observations of natural and physical phenomena at work in shaping the earth's surface, and (2) to emphasize science as a process of inquiry by providing the opportunity for the student to observe, collect, and process data and make interpretations.

Just as the Russian Sputnik moved science educators in the fifties, the environmental press of today is demanding the attention of all educators. Only through education of young and old can concern for the quality of our environment be generated. Hogtown Creek, nearly a lifeless sewer in the not too distant past, may be observed on the basis of what man does to his natural environment. From this concern for the environment came the last of the four primary goals: "To develop an understanding and concern for our natural habitat in order to involve the student in the perpetuation of a quality environment."

The writing of the general objectives stated above was not difficult, but evaluation on the basis of these as stated may prove to be impossible. It is, therefore, desirable, in fact, mandatory, that these general objectives be supplemented by a set of specific objectives on which to base evaluation.

Preparation of specific objectives for field study requires much thought and careful planning as well as teacher familiarity with the area under study. Skill in the technique of writing behavioral objectives is gained only by reading and doing.

The procedures followed may be categorized as: (1) literature research and (2) the actual writing of the behavioral objectives. Based on several references from the literature, the following model is suggested:

1. State the over-all goals or objectives.
2. Develop a list of behavioral objectives which apply to each over-all goal.
3. Plan teaching strategies to achieve the objectives.
4. Select methods of evaluation which will determine the degree of attainment.
5. Feedback and revise.

Following this general format the first general goal was considered: to develop in the student an awareness of the uniformitarianistic qualities and of the universality of the natural forces and processes through which the earth's topographic features have evolved. For this study, the "forces and processes" were limited to those related to streams, their dynamics and their characteristic features. The processes and forces at work in a stream produce peculiar and specific features regardless of the time and place. It was considered educationally profitable for students to observe a system first hand in which the forces were currently producing the features. To extend this personal observation toward acquisition of the concepts of universality and uniformitarianism some additional activity was needed. Hence, students were shown slides of similar features in several stream systems of other times and other places. They were asked to apply their "field knowledge" to identify and account for these features. Through this activity it was predicted that the students' concepts of both universality and uniformitarianism would be enhanced and extended. A measure of the student's ability to relate the observed features in Hogtown Creek to features elsewhere was considered a measure of his grasp of these concepts.

This now had to be expressed in behavioral terms to be of value to both teacher and student. A breakdown of a behavioral objective indicated that it should include a statement of (1) the educational intent of the teacher, (2) what the learner will be doing when he demonstrates his achievement of the teacher's intent, and (3) how the teacher will know when the student is demonstrating his achievement. The objective should be represented by at least one task, which must be designed to elicit this behavior and should meet certain criteria. That is, the tasks (1) must be usable or practicable, (2) must be based on acceptable principles of learning, (3) must be suitable for the various levels of the learners, and (4) must be universal for all groups in our society.

A grasp of the concepts of universality and uniformity could only occur in this situation if the student could observe certain features and processes in the field and then relate them to other systems. Two activities thus became apparent: (1) the student had to make observations at the creek under study, and (2) the student had to observe slides of other systems. In the field situation it was believed necessary to guide the student as he made his observations. Since this was just one of the tasks anticipated for him, it was necessary that this one receive the same emphasis as the more specific quantitative tasks. An observational guide sheet for this first activity was developed for each student and incorporated into the field guide. All significant features which had been observed at each site during the preliminary investigation were listed. Sufficient space was provided for students to specify where they noted these features and the conditions under which they were occurring. Prior to beginning any of the quantitative studies, students and their designated teacher-guide walked a specified portion of the creek valley in the vicinity of each site. The tour was paced slowly enough for students to see, to ask, to comment orally, and finally to record in writing. Where certain features might have been overlooked, using questions, the instructor aided and encouraged the students in their observations.

The behavioral objective for the first activity was now developed in parts:

1. The educational intent of the teacher: The student will be able to identify stream related erosional and depositional features.
2. Learner activity: He will demonstrate his ability to identify these features by making identification from a set of slides which he has not seen previously.
3. How the teacher will know when he demonstrates this ability: The student will record his identifications either orally on tape or on a written observational sheet.
4. Definition of acceptable performance: The student will make his identifications with at least 70 percent accuracy.

Combining all of the parts into the whole resulted in the following statement:

"When the student completes his observations of the erosional and depositional features of Hogtown Creek, he will be able to identify similar features when viewing these features on slides. He will demonstrate his ability by recording his identifications orally on tape or in written form on an observational record sheet. He will make the identifications with at least 70 percent accuracy."

The second activity related to the first primary objective required the student to relate his observations to another stream system. The Grand Canyon of the Colorado River and Hogtown Creek are relatively the same age. Although they are so unlike in scale, they are very similar in active forces, processes, and features. Hence, the Colorado River was selected as the stream system for students to use in their comparison activity. Because of individual differences in reading competence and other learning skills, several techniques were used to introduce students to the Grand Canyon and the Colorado River. A fellow teacher brought his personal slide collection of the area and spent a class period in "show and tell". A second technique used an older student from another class as the "teacher". The student accepted the responsibility of searching the Grand Canyon and the Colorado River and presenting a summary to the earth science class. His presentation was taped for those who were absent or who needed to listen again. A third method used the Learning Resource Center available at the school to provide materials for the class related to the Colorado system. The materials kit included books, pamphlets, articles, reprints, film strips, and documentary films.

The materials and resources presented a description of the

Colorado River system since it could not be visited in person. No interpretation of the geological history of the system was attempted or, in fact, desired. The movie, for example, presented information about the amount of sediments carried, the flow rate, the length of the stream, and its use for irrigation. Students, then, used the information to compare and contrast the streams on the basis of features produced, forces at work, and unique characteristics of flow rate, gradient, velocity, and load. Slides used in teaching activities were not used later in evaluating learning.

Once the student had been introduced to the stream system by one or all of the methods above, he was asked to relate the two systems on the basis of their similarities and differences. Again, based on individual differences, at least two ways had to be designed for students to demonstrate attainment of the objective.

Stating the objectives in parts as described previously proved a productive way to proceed.

1. Educational intent of the teacher: The student will be able to describe similarities and differences between Hogtown Creek and the Colorado River.
2. Learner activity: Oral discussion recorded on tape or a written essay will be the vehicle by which the student may demonstrate his ability to recognize the specified similarities and differences.
3. How will the teacher know when he demonstrates this ability: The student will discuss or write about at least six similarities and/or differences. The teacher will listen to the tape or will read the essay to determine if the student is successful in making the comparison.

4. Degree of success: The student will describe at least six of the similarities or differences with at least 70 percent accuracy.

The parts of the objective were next structured into a whole and became the second behavioral objective: "The student will view the processes, forces, and related features involved in the evolution of Hogtown Creek and will view slides of the Grand Canyon and the Colorado River. The student will then describe orally on tape or in essay form at least six of the similarities or differences between the processes, forces, and features characteristic of these two great valleys with at least 70 percent accuracy."

Both objectives offer two ways for identification of the student's achievement level. The method of identification must be determined by each individual teacher on the basis of his own student population and its needs. A ninth grader with a reading level of 4.2, for example, cannot, fairly and honestly, be expected to write an essay as a demonstration of his competence in making observations. In the evaluation process, the teacher must always strive to measure the student's achievement exactly relative to the objective as it is stated. If <u>correct spelling</u> of "meander" is part of the objective, a student's recording the feature as a "mianter" is not acceptable. If <u>identification</u> of this feature is the objective, the student's ability to spell the word correctly should not be considered in the evaluation. It is certainly desirable to move the student forward in all areas of his intellectual growth and development, however, and correct spelling should be encouraged continually. Since one of the purposes of the behavioral objective is to make clear to the student what is expected of him, what is expected must be specified in the objective if it is to be of any value either to the student or the teacher.

The last objective developed in the field guide was aimed at the affective domain. This domain refers to values, attitudes, feelings, and appreciations. The observable behaviors in this domain are open to interpretation; hence, the teacher must make inferences from the observed behavior. Further, objectives in this domain do not necessarily relate specifically to any one of the primary objectives. Rather, it simply seeks to identify positive behaviors exhibited by students. Since students in the study were not aware of this objective, they were not biased by their desire to meet a specific objective.

The objective reads: "The student will demonstrate a positive attitude by making positive oral contributions in the form of questions and comments at least once during any discussion occurring during the field study." In the evaluation of this objective, the teacher used a checklist. The names of the students were recorded as they participated in the discussions, made comments, or participated in the activities in some way not characteristic of their previously observed behavior. Some students who participated through voluntary comments and questions were exhibiting a unique behavior for those particular students. In the informal, relaxed atmosphere of the outdoor study, students who never contributed voluntarily in the classroom became actively involved.

Such evaluations may result from conversations at lunch breaks or rest stops as well as during the study. Two students who had been discipline problems in the classroom performed on an acceptable basis in the field. One commented, "This ain't boring at all; we thought it would be different and no fun. Can we do this again?" On a later field trip these two students did more than their share in carrying equipment and successfully completing their quantitative measurements. By the end of the third field trip, these boys were able to tease and be teased; good rapport developed between them, the class, and the teacher; and they completed all of their designated tasks. Other students showed a positive attitude about school activities in general. These examples are given to emphasize to the teacher that open-mindedness and flexibility are mandatory when dealing with the evaluation of objectives in the affective domain. It also points out that the evaluation must be made by the teacher who knows the students.

The implication of affective objectives to the teacher is fairly clear. These serve to alert the teacher to ways and means of arousing the curiosity of students, of getting them involved, and for developing materials and techniques to meet the individual needs of students, particularly those who tend to be reluctant about learning.

Both the goals and the objectives were presented to the evaluation group as part of the initial field guide. The goals and objectives were revised in response to the individual evaluator's suggestions and are presented next in their revised form.

PRIMARY GOALS:

1. To develop in the student an awareness of the universality of the natural forces and processes through which the earth's topographic features have evolved;

2. To carry the student out of the confining classroom and into direct empirical and quantitative observations of natural and physical phenomena at work in shaping the earth's surface;

3. To emphasize science as a process of inquiry by providing the opportunity for the student to observe, collect and process data, and make interpretations;

4. To develop an understanding and concern for the natural habitat in order to involve the student in the perpetuation of a quality environment.

BEHAVIORAL OBJECTIVES:

1. When the student completes his observations of the erosional and depositional features of Hogtown Creek, he will identify similar features from slides with at least 70 percent accuracy.

2. The student will view the processes and forces involved in the evolution of Hogtown Creek and will view slides of the Colorado River and the Grand Canyon. The student will then describe orally or in written form the similarities and differences between the processes and forces shaping these two valleys with at least 70 percent accuracy.

3. During the field trip the student will demonstrate at least once his ability to manipulate the various instruments by measuring gradient, velocity, and cross-sectional area. His data will agree within a selected tolerance of the instructor's data for each activity (20 percent tolerance for gradient, 10 percent tolerance for area, and 5 percent tolerance for velocity).

4. The student will demonstrate his ability to interpret data on gradient, velocity, discharge rate, and cross sectional area either in a taped oral discussion or by written assignment by correlating the quantitative measurements with the structural characteristics of the stream. He will do this with at least 70 percent accuracy.

5. The student will demonstrate his ability to evaluate his

observations and accumulated data by identifying at least two of the effects man has already had on the evolution of Hogtown Creek and by hypothesizing what one future effect of man's actions will be.

6. The student will interpret the conditions under which sediments were laid down after viewing depositional structures along the Creek. He will do this by examining a core sample of sediments in the laboratory and interpreting the relationships of the various types of sediments in the core in oral or written discussions.

7. The student will demonstrate a positive attitude by making positive vocal contributions in the form of questions or comments at least once during any discussion occurring during the field study.

The teacher is reminded that the seventh objective is an affective one and should not be included in handouts to students or called to their attention at any time. Awareness of this objective would in itself affect the students' behavior and should therefore be omitted from the field guide.

Development of the Activities

Once the objectives were stated and the students' behaviors or activities were stipulated, the teacher's task was to design activities for the classroom which would prepare students for successful participation in the field as well as the follow-up activities to apply the observations made in the field. In addition, any additional instruction needed prior to any student evaluation had to be planned.

Some of the questions for the teacher to consider when planning appropriate activities are illustrated by the following:

1. What skills should the learner develop prior to the field study?
2. What classroom activities may relate to developing these necessary skills?
3. What aids are necessary for the in-field study?
4. How may the level of achievement be evaluated to the best advantage of the student?
5. What follow-up activities will be needed to extend the learning experiences of the field activity?

In order that teachers may observe the methods and techniques used in meeting the objectives in this study, activities related to the first four behavioral objectives as stated previously are presented. The first and second behavioral objective requires that the student make and interpret his observations of Hogtown Creek and then relate these to the structures and features associated with the Colorado River. It was assumed that few students have had previous opportunities to participate in such an activity. Reading levels in the class ranged from fourth grade to twelfth grade. Achievement levels indicated a comparable range. These classifications, along with the lack of experience, were considered in all phases of the development of the related activities.

The classroom introduction to this kind of activity may be approached in several ways. In the process of this study, slides from various regions were used, and students were asked to view and then to write observations, pointing out all interrelationships they could. The procedure may include the presentation of a view of a youthful river in which both rapids and waterfalls are present. The valleys are steep sided indicating that the river's primary function at the moment is one of down-cutting rather than lateral erosion. The rapids indicate the same function. Waterfalls indicate that there has been a change in the rock structure and composition in the area over which the stream is flowing. A steep gradient is indicated by the observed features. An estimation of the stream's competency may be based on the same observations.

Several other techniques may be used to emphasize and develop observational skills. The class may be asked to describe the dress of one of the students who is asked to leave the room. Each student may be given a soil sample and asked to observe the sample with a hand lens. Each may examine a flower in detail and record observations. Since the study specifically involves streams, students may be asked to observe a stream table in action. The features developed by the stream on the table are similar, although on a smaller scale, and may be altered by increasing or decreasing the gradient, the flow rate, or the stream bed. In this way, the student may learn to associate certain structures and features with the related stream dynamics.

Several "practice sessions" introduced students to the field activity and alerted the teacher to the needs of certain class members. In view of these needs an additional aid was structured for the actual field study. The investigator made one last pre-trip examination of the sites, noting specific features available for students observational activities. These were listed on an "observational record sheet" with space left for students' comments and were incorporated into the field guide. During the field trip itself, students used this as a guide as they participated in the empirical observational aspects.

Since this was one of the activities in which all participated, the following procedures were used in the field. Prior to beginning any quantitative studies, students and the teacher-guide surveyed the full length of each stream segment under study. This was done informally and slowly, involving such activities as small group discussions, individual assistance for students, careful examination of specific features, and calling attention to features which had not been presented during earlier investigations. In general, this procedure supplied students with an overview as well as background information about the Creek and its characteristics. It was, on a small scale, a "pre-trip investigation" of the site to be studied. Once this was accomplished, students proceeded with other activities.

The additional activity necessary to meet the second objective was related to the student's gaining some knowledge about the Colorado River. This, of course, was done vicariously and, in consideration of the range of reading abilities, was accomplished in various ways. The wide range of differences meant that information about the river had to be presented in ways which insured that all students were given the opportunity to achieve the second objective successfully. These are the ways information about the Colorado River was presented:

1. An advanced student from the tenth grade assumed responsibility for an in-depth study of the literature relating to the Colorado River and the Grand Canyon. The student then presented information orally and informally to the class in a lecture-discussion-question-answer experience. This was taped for use by anyone who desired to listen again.

2. A seventh grade core teacher who had vacationed along the Colorado River many times had a collection of colored slides of the area. These slides with his commentary were presented during a class session. The presentation was conducted slowly with both the teacher

and the visitor discussing, questioning, and commenting on each slide as it was presented.

3. The P. K. Yonge Learning Resource Center developed kits for the Colorado River study. Kits contained reading materials, film loops, film strips, maps, and documentary films.

Use of samples of the rocks and sediments of the area would have been valuable but were not available for this study. An effort will be made to secure representative samples prior to the next study involving Hogtown Creek and the Colorado River.

The student had now, in a sense, participated in two field trips--one first-hand and the second vicariously. Theoretically the class was now in a position to make the desired comparisons between the two stream systems.

The first objective stipulated that the students identify features from slides showing structures similar to those viewed at Hogtown Creek. The slides presented various rivers and stream systems in the United States and Canada. Students were given a set of guide questions, and background information was supplied orally with each slide as it was shown. The set of slides was made available for students to view individually if they desired, and their identifications could be oral (taped) or written.

Because of the need to minimize the reading and writing limitations of students, the evaluation of achievement of the second objective was made through one of the following procedures:

1. The student wrote a short essay discussing the similarities and differences between the two systems.
2. The teacher and student discussed the similarities and differences together.

3. The student chose to tape his conclusions by himself.

There are many additional and perhaps more efficient technique. These examples should serve only as a point of departure for individual teachers to adjust their evaluation methods to the individual needs of their students.

The third objective called for quantitative measurements and specified that students demonstrate manipulative skills in the use of various instruments. Several factors were considered: (1) students knew little or nothing relative to the concepts involving gravitational forces; (2) some students' mathematical skills were inadequate; and (3) the class was to produce its own instruments. These factors controlled the procedures the teacher used to develop the needed basic understandings before attending to the development of the equipment and the techniques for using the equipment.

Since two of the quantitative measures involved gravity, the initiating activity introduced some basic understandings about gravity and its effect on flowing water. Gravitational acceleration was introduced by using an inclined plane. Students were able to observe (but were not required to measure) that the farther the marble rolled down the inclined plane, the faster it was moving. The slope of the land was likened to the inclined plane and the water to the marble. The idea that the water surface was a plane surface essentially parallel to the surface of the stream bed was demonstrated by using a small homemade flume through which water was allowed to flow. An additional point emphasized was that gravity was moving the water downslope to the lowest level the water could reach under the circumstances. This was also demonstrated through the use of the stream table. The water sources were turned off after the elevation difference between the "lake level" at the one end of the table and the "spring head" at the other end of the table was determined. Students were then questioned about the effect of measuring the elevation between two points using the bottom of the stream bed rather than the water surface. Toothpicks were placed at two points, carefully selected by the teacher. One was placed at a spot where a deep hole had developed in the stream bed and the other at a point where a temporary base level had developed. As the variances in the gradient were noted, students were introduced to the necessity of using the water surface for determining the gradient. This was also emphasized in the classroom using two cardboard slopes--one smooth and one with similated potholes. Students could see that water flowing down such an uneven slope would present a relatively smooth surface and would give a more realistic and accurate measurement of the overall slope. A student constructed a small, glass-front box, similar to an ant farm, in which water may be viewed as it flows over an uneven surface.

Velocity was the second measure requiring some basic instructions. A marble rolled across the classroom floor introduced the relationship between distance and time. Allowing the marble to come to a dead stop and measuring the relationship between distance and time gave students the opportunity to note differences in velocity at different points in time. The concept of gravitational force was discussed as the force which produces the velocity in moving water, using the small flume into which water was poured while the flume was level and then when elevated. In addition, students could see that the marble eventually stopped its movement along the floor and could associate this with frictional force. Questioning led students to determine why water in streams does not continually accelerate as it moves down stream

The equilibrium existing between the gravitational force and the frictional forces was suggested but was not discussed in detail. Some questions were raised by students, some by the teacher, but no conclusions were drawn prior to completion of the study. Questions raised concerned such things as the effect of the shape of the stream channel, the volume of the water, and the effect of the curves in the stream on the velocity of the water. The mathematics department was asked to review and extend the students' skills in the manipulation of velocity relationships and in computing areas and volumes since many of the questions raised by the students suggested a weakness in these skill areas.

The students and the teacher were now able to concentrate on the development of the needed instruments. Although the school has alidades and a surveyor's transit, part of the study called for students to develop simple but usable instruments. The investigator and two volunteer students who showed some interest in this aspect of the study began working on a gradient instrument. Because of the nature of the creek and the anticipated sophistication of the instruments, the linear distance over which the gradient would be measured was predetermined at 50 feet. If lenses had been incorporated into the instrument, for example, additional time would have been required to introduce the necessary information concerning lenses and light characteristics.

Every effort was made to keep the construction of this instrument simple and inexpensive. The materials included a metal tube, some thread, two small wooden strips, scrap metal pipe, nuts and bolts, and two line levels. The greatest difficulty arose in aligning cross hairs at each end of the tube for sighting. This was done by arbitrarily selecting a point on the circumference at one end and determing the corresponding point on the other end with a plumb bob. After this was accomplished, the other three points (90° apart) were marked off at both ends and the cross hairs attached. A line level was attached to the tube (Figure 5) in order that the tube could be sighted level. The tube was then attached to a length of pipe for support in such a way that the tube could be adjusted into a horizontal position. In order to be certain that the pipe maintained a vertical position, small flat washers were used as plumb bobs since no circular level was available. These were crude methods of levelling, but the materials were available at little or no cost.

While two students worked on this instrument, others worked on producing floats of different densities. These were produced by loading fishing floats with lead weights and were used quite effectively in measuring velocities where the water was relatively deep. In extremely shallow areas the old "leaf on the water" method was used and proved satisfactory also. The investigator preferred the float method where possible because it involved the students with the concept of different densities.

The cross-sectional area materials were even more simple than the preceding materials. A calibrated piece of twine was stretched across the Creek right at the water level. The string was calibrated in six-inch units to record the depth of the stream for every six inches along the string (Figure 6). Students calibrated the string using permanent ink to mark each foot interval in blue and each half-foot in red. The depth was measured with a meter stick to which a plastic coffee lid was attached, preventing its sinking into the soft bottom of the stream bed.

Although a chalk line was used to measure the linear distance between the instrument man and the rod for the gradient measure, an additional method was needed to measure the actual flow distance of the Creek. A student suggested pacing the Creek, but this was discarded when the rest of the group decided that he could not make each pace the same distance. The idea of using a bicycle wheel was then presented by a student. Upon its acceptance two students volunteered for this project. A starting point was marked on the wheel donated by a student. The circumference was determined, and the spokes were used to calibrate the rest of the wheel. Students pushed the wheel up the middle of the Creek from the rod man to the instrument man and recorded the actual flow distance.

Two additional pieces of equipment needed were the "rod" for the gradient measurement and a stop watch for the velocity activity. Students calibrated the rod, and the physical education department volunteered the use of a stop watch. This completed the list of the instruments needed for the study.

By the day of the field trip, the class members had practiced using the gradient instruments, the bicycle wheel, and the stop watch. The cross-sectional area project had been practiced on the chalkboard. A simulated stream channel was drawn on the black board and a string attached to represent the water level. The depth of water under the string was then determined (Figure 6) and the area was computed.

Data collected on the field study were recorded on the appropriate sheet in the students' field guides. Students were encouraged to record their data in the field even though they were not actually involved in the measurements at each site. The importance of accurate and complete records was continually emphasized.

Upon return to the classroom, data were shared with the students who had been unable to record in the field. Then each student computed the gradient over the 50-foot linear distance. The average velocity of the water was computed for the three sites investigated. Students computed the cross-sectional area using mathematical skills in finding areas of rectangles and triangles. In addition, two students were asked to plot a scaled diagram of the measured area on a piece of graph paper. The mass of the entire paper was determined; the stream-bed profile was cut out of the sheet and its mass determined. Students then calculated the cross-sectional area of the stream using the following relationship. Mass of the paper (total): Area of the paper (total) = Mass of the profile: Area of the profile. The class results were nearly identical with the results obtained by the two students with the scale. The major difference was the length of time required to calculate the area. Others in the class chose to duplicate their efforts and calculated the area both ways.

Computation of the discharge rate required additional instruction because it was difficult for students. A calibrated burette aided in teaching this relationship. The burette was filled with water and the rate with which it emptied was demonstrated and calculated. Students calculated discharge rate using the cross-sectional area and the distance the level of the liquid lowered over a given time. Since the burette was calibrated, their calculations were easily checked. Following this activity, students moved to calculations related to the stream.

The fourth objective called for students to correlate data with characteristics of the stream channel. Several students asked to revisit each site as they worked on this activity. Since this was physically impractical, the slides of each of the sites were made available.

Through vicariously revisiting they not only saw the pictures but could hear, in memory, the rush of water down the canyon or the slow drip of spring water from the contact between the clay and the overlying sands.

These activities serve only as suggestions. They were satisfactory for the investigator, the teacher, and the students of this particular class. They might not be as satisfactory for another teacher at a different time with a different set of students. How successfully the students performed under these circumstances with each activity served as a basis for revision or extension of each activity by the instructor. The teacher is reminded that to reach the educational intent is the primary objective. This can only be achieved successfully if the proper vehicle, the appropriate fuel, and the most effective routes are provided for the participants on such an educational journey.