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Engineering Field Notes

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Engineering Technical Information System

1994 *Engineering Field Notes* Article Awards

It is that time of year again. Time for you (our readers) to tell us which 1994 articles you feel were most informative, beneficial, and interesting; which articles helped your office save money; and which articles helped you develop more effective ways of accomplishing your work.

Although only three volumes were issued in 1994, the quality and diversity of the articles did not diminish. We shared information in many different fields, including geometronics, ecosystem roads management, facilities and the structures, and geotextiles. *Engineering Field Notes* continues to provide a means for Forest Service engineers at all levels and in all Regions to share their experiences. We feel that this sharing is vital, and we applaud each of our authors.

Once you have chosen 1994's top three articles, please complete the rating sheet on the following page. Rate only three articles from 1 (best) to 2 (second best) to 3 (third best). If you feel that an article has helped or will help the Forest Service save money or other resources, please let us know. Remember, with *Engineering Field Notes* it is one person, one vote—so your vote counts!

After you have voted, cut out the rating sheet along the dotted line, fold it and staple it closed, and mail it back to us at *Engineering Field Notes.* For your vote to count, we must receive you rating sheet by May 1, 1995.

Contests aside, we would like to thank each and every *Engineering Field Notes* author, as well as all of our readers who made 1994 a great year. Each one of you deserves our thanks for helping to foster an environment where information and experiences are viewed as valuable resources and are shared accordingly.

We would also like to take this opportunity to encourage you to start thinking of an *Engineering Field Notes* article for 1995. Why not share your experiences through *Engineering Field Notes* in 1995?

1994 *Engineering Field Notes* Awards

ARTICLE	AUTHOR	CHOICE (1, 2, 3)	$ SAVED
January-April			
"Interagency Agreement between the USGS and FS for the Production and Maintenance of a Single-Edition Primary Series Quadrangle Map"	André J. Coisman	—	—
"The Lasersoft Revolution"	Jeff E. Moll	—	—
"Licensing Requirement of Federal Engineers"	John L. Zirkle	—	—
"Road Closure and Obliteration Project"	Jeff E. Moll	—	—
May-August			
"Deep Creek Low Water Crossing Osceola National Forest"	Bill Webb	—	—
"Erosion Control/Trout Habitat Structures"	Tracey Guerin	—	—
"Excavators for Site Preparation"	Dick Karsky	—	—
"Field Application and Review of Hand-held Laser Survey Instrument; Grand Mesa, Uncompahgre, and Gunnison National Forests, Gunnison Engineering Zone"	Gordon W. Griswold	—	—
"Solid/Semi-Solid/Liquid Ignition Devices"	David Dieziger, Jerry Jeffries, Paul Evenson, and Jim Tour	—	—
"The Thin Mud Timber Sale Chip and Spread Project"	Phillip Archibald and Jeff E. Moll	—	—
September-December			
"Burgess Junction Visitor Center"	Lexie Benson	—	—
"Flower Pot Wall"	John Mohney and Bill Powell	—	—
"Partnering: The Future Ain't What It Used to Be"	Jerry Coleman	—	—
"Road Closure and Obliteration Project, Project Submissions to Date"	Jeff E. Moll	—	—

TEAR ALONG THIS LINE →

COMMENTS: ____

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Name ______________________
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1994 Forest Service Engineers of the Year

Three outstanding individuals have been selected as the 1994 Engineers of the Year. The winner of the management category is William P. Lisowsky from the Arapahoe and Roosevelt National Forest in Region 2. Dr. Rajai H. Atalla, of the Forest Products Laboratory, is the winner in the technical category. The Technician of the Year is Paul R. Cole from the Plumas National Forest in Region 5. Congratulations to each of our 1994 winners!

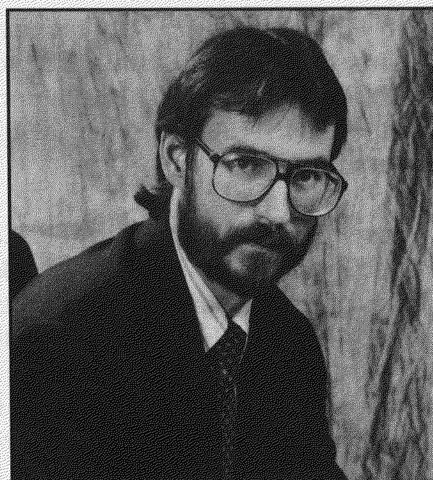
In recognition of their achievements, the Director of Engineering will present each a special plaque and cash award at the ceremony in Washington, DC, on April 12, 1995. A brief summary of their individual accomplishments and a photo of each winner is included in this article.

These outstanding individuals were selected from an excellent list of nominees from the National Forest System and Research. Finalists in all of the categories included:

Management	*Technical*	*Technician*
Roy Grant	Curtis Glasoe	Butch Selway
Lou Liebbrand	Dr. Bill Krausmann	Doyle Ashby
Ted Fitzgerald	Randy Tate	Pablo Chavez
Bob Bader	Jess Bengoa	Frank Hurta
Douglas B. Macdonald	Stephen P. Sichau	Bill Keith
Ruben Natera	Ronald Cornell	John Dillingham
Steven Oravetz	Jeff Moll	Leroy Drittler
Michael Ritter		Thomas J. Sanders
		Paul Buell
		Victor Hager
		John Hillis

William P. Lisowsky

Engineering Manager of the Year



As the Forest Engineer on the Arapaho and Roosevelt National Forests and Pawnee National Grassland (ARNF/PNG), Bill has been recognized for providing quality leadership in a variety of areas. His ability to effectively manage personnel and programs on his Forest has been acknowledged by his performance appraisal ratings of superior and outstanding; his outstanding interdisciplinary support to Ranger Districts and the Forest has been recognized with a Certificate of Merit from Forest Leadership Team peers; and he has been nominated for a Supervisor Award for Women's Equality Day from the Department of Agriculture.

Bill has been proactive in the development of many forestwide program initiatives and partnerships. He has served on many interdisciplinary teams, often as the team leader. Examples of the areas in which Bill has proven his technical leadership skills include:

- He helped develop project management teams with engineering, recreation, and other specialty personnel at both the supervisor's office and at the District level. His efforts have led the ARNF/PNG to complete over $10 million in facility improvements and capital investments in the past three construction seasons, and a sustained construction and maintenance program. Many of these processes, standard designs, and prototype programs have been shared and adopted by other units regionally and nationally.

- His ability to work closely with District Rangers and technical staffs has greatly improved the overall products and aided efforts to implement ecosystem management. Bill has demonstrated outstanding leadership in the ARNF/PNG forest planning and travel management efforts. Under his guidance, Recreation and Engineering have teamed to move closer to truly providing "customer service" while protecting resource values.

- Bill has started reorganizing the lands program with a team concept. Decisionmaking, recommendations, and evaluations will be done in a boundaryless fashion by an overall forest and grassland lands team composed of all lands personnel.

- Using a combination of interagency, interregional, and in-house design centers and contract administration, Bill has provided leadership in the completion of an incredible amount of hazardous material removal, water system upgrades, and other infrastructure construction and rehabilitation work.

- His ability to work closely with city managers and engineers, county commissioners, and State agency directors is displayed by the successful development of $1 million of partnership projects and $1.5 million of ISTEA and Federal Highway Administration (FHWA) projects.

- Bill is an active member of the ARNF/PNG Leadership Team, a member of the Forest Plan Revision Interdisciplinary Team (IDT), and a member of the Regional Continuous Improvement Process (CIP) Evaluation Team. He also provides technical support to three major ski areas. Bill is active in fire suppression efforts. He has participated on project fires as an incident command unit leader or section chief in 6 of the last 10 years.

Bill has also developed and supported human resource related programs. Examples of the areas in which Bill has proven his managerial leadership skills follow.

- During the past 3 years, Bill has assisted in the development of a forestwide accessibility committee, served as the leadership team advocate for the program, and recruited and hired outstanding, physically challenged individuals.

- Bill strongly supports work force diversity. Ten of the 15 employees who have joined Bill's staff in recent years have been women, minority, or physically challenged. Bill's nomination for the Supervisor's Award for Women's Equality Day by those who work with him is a good example of his commitment to his employees.

- He is a leader in providing an environment for balancing careers and personal needs. Bill promotes open communications and a safe working environment for all employees. He uses a variety of ways to make information available to all employees and foster better personal relationships, including team workdays, afterhour get-togethers, brown bag lunches, and other information sharing meetings.

- Bill is a strong supporter of career growth and enhancement. During the last 5 years, seven engineers under his supervision have taken and passed either the Engineer in Training (EIT) or Principal Engineer (PE) exams. Two-thirds of the 15 employees in his support group have taken college-level courses related to their job or development. Bill has also attended many CEU credit engineering training sessions and completed college correspondence courses in related resource management areas.

- Bill has been a key member in development of the Rocky Mountain Regional Leadership Team reinvention effort.

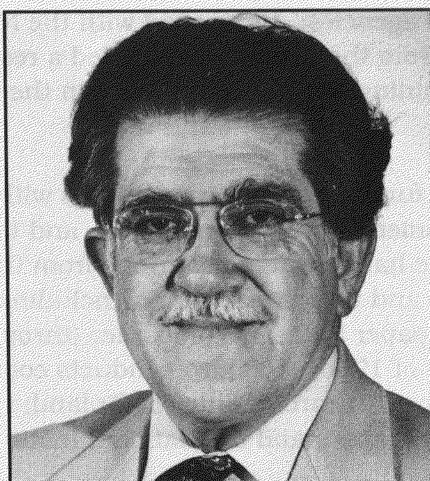
- He was the regional representative to the 1993 National Engineering and Recreation Budget Meeting.

Bill has also demonstrated his leadership ability by being active in his community. He has served as coach, school board member, volunteer, committee chair, and advisory committee member for many organizations. These include the YMCA, St. Johns School, Cub Scouts of America, U.S. Fish and Wildlife Service Breeding Bird Survey, Colorado State Bird Records Committee, and the Colorado Field Orinthologists Regional Compiler for Northern Colorado.

Bill Lisowsky has proven his ability to provide excellent leadership in technical, managerial, and personal areas of his life. A quote from one of his fellow employees best describes Bill's capabilities, "Bill is respected throughout the Rocky Mountain Region for his professional engineering expertise; but most of all his sensitivity to others' rights, his sense of humor, and his friendship."

Dr. Rajai H. Atalla

Technical Engineer of the Year



As the project leader for the Chemistry and Pulping Research work unit at the Forest Products Laboratory (FPL), Dr. Rajai (Raj) Atalla has been recognized for providing quality technical leadership.

His contributions in engineering research have been acknowledged by his superior performance appraisal ratings, Certificates of Merit and Performance Awards, and elections to fellowships. In 1993, Raj was elected a fellow of the Technical Association of the Pulp and Paper Industry (TAPPI). Election as a fellow is the highest honor that TAPPI bestows upon a member for scientific and technical achievement. In 1992, Raj was elected a fellow of the International Academy of Wood Science (IAWS). This honor is reserved for individuals who have achieved distinction for scientific contributions in wood science and utilization. Raj also has the distinction of being an adjunct professor at two prestigious academic and engineering research institutions: the University of Wisconsin-Madison and the Institute of Paper Science and Technology.

Raj has made many contributions in developing new technologies. By combining state-of-the-art knowledge of wood chemistry and chemical engineering science, Raj has developed process technologies that conserve forest and water resources and avoid adverse effects on air quality and the global ecosystem. Examples of the process technologies that Raj has been involved with include:

- He used Raman spectroscopy and solid-state nuclear magnetic resonance to study the basic cell wall morphology and chemistry of wood and pulp fiber.

- He discovered and demonstrated that the crystalline domains in native cellulose are composites of two different crystalline forms.

- He demonstrated that lignin within the wood fiber cell wall is more highly organized than had been previously recognized. Results of this research contributed to subsequent work that showed that pathways for electronic charge transfer occur in lignin in the native cell wall of wood.

- As the leader of a team, Raj developed a whole new chemistry for pulping and bleaching wood. A patent for polyoxometalate technology was awarded to the FPL in 1994 as a result of his research in this area.

Raj has also been very resourceful in forming partnerships and cooperating with outside agencies. He worked with the National Cancer Institute to collect taxol from the Pacific yew. He led a research program that was aimed at determining the amount of taxol in the heartwood of this species.

He has received funds through partnerships with the Department of Energy, Environmental Protection Agency, and the Bureau of Engraving and Printing. He has also received funds from the USDA Competitive Grants Program and the private sector, including a consortium of six major pulp and paper industry companies (through use of the Technology Transfer Act of 1986). Raj also conducts cooperative research with VTT, the Technical Research Center of Finland; the School of Forestry at Tokyo University, Japan; and the National Institute of Science and Technology.

He is a member of the American Chemical Society, the American Association for the Advancement of Science, Sigma Xi, the International Academy of Wood Science, Tau Beta Pi, and TAPPI. He has been a cochair of the symposium on Biogenesis and Structure of Cellulosic Fibers for the International Dissolving Pulp Conference, chairman for the Symposium on the Structure of Cellulose for the American Chemical Society; and chairman of the Gordon Conference on Chemicals and Materials for Renewable Resources.

Raj has authored or coauthored more than 80 scientific publications, presented 29 invited research papers, and provided consultations to the industrial technical staffs of a variety of pulp, paper, and allied field companies. He has also provided consultations to the Library of Congress, the Polytechnic Institute of Milan (Italy), CERMAV of Grenoble (France), Helsinki University (Norway), and Hokkaido University (Japan).

Raj Attala has demonstrated his ability to be a leader in engineering research, not only through his achievements at work and in outside organizations, but also by contributing to the academic community. Raj serves as a thesis advisor for graduate students at the University of Wisconsin and the Institute of Paper Science and Technology. He has also started cooperative activities with Clark Atlanta University, a historically black university in Georgia. Raj is working with graduate and undergraduate chemistry students to help attract them to research related to pulp and paper. He has demonstrated a commitment to current and future engineering research.

Paul R. Cole, Jr.

Engineering Technician of the Year

Paul R. Cole provides technical expertise to the La Porte and Oroville Ranger Districts in a variety of areas. Demonstrations of the types of activities he is involved with include:

- Paul developed the plans and specifications and administered the contract for a slip-in water tank that could be utilized with 10-yard dump trucks.

- He developed specifications and contracted for completion of road inventories on the La Porte and Oroville Ranger Districts.

- He researched and implemented the use of computerized traffic count analyzers for the La Porte and Oroville Ranger Districts. The counters are used in cooperation with law enforcement in establishing illegal forest product haul during night hours.

- Paul worked with the unit's Working Capital Fund (WCF) mechanic to develop a tool used for checking the adjustment of a truck's air brakes.

Paul has also provided leadership through technical means. He maintained contacts with the Driver's Safety Council and continued a driver's training program until the national program was reinstated. He facilitates an annual meeting of forest engineering personnel to review job hazard analyses. In order to improve the efficiency and effectiveness within engineering, Paul requested and was granted purchasing authority. This streamlined the processing of small purchases and freed up other purchasing agents to provide increased service to other functional areas. Other examples include:

- He provides contract administration support for roads, facilities, and special projects. He is certified in all engineering construct areas except water and wastewater.

- Paul manages the road maintenance and cost share programs and coordinates annual maintenance plans with three major cooperators.

- Paul coordinates required surveys and site surveys for maintenance projects, including rights-of-way and structure replacements.

- He is the sign program coordinator and provides technical support in developing sign plans for recreational facilities and coordinates sign purchase and installation.

- Paul coordinates maintenance activities and special projects with District and supervisor's office specialists. Paul's crews are currently working to reestablish a wetland site near Bucks Lake.

- The Oroville Ranger District also requested that Paul provide technical advice during the construction of the transportation network for the Grizzly Powerhouse Project.

Paul has been able to achieve considerable results in force account programs with which he has been involved. These include:

- Under Paul's direction, a new forestwide trails inventory and accounting system was developed and implemented. He also planned, designed, and constructed improvement at the Plumas' Feather Falls (sixth highest falls in the United States) trailhead. Paul was instrumental in coordinating the survey and design for over 4 miles of new trail, parking lot expansion and paving, campsite construction, utility installations, and construction of barrier-free restrooms.

- He is improving and upgrading the water systems by making his road maintenance crews available for water tank erections, waterline installations, and collection gallery developments.

- Paul prepares the specifications, contract clauses, and schedules for delivery and use, and administers equipment rental contracts.

Paul has also proven his ability to work effectively with others. He coordinated with the FHWA during planning and construction on Forest Highway 119. This project required him to work closely with representatives from the Butte County Engineering Department, representatives from Plumas County, California Transportation Department personnel, and private landowners. He also worked with the forest archaeologist and the FHWA engineers to identify prehistoric sites and establish methods to protect these sites during construction.

Paul strongly believes that individuals make a difference in the community. He is very active in his church and makes contributions to it by using his skills as a certified locksmith and a certified asbestos maintenance worker. He is active in the Youth Soccer Club; teaches two classes, "Orienteering" and "How Trees Grow," to fourth- and sixth-grade students; formed ties with Laotian, Vietnamese, and Romanian families living in the community; and has been involved with the International Student Exchange program and hosted a Bolivian student.

Paul Cole's commitment to accomplishing new projects has been completed in addition to his regular program of work. He is responsible for contract and maintenance work on two districts, including 1,400 miles of road maintenance and other wildlife and watershed projects. Paul has proven his ability to provide excellent leadership and support in technical, managerial, and personal areas of his life.

Solving Dry Problems with Geotextiles

Paul Standing, Civil Engineering Technician
Steve Jenner, Recreation Technician
Peaks Ranger District
Coconino National Forest, Region 3

Reviewer's Note

This project demonstrates the benefits of innovation and modification of standard practices to meet local conditions. Most notable to the paper's reviewers are:

1. Construction during winter conditions utilizes available moisture in the native soils and avoids summer recreation use. Normally, the practice of ripping frozen ground and compacting is not recommended because it is highly probable that frozen material will be incorporated into the work which, when thawed, may leave soft spots.

2. The weight and strength of the geotextile was increased to withstand expected construction operations. This was then field-tested to ensure expected results.

Richard A. Kennedy
Technical Reviewer

Introduction

This project involved a different application of geotextiles. Normally, geotextiles are used to address problems with wet ground conditions. This project addressed dry ground problems. Loose, dry cinders (an uncemented, glassy, lightweight volcanic soil), which make up most of the soils in the project area, are difficult to drive in during the summer, which is the season of highest use.

Background

The "Cinder Hills" is a separate management area on the Coconino National Forest (NF) 10 miles northeast of Flagstaff, Arizona. This 122,560-acre area is unique among southwestern forests. Created by massive, recent volcanic activity around the San Francisco Mountains, this area with its loose cinders and tall cinder cones, provides a challenging offroad experience. The area has been in use by off-road enthusiasts for the past 30 years. NASA used a part of the area to train astronauts in the 1960's because of its moon-like surface. As a result, 13,500 acres have been set aside and are being managed for off-road vehicles. This is one of only a handful of off-road designated areas in the State of Arizona. During holiday weekends, several thousand people use the area, with the usage growing every year.

Problem

The very conditions that give the greatest challenge to off-roading also create the greatest headache for access to and through the area. The season of greatest use is summer, when the cinders are at their driest. Getting stuck was the norm. Travel was mostly restricted to the one or two routes that had achieved moderate compaction through the years. The area's usage has grown each year, and the most common vehicle has changed from pickups to large motor homes pulling trailers. The roadbed and the surrounding ground were at the same elevation (see photo 1) and it was often difficult to tell where the road was (see photos 2 and 3), especially after a windstorm. Dry cinders are difficult to blade and shape, and tend to lose their shape very quickly. With the change in vehicles and the increased use of the area, a well-defined roadbed with an easily maintained, compactable surface was required.

Solution

A decision was made to construct a turnpike section with ditches on both sides. Turnpiking would define the roadway and help raise the roadbed above the surrounding ground. It was also decided to add an additional 6 inches of pit run material, consisting of a gravel/pumice material with clay fines, to further raise the roadbed and provide a compactable, maintainable surface. Just placing the pit run over the cinders would not provide a long-term solution. The pit run would be pounded down into the cinders with the traffic. A woven geotextile was used as a separation layer between the pit run material and the cinders.

Construction

The only time that cinders can be effectively bladed and shaped is when they are wet. Hauling water is too expensive, so winter is the most economical time to work cinders. To save money, the project was constructed Force Account. The Forest construction and maintenance (C&M) crew and an adjacent Forest's C&M crew supplied the equipment and operators. Hand crews were District fire, recreation, and wildlife personnel. This meant taking time away from other work so the time available was shortened. The combination of winter-only work and reduced crew time meant that only a small amount of time was available in which to complete the project.

Normally, the method of placing material over geotextiles is by end-dumping and spreading. The length of the project and the time available ruled out this approach. The strength of the geotextile was increased over what was needed for separation so the project could be built by using a combination of end and belly dumps and driving over the fabric with the equipment. Prior to beginning the project, one roll of fabric was purchased and a test section was constructed. No major problems were noted, so we went ahead with the project. Pioneering, rough grading, placing the geotextile (see photo 4) and pit run (see photo 5) over 6 1/2 miles of road and twenty-two 60- by 120-ft. parking lots took only 3 months.

Procedure

The entire 6 1/2 miles was cleared, ripped, grid rolled, and rough graded prior to placing any geotextile. The dozer was needed at the pit to push the overburden for the loaders. Only one roll of fabric was laid out at a time. The pit run material was applied in one layer. Due to the moisture content, compaction was achieved with one layer by using the hauling and spreading equipment. Normally, the final blading occurred several days later. During the clearing operation, the trees were pushed whole and then cut into lengths. The tops, limbs, and stumps were hauled to an old pit, and the logs were sold. It was decided not to screen the overburden. All 2-inch plus rocks were hand-culled from the material onsite and piled next to the road (see photo 6). They were later hauled off the project to an old pit. This added some labor costs to the job, but the final results were worth it. The job looked very clean at completion.

Problems During Construction

The original plan was to pioneer with a motor grader. An ice layer about 2 inches thick, 3 to 6 inches under the surface, was encountered that the grader was unable to break up. A TD-20 dozer with a single ripper was used to break up the ice (see photo 7). Then a grid roller was pulled over the large ice chunks to break them down. Driving over the geotextile caused very few problems. The only tears were caused when the grader hooked the fabric with a corner of the blade or when a truck would spin its wheels.

Cinders dry out very fast. After a few days of no moisture, there would be soft spots. When the trucks hit these spots, the fabric would be pushed down, causing bunching.

The biggest problem in laying the fabric down was wind. Hand-shoveling of cinders along the entire edge was required to keep the fabric in place while spreading.

While winter was the best time to work the cinders, it was not the best time to work with the 6-inch material lift. The material was taken out of a stockpile of overburden from a pumice mine operation. It was at optimum moisture when the project was started, so very little moisture was needed to make it too wet to drive over. More time was lost because the plating material was either too wet to work with the grader or to drive over than because of any problems associated with the geotextile. Most of the time we were able to blade off the snow and keep working.

Outcome

The results were better than we had hoped (see photos 8, 9, and 10). Not only was the road surface drivable all summer, but the hills, which had 5–6 percent grades, had very little or no washboarding. There was no settlement due to failure of the fabric. Doing the project Force Account contributed to its success. Flexibility in dealing with the weather and unforeseen developments kept the costs down and allowed us to try different solutions without the hassle of contract modifications.

Technical

Fabric: Mirafi 600X, a woven geotextile with a grab tensile strength of 300 lbs. $0.42/sy F.O.B. Flagstaff.

Total cost: $314,000.

Equipment used: TD-20 Dozer, Cat 14 blade, three 20cy belly dumps, one 20cy end dump, and two 10cy end dumps.

Funding source: Off-Highway Recreation Fund Grant from the State of Arizona.

Summary

One year has passed since the project was completed. The outcome has met or exceeded expectations. No major change in construction procedures is needed. Some additional work will be needed on roadside drainage, and several soft spots in the pit run borrow should be removed. In all, this should take about 4 days. This use of geotextile should work in any dry soil types.

Photo 1.—Roadway before application of geotextile.

Photo 2.—A roadway before geotextile is applied.

Photo 3.—The "before" of a parking area.

Photo 4.—Laying out fabric on a parking lot.

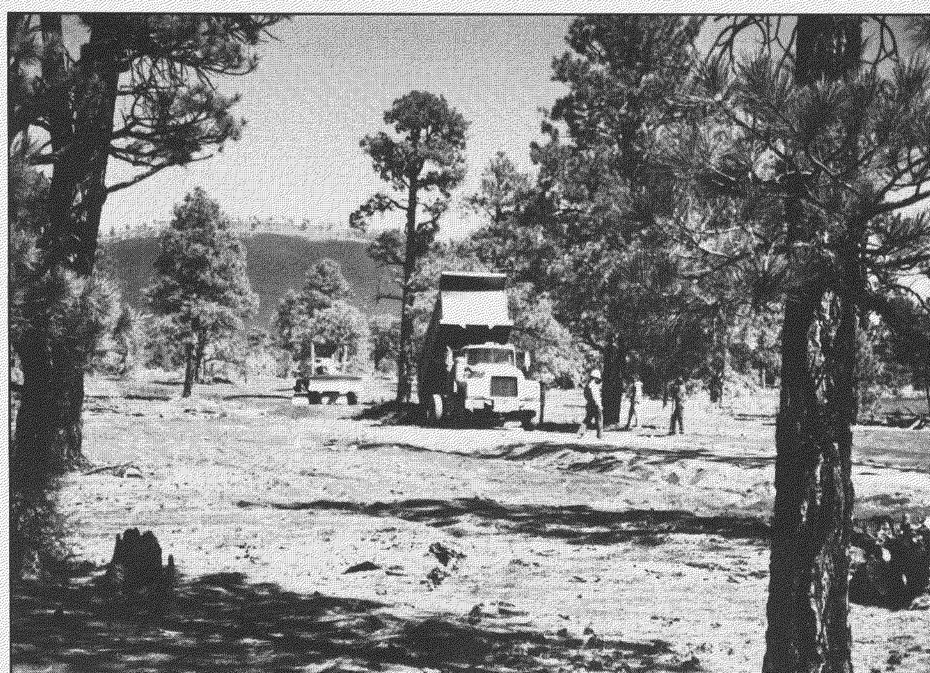


Photo 5.—Placing pit run borrow on the fabric.

Photo 6.—Hand cleanup of oversized rock in the pit run layer waiting to be hauled off.

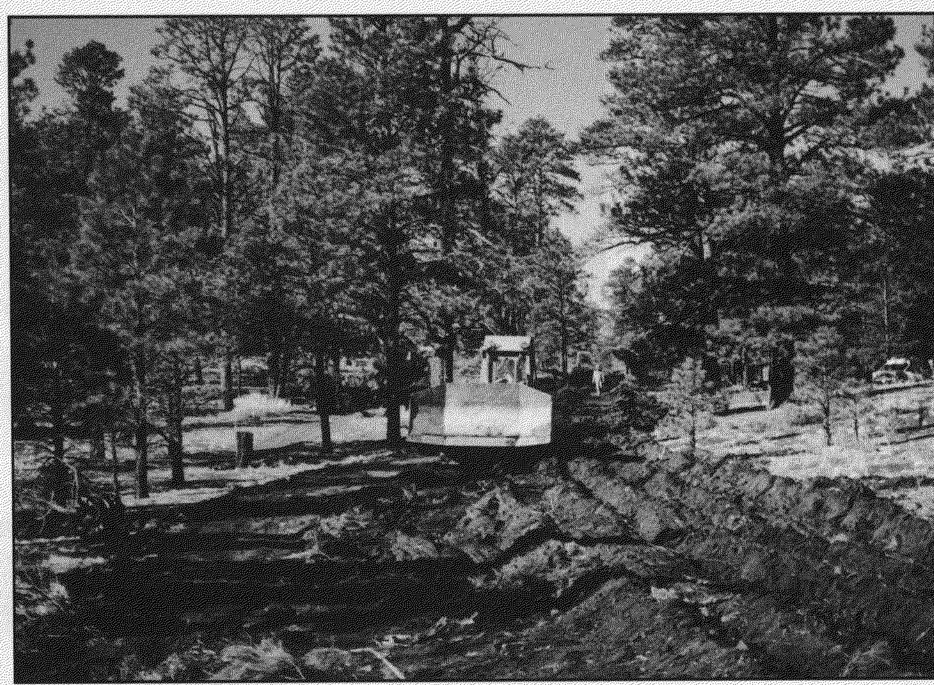


Photo 7.—Pioneering with a TD-20, ripping the ice layer.

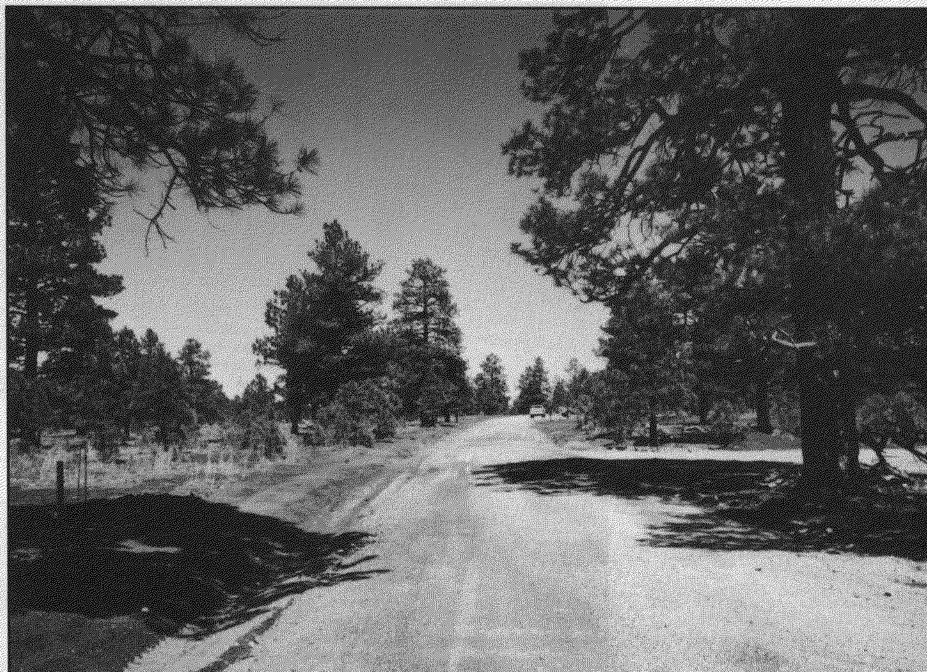


Photo 8.—The same roadway in photo 2 after geotextile is applied.

Photo 9.—Roadway in photo 1 after application of geotextile.

Photo 10.—The "after" of a parking area.

The Spelunker's Delight: Cave Surveying Made Easy

Jeffry E. Moll, P.E.
Roads Project Leader
San Dimas Technology and Development Center

Michael Harrison
Cave Technician
Guadalupe Ranger District, Lincoln National Forest

Ransom Turner
Cave Specialist
Guadalupe Ranger District, Lincoln National Forest

Warren F. Sutton
Civil Engineer
Cibola National Forest

Introduction

The purpose of this report is to document results of a laser system survey of Cottonwood Cave, one of over 110 known caves on the Guadalupe Ranger District of the Lincoln National Forest (NF). Illustrated are laser system capabilities and the potential for automated manipulation of resulting data into resource cataloguing, monitoring tools, and improvements designed to aid cave management. Cave resources exist the world over; the location for this trial of the laser system was chosen based on accessibility and the willingness of district personnel to try new technologies. Caves are discussed against the backdrop of the Guadalupe Ranger District, as it has been instrumental in developing Forest Service cave management programs.

No permanent benchmarks were established during the survey; it was intended for test purposes only and not to officially map the cave or provide the basis for design of improvements. The effort was made mainly to test the underground performance of the laser instrument, to aid in developing cave surveying methodologies, and to experiment with the automated reduction and manipulation of resulting data.

The test and subsequent manipulation of data met expectations. The laser system is useful for mapping, and data can provide the basis for design of improvements, assist in monitoring cave rescues, and developing trending information. Futuristic applications include computer-aided virtual reality trips into caves.

The report provides background information on caves in the Guadalupe Mountains, cave surveys, specifics on the Cottonwood Cave survey, and recommendations for planning and performing cave surveys. An appendix contains a discussion of difficulties to be expected when surveying caves, details of a survey routine developed for caves in which the instrument compass fails to function properly, and information concerning manipulation of cave survey data.

Background

Caves exist on Federal, State, and private lands across the country and on every continent. The Lincoln NF has remarkable and important cave resources; indeed, visitors and scientists come from the world over to explore, study, and enjoy these caverns in the exposed Permian-age reef. The nonrenewable resources are extremely fragile; the rising popularity of spelunking and scientific interest have increased the potential for damage. The Federal Cave Resources Protection Act mandates Federal Agencies to secure, protect, and preserve significant caves on Federal lands for the perpetual use, enjoyment, and benefit of all people. This involves management designed to preserve the delicate balance between natural undisturbed ecosystems, recreation, research, and use of surface areas above caves.

Description of Caves on the Guadalupe Ranger District

Caves on the district contain undisturbed significant world class formations, depositions, and speleothems of rare form, size, and beauty. The caves are relatively dry, although humidity in deeper caves is normally 99 percent, allowing many actively growing speleothems; known caves contain pools, but none have running streams. Rooms vary in size; some exceed 100 meters in diameter, some have ceiling heights of 60 meters, and some contain vertical pits over 100 meters deep. Surveys reveal some caves are made up of several kilometers of passages. The development of many caves is joint-controlled; joints or fractures control water migration and solutional activities, allowing a unique geologic process in which hydrogen sulfide gases mix with ground water to dissolve huge chambers in limestone.

Cave Resources of the Guadalupe Ranger District

The caves exhibit prehistoric and historic use, fossils, bat hibernacula and nurseries, solutional formations, sediments, and other examples of hydrological, geological, and biological processes. Unique, nonrenewable geological formations and paleontological and biological resources, including a variety of rare and endangered plants and animals, exist in the caves. Wildlife and vegetation are found near entrances. Interiors support bats snakes, insects, and microorganisms. Isolated pools within unexplored passages probably contain invertebrate and microorganism populations that have been undisturbed for thousands of years. Pristine cave ecosystems provide unique opportunities for scientific research; it is necessary to prevent disturbance or destruction by contaminants brought in by explorers or resulting from surface activities.

Faunal remains that are thousands of years old are found in several caves; some are quite rare. One cave contains two complete skeletons; one of an extinct Pleistocene Jaguar (only a few specimens are known), and another of perhaps the most complete Pleistocene short-faced bear ever found. Many caves contain clay deposits rich with pollen and charcoal; stratified deposits that date back 30,000 years present an unparalleled record of past ecosystems, offer a unique opportunity for paleoecology study, and enable reconstruction of plant and animal communities that lived in and around the cave long ago.

Recreational Opportunities in Caves

Recreation constitutes the majority of use. Many spelunkers hike ridges on the district in the attempt to find new caves; some caves offer physical challenges not available anywhere else. The scenery around many caves is unsurpassed in the State, and caves on the Forest are among the most beautiful in the world.

Cave Management

In 1972, the District began the first Forest Service cave management program. It became clear that cave management prescriptions were necessary if delicate cave resources were to be preserved and protected from vandalism and unintentional damage caused by caving. Priorities included cave inventory and establishment of classifications for contents and hazards.

Cave Surveys

Surveys are a necessary part of a cave management program. Mapping and inventory are required for documenting physical attributes, while realizing that the extent of caves, their size and shape, and the composition and location of their various resources form the basis for management. Surveys provide information that is useful to visitors, including the length and grade of trails and the locations of points of interest along the way. Viewing cave survey plots can provide the flavor of spelunking to cave enthusiasts who are unable to physically tour caves. To active cavers, they are useful in determining which cave best deserves devotion of limited time and energy.

Methods used in the past for cave surveying mainly included the standard traverse and cross section routine that used cloth tapes, hand clinometers, and hand or staff compasses. This is probably the simplest routine used to document features along a strip or corridor. Higher precision instruments, such as engineering levels, transits, theodolites, and electronic distance measuring (EDM) devices, are used for higher order work. Distances to breaks and points of interest on walls and ceilings must be estimated when using conventional instruments, as these locations are inaccessible to head chainpersons or prism rodpersons. For example, the maximum ceiling to floor dimension in the main chamber of Cottonwood Cave was previously estimated at 27 meters (90 feet); the laser instrument measured the much greater distance of 53 meters (173 feet).

Past survey systems required head chainpersons or prism rodpersons to hike across the cave floor to walls, formations, or points of interest. The laser system functions with much less foot traffic, greatly reducing disturbances and irreversible impacts.

Cost information for past surveys is unavailable; extrapolation of information from road projects indicates possible savings of 59 to 75 percent (Moll, 1992) due to laser use for cave surveys (Griswold, 1994). Laser system economics and functionality make possible the completion of more individual cave surveys—within the same time and budget allowed for standard methods.

The Cottonwood Cave Survey

The instrument—the Laser Technology, Inc. (LTI), Criterion 400 Survey Laser—functioned well underground, making and downloading three-dimensional (3-D) measurements to the LASERSOFT survey management platform. The accuracy and precision of the laser exceeds that of hand instruments (Moll, 1992), providing data suitable for most applications. See figure 1 for the field hardware setup. Prior to the effort, it was uncertain how the instrument compass would perform in supplying azimuth measurements below ground.

LASERSOFT converts survey data into stacks of 3-D coordinates importable to computer-aided design (CAD) software, allowing plan, profile, cross-section, and perspective views to be constructed and contoured as shown in figure 2. At the time of the survey, no metric version of LASERSOFT existed; therefore, the plots shown in figure 2 are in feet rather than meters. LASERSOFT was created by LTI software engineers to manage laser surveys. It runs on certain handheld MS-DOS compatible date recorders and personal computers (PC's). The Corvallis Microtechnology, Inc., (CMT) pc5-1 recorder was used for this survey.

The survey was performed by Tony Beke, facilities engineer on the Lincoln; Pete Brady, maintenance worker; Warren Sutton, civil engineer on the Cibola; and Jeff Moll, roads project leader at San Dimas Technology and Development Center. The survey was supervised by Mike Harrison, a cave technician on the District, and was sponsored by the recreation program at the San Dimas Technology and Development Center.

The survey of Cottonwood Cave began with foresight/backsight (FS/BS) traverse links in an effort to determine compass performance underground. This is a recommended practice for detection of local attraction problems, such as those caused by mantic materials in the bedrock. The azimuth readings were within the manufacturer's specified tolerance, allowing use of the standard traverse and cross-section routine. If the

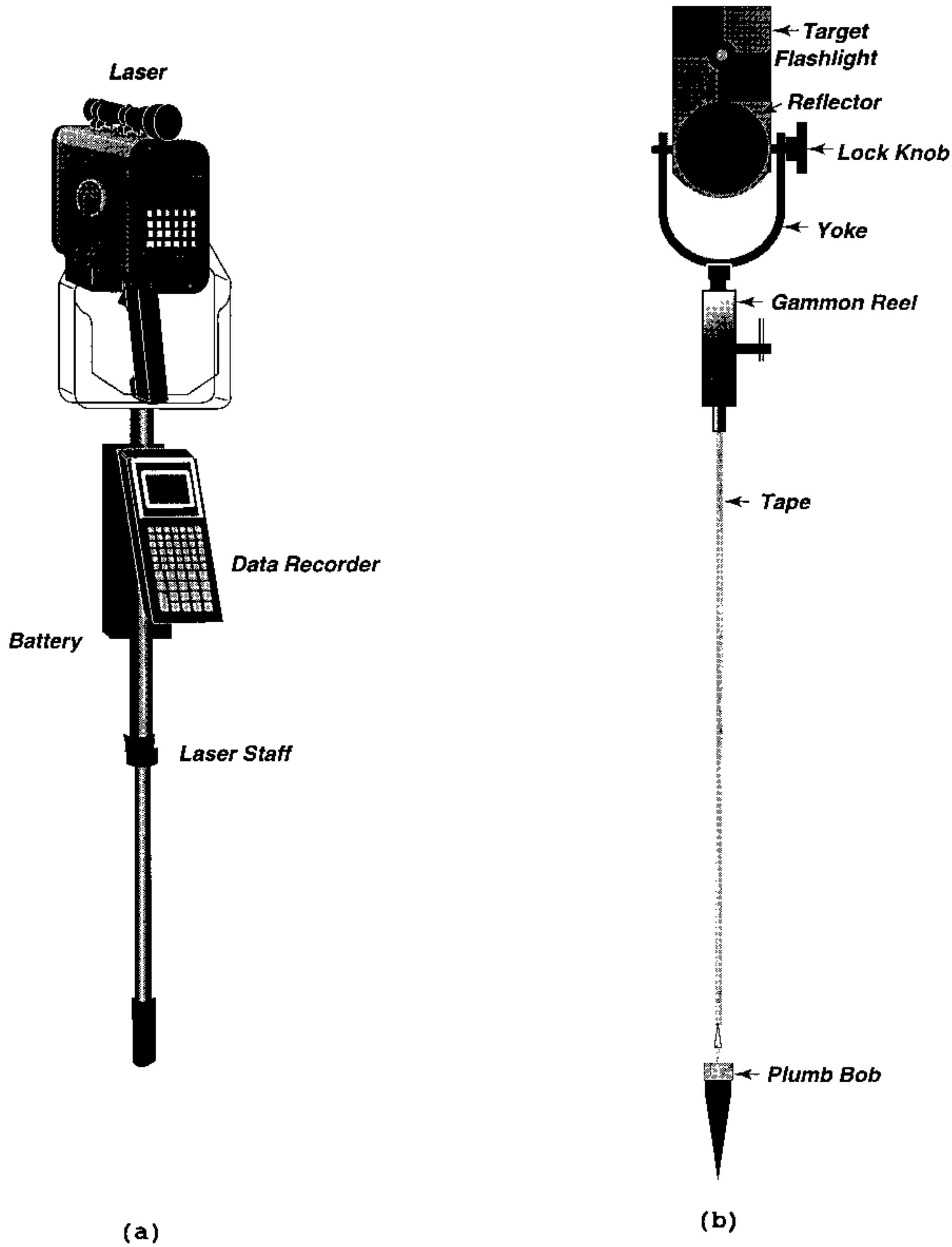


Figure 1.—Laser survey system hardware. (a) Instrument, battery, and data recorder mounted on telescoping rod. (b) Yoke-mounted reflector assembly with gammon reel, tape, and plumb-bob.

compass functions adequately in the cave, a "repeating radial" routine may also be used for side shots made from points of intersection (PI's) and turning points (Moll, 1994). This increases survey efficiency and effectiveness, as side shots may be quickly made to any point in any direction. Compass malfunction due to magnetic anomalies would dictate execution of a "triangulating traverse" routine, with cross-sectioning as described in the appendix.

The survey consists of a 343-meter (1120-foot) traverse having 19 PI's, and shows a 70-meter (230 foot) drop in elevation. Each traverse "link" is composed of foresight from one PI to the next, and a backsight from that PI back to the previous PI.

This traversing routine allows averaging of FS/BS data, increasing accuracy and highlighting discrepancies, as BS data should be the same—within instrument sensor tolerances, operator error, and accounting for directional differences—as the FS data. Consider the data for traverse link 3–4:

	FS - PI 3	BS - PI 4
azimuth (degrees)	333.7	153.5
vertical inclination (degrees)	-5.7	5.8
slope distance (meters, feet)	17.34, 56.9	17.47, 57.3

The occurrence of discrepancies between distance and inclination readings on a link—barring instrument operator error, such as not properly plumbing the instrument or reflector rod, and sensor tolerances—are unlikely. Azimuth readings, however, are subject to localized attraction and should be carefully monitored as to differences between FS and BS on a link. Note the opposing sign on the vertical inclination, as the FS is looking downhill (and thus has a negative sign) and the BS is looking uphill. The difference in azimuth is approximately 180 degrees.

The plan, or plot of horizontal change on the traverse, shows change in direction versus horizontal distance between PI's. The profile, or plot of vertical change on the traverse, shows slope versus horizontal distance between PI's. Each PI is cross-sectioned along the bisect angle in the traverse. The cross-section is simply a slice that illustrates cave dimensions on the angle bisector, and is made up of "side shots" from the PI (or a turning point) to points of interest on the cave floor, walls, ceiling, or formations (see figure 2 for plots of the survey).

The bisect direction can be determined by LASERSOFT or approximated by using the road surveyor's method know as "throwing a wammie." To throw a wammie, you stand over the PI facing your best guess as to direction, extend one arm towards the back PI and the other towards the front. Close your eyes and bring palms together in a clap; your hands will be pointing in the approximate direction. With practice, the direction may be determined within ± 3 degrees of actual.

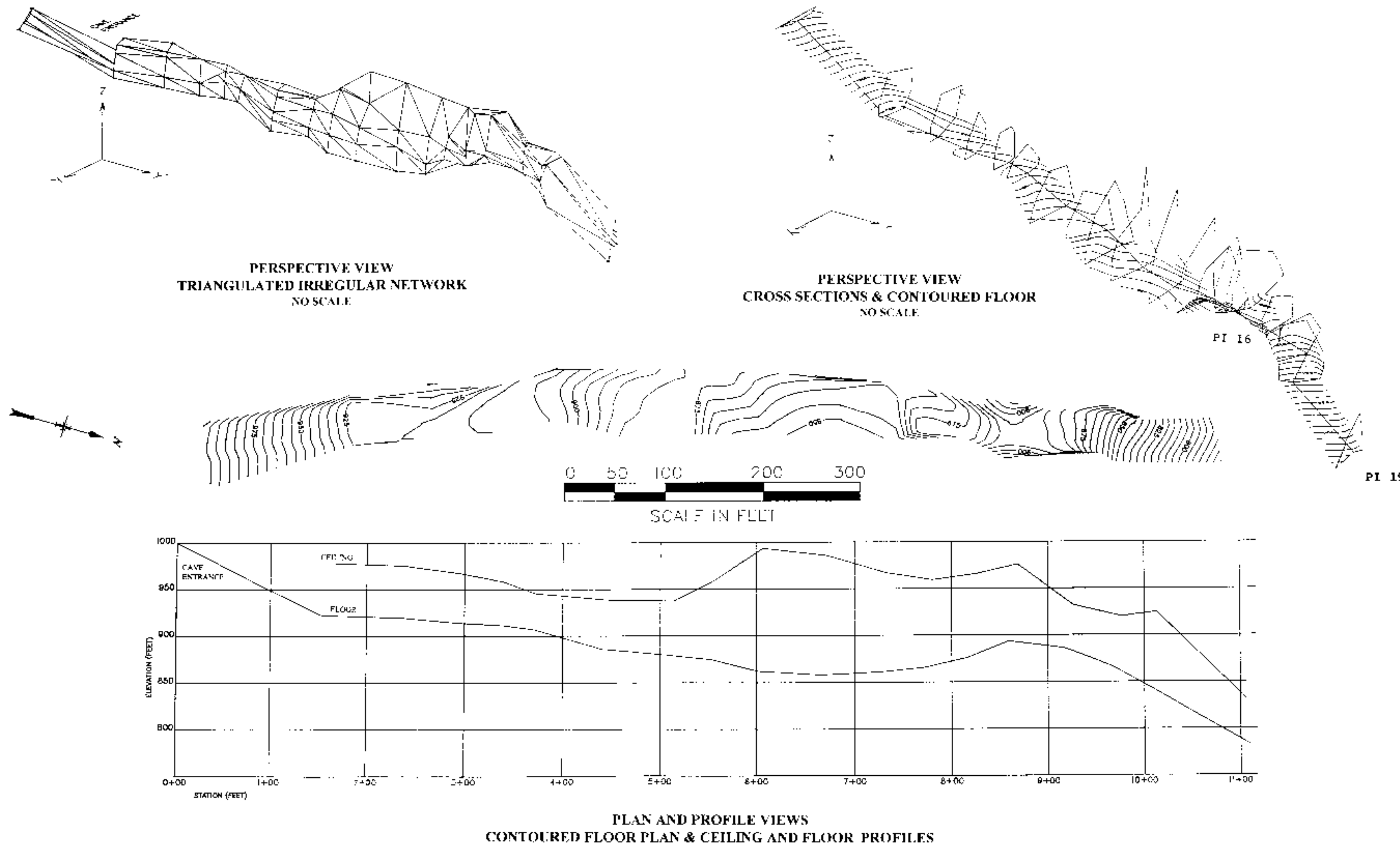


Figure 2.—Cave Survey Views

Some difficulties to be expected during cave surveying are found in the appendix.

Conclusions

The laser survey system is available to aid in cave management; the laser instrument functions properly in limestone formations devoid of bedrock containing magnetic anomalies, while a "triangulating traverse" has been developed for sites that do have local attraction problems. The system provides accurate and effective measurements of "hard to reach" cave walls and floors, with potentially less disturbance to fragile underground resources. Based on information from laser system use on road projects, cost savings of 59 to 75 percent are possible.

Recommendations for Performing Cave Surveys

A. Ensure the cave management plan includes establishment of survey parameters that include what the survey is expected to accomplish. Survey standards, precision, location of points to be surveyed, and survey methodology will be dictated by this information. Some examples are as follows:

1. Measure, map, and plot physical features, such as size, length, slopes, depths, heights, sections, formations, and resources.

2. Provide the basis for design of improvement, such as gates, trails, handrails, and other facilities.

3. Provide the basis for monitoring and trending of cave resources. An example of this in Cottonwood Cave involves the slope between PI 16 and PI 19, as shown in figure 2. Cave specialists estimate each visitor moves 0.03 m^3 (1ft^3) of soil down the slope. Contour maps generated from subsequent surveys may be overlaid and earthwork quantities calculated to monitor this situation and plan its alleviation.

B. Prior to conducting the survey, the points to be surveyed must be located and the formations and features to be documented or catalogued reviewed by the crew.

C. The survey crew must be fully trained on laser system use, capabilities, and limitations.

D. The survey crew must be familiar with the cave and the information in A and B above.

E. Perform a test of the compass, such as FS/BS traverse links, to determine available or required survey methodology. Remember, the compass is extremely sensitive not only to naturally occurring magnetic attraction, but to ferric metal and equipment such as flashlights, watches, and the data recorder.

F. When performing simple mapping surveys using the standard traverse and cross-section routine, consider making cross-sections perpendicular to the length of the cave rather than on the bisect angle in the traverse line. This will typically minimize cross-sectional measurements and area, and give a better representation of cave dimensions.

G. A safety plan must be prepared specifically for survey crew activities. The crew must receive training on special safety gear for caves. Meetings to increase awareness of safe practices in caves are highly recommended.

Additional information on the LASERSOFT survey platform and the laser survey instrument may be found in the January-April 1994 issue of *Engineering Field Notes* (Moll, 1994).

References

Moll, Jeffry E., "Low Volume Roads Survey Laser," Project Report, Technology and Development Program, San Dimas Technology and Development Center, USDA Forest Service, May 1992.

Griswold, Gordon W., "Field Application and Review of Hand-Held Laser Instrument Grand Mesa, Uncompahgre, and Gunnison National Forests Gunnison Engineering Zone," *Engineering Field Notes*, May-August 1994.

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Appendix

Difficulties Of Cave Surveying

Several difficulties were encountered during the Cottonwood Cave survey, some of which are specific to surveying in low-light or no-light environments. Use of "reflector assemblies," with flashlight targets, reflectors, and bullseye plumb bubbles is helpful, as the flashlight is necessary for sighting the laser instrument.

1. In the course of rod plumbing, the rodperson's headlamp sometimes was confused for the target light (see figure 1) by the laser operator. This results in null laser reading, as the instrument must be aimed at the reflector for measurements to be made (with the filter installed on the instrument). The rodperson can alleviate the problem by shielding the headlamp and any lights other than the target from the view of the laser operator.

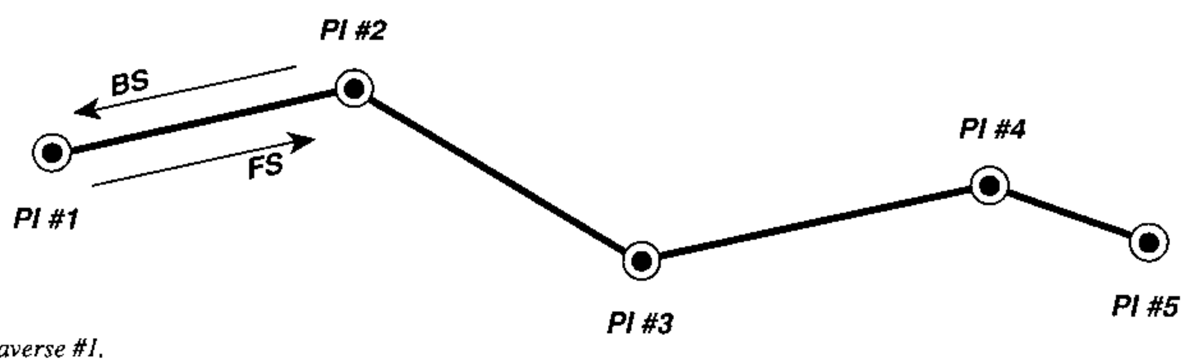
2. The laser instrument successfully makes azimuth measurements only when instrument inclination is in the vertical window of ± 15 degrees. Several traverse links were steeper than 15 degrees; the instrument makes slope distance and inclination measurements, but not the azimuth. The azimuth

measurement is made by scrolling to the azimuth screen on the instrument, holding the instrument within the 15-degree window, sighting the target with the EDM sight, retriggering the instrument, and scrolling back to the horizontal vector screen. The problem arises when attempting to use the EDM sight in the dark. The operator on this survey shone a penlight into the sight, illuminating it, but this introduced sufficient local attraction to cause compass errors of up to 12 degrees. A scope light may be the solution to this problem. The sighting triangle is visible in the low-light environments; with practice, properly using the EDM sight in the dark may become easier.

3. Vertical inclination readings are made only in the vertical window of ± 60 degrees. When cross-sectioning walls and the ceiling of the cave—which involves removing the filter from the instrument and not using the reflector assembly—inclinations are often outside this window. One solution is attaching a vertical inclination scale, in degrees, to the side of the instrument. Vertical inclination readings may be manually estimated from the scale and keyed into the VI slot of the LASERSOFT data entry screen. A sheet of plastic, with scale gradations in indelible ink, would make a suitable scale. For cross-sections made along the angle bisect, the direction may be estimated by throwing a wammie and illuminating with a flashlight. This azimuth is manually keyed into the appropriate slot of each data entry screen, as are the inclination readings.

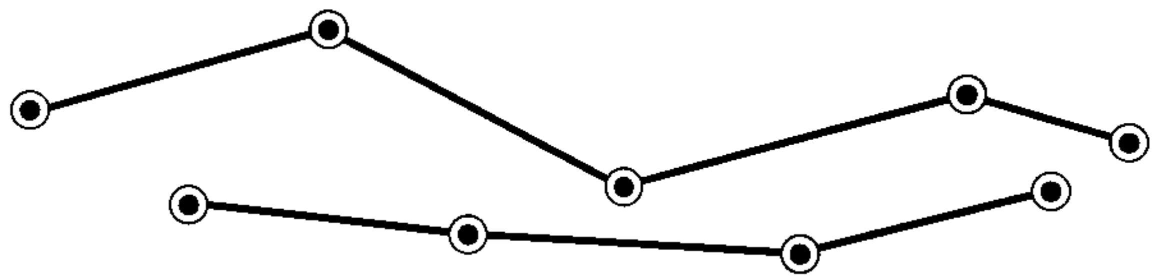
The Triangulating Traverse Survey Routine

Should local attraction adversely affect laser instrument azimuth readings, a triangulating traverse routine may be used to complete the survey without relying on horizontal angle measurements, except possibly a reference azimuth. Basically, PI's for more than one traverse—the number depending on the width of the project corridor and site conditions—are located, with sufficient side shots made to form triangles linking all PI's. If traverse #1 has "n" PI's, traverse #2 has n-1, then traverse #3 again has "n" PI's, and so forth. Each traverse is surveyed in the standard fashion, with FS and/or BS between PI's, depending on the required accuracy. An example of how traverse #1 might appear in plan view is as follows:



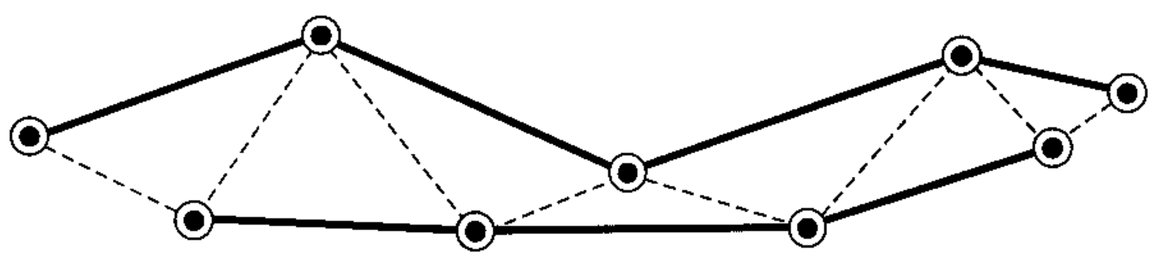
Traverse #1.

Traverse #2 PI's are laid out as follows, with enough distance between traverses to give depth to the resulting triangles (approximately one-half the distance between PI's) :



Traverse #1 and traverse #2.

Subsequent traverses are laid out in similar fashion. Side shots between PI's are surveyed-in as follows:



Side shots forming triangles between traverse #1 and traverse #2.

The law of cosines is used to reduce horizontal distances on triangle sides to a solution of all interior angles, which, with a reference azimuth made—perhaps outside the cave—are used to calculate azimuths for all traverse links and, subsequently, 3-D coordinates for all PI's. Bisect directions are estimated for cross-section side shots by throwing a wammie.

Data Conversion and Import into Autocad

The ASCII conversion routine in the LASERSOFT software converts raw traverse and side shot data into an ASCII file containing 3-D coordinates for each point surveyed. The points are then imported into Tontocad as follows:

1. The ASCII file built from LASERSOFT is renamed from having an .ACD extension to a .DAT extension.

2. A horizontal scale factor is selected from the File/Utilities menu in Tontocad so that text brought in will have adequate size. For this project, 50 was used. Under the Programs menu and the Survey/COGO submenu, the Import Point/Traverse File option is selected.

3. The appropriate file to be imported is selected from the dialog box that appears. Plot points only option is selected. The format of the ASCII file that LASERSOFT creates is comma-delineated as follows: point number, northing, easting, elevation, comments.

This option may be selected from the dialog box. The options "plot point numbers as text," "write comments as text," and "plot Autocad points" are also selected.

The 3-D points of the cave can be viewed from any direction by changing view point (vpoint command).

Sorting Points

Now comes the task of determining from the scattering of points which points are associated with the floor, walls, and ceiling of the cave. Since the survey data was gathered in an organized way, it was not difficult to construct the cross-sections at each of the traverse points. All of the points were assigned a number by the conversion routine. The point numbers are organized such that the traverse point number is first, then the side shot numbers are consecutive in the order in which they were made; this rule applies to each cross-section. The side shots were made along the bisect angle, starting at the left side from the floor working toward the ceiling, with the same procedures on the right side. The corresponding point numbers were in the same sequence. Using the following procedure, the traverse and cross-section are drawn in Autocad:

1. The traverse is drawn by connecting all of the traverse points with a 3-D polyline. The traverse points are easily identified, as they have the smallest point number along a cross-section.

2. The point numbers along the cross section of each traverse point are connected by a 3-D polyline, starting at the traverse point, and follow the sequence of point numbers for left and right sides of the cross-section.

Contouring the Floor

The surface modeling module from Eagle Point Software was used to assist in contouring the floor of this particular cave. Eagle Point uses the triangulated irregular network (TIN) method for modeling surfaces. The TIN is an array of lines connecting 3-D points in the form of triangles. Once the TIN is formed from a set of data points, a grid or contours may be constructed.

Before the floor is contoured, its separation from the ceiling is required. The overhanging data points along the walls and the ceiling of the cave would obviously confuse the software. We attempted to build a TIN from all of the data points in this case, but it resulted in a fatal error in the software. It is likely that contouring caves is an application not foreseen or provided for by software designers. Separating the floor from the ceiling is accomplished by selecting the floor points and placing them in a separate Autocad layer. By viewing the cave from a 3-D view point, the floor can easily be visualized and selected for a layer change. A TIN is then constructed only on the points in the floor layer. These steps are summarized here:

1. Initiate Eagle Point and open the cave drawing. Freeze all layers except the floor layer.

2. A boundary is drawn around the perimeter of the floor points with a closed 3-D polyline. The Surface Modeling menu under EDSC is selected. Under TIN, select Boundary. A dialog box pops up and asks for the surface model library. At this point, a surface model for the floor is created. The boundary is then selected.

3. Under the TIN menu, Make TIN is selected. From the dialog box that appears, Make TIN and Make Contours are selected. When prompted by the software to select points, "all" is entered. When prompted concerning a boundary, "yes" and "p" for predefined are entered.

4. The program proceeds to generate contours.

The initial completion of the above procedure, including transferring survey data into Autocad, constructing cross-sections, and contouring the cave floor, required 3 hours of CAD operator time. It is estimated that the experience gained would allow the operator to cut this time in half for subsequent executions of the effort. The time required will obviously depend on the individual CAD operator's experience and abilities.

Development of Cushion Aggregate on Native Surfaced Roads by Use of the Roto Trimmer

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Region 1, Idaho Panhandle National Forests

Photo 1.—Roto trimmer in operation.

Introduction

In suitable rock types, the Roto Trimmer is an effective tool to break down oversize material and bedrock sections in the road surface. The Roto Trimmer reduces this material to 3- to 4-inch minus aggregate type material. The resulting surface has a significant increase in rideability (smoothness) and now can be graded and maintained, where previously the grader bounced over the cobbles and boulders and was not able to generate enough material to cover up the rough areas. The Roto Trimmer aggregate is less expensive than using either pit run or crushed aggregate to provide cushion for the road.

There are many roads that would benefit from processing by the Roto Trimmer. It is an effective way to stretch surfacing dollars to cover more miles.

It is extremely important that proposed roads be evaluated in the field to determine if the materials are suitable for processing by the Roto Trimmer. The evaluation criteria for this project are explained in the text of this report.

General

During 1992, a relatively new type of equipment was evaluated on the Idaho Panhandle National Forests (NF's). The equipment was used to manufacture a 6-inch thick layer of aggregate type surfacing on native surfaced roads, using the existing native material that was already in place. The equipment consisted of a rotary milling machine (Roto Trimmer) and associated grader, compactor, and rock-fracturing drill. The Roto Trimmer was developed in Alaska to break up frozen tundra, but had seen little use in the States as a road surface milling machine. The Roto Trimmer is like a giant rear-mounted roto tiller that is equipped with 184 carbide teeth that are spirally mounted around a central shaft. It is pulled through the road surface, digging, and breaking the rock it encounters.

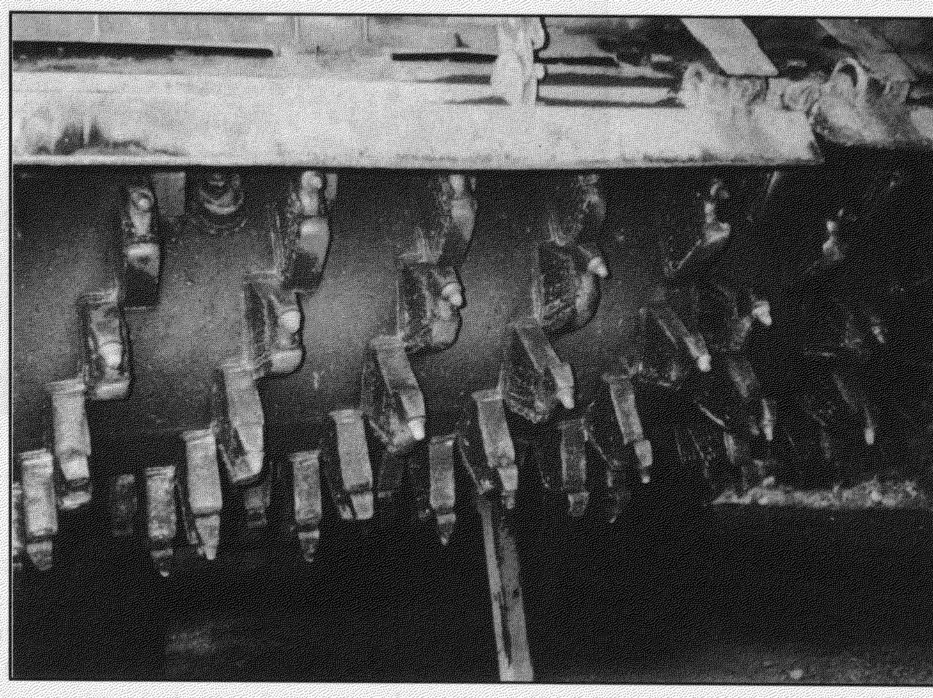


Photo 2.— Roto trimmer teeth.

Roto Trimmer equipment processed 24.7 miles of native surfaced roads. On 16.9 miles, the processed road surface functions as the running surface. On 7.8 miles, the processed road surface serves as the aggregate base material for new crushed rock. Approximately 2 miles of old

Photo 3.—Roto trimmer in action.

bituminous surfacing were also processed and converted to aggregate surfacing.

The project roads are used for both timer haul and recreation traffic. They had surfaces composed of sand and silt with numerous residual cobble- and boulder-size rock fragments and frequent bedrock sections. The road surface materials were derived from the weathering of Precambrian Belt quartzites, argillites, and siltites. The bedrock is usually thin bedded (1 to 6 inches between bedding planes). There are frequent fractures and incipient fractures (planes of preferred breakage) these are usually at steep angles to the bedding planes. These fractures are present in the inplace bedrock and in the rock fragments (cobbles and boulders). The cobbles and boulders are usually tabular in shape.

Determining Subgrade Suitability for Roto Trimmer Processing

Project roads in the contract and others were evaluated in the field by geotechnical personnel to determine their suitability for processing by the Roto Trimmer.

Field evaluation identified the following items as important in determining whether material is suitable for processing by the Roto Trimmer. Most items were done by visual observations in the field.

- geology of the subgrade materials (i.e., bedrock, residual material derived from the bedrock, alluvial gravels, glacial tills, etc.);
- the type of bedrock;

Photo 4.— Typical native road surface.

- thickness of the bedding planes in outcrop;
- fracture spacing in outcrop;
- attitude of the bedding planes in outcrop;
- hardness of the rock (scratchability);
- size, shape, and the amount of the cobbles and boulders in the subgrade; and
- the relative amount of effort required to break a handheld rock fragment with a rock hammer.

It was determined that the most suitable areas for Roto Trimmer processing were those with thin bedded sedimentary bedrock. These bedding planes provide an extra fracture plane now found in massive rock types. This thin bedded bedrock produces tabular rock fragments with the shortest dimension being between the bedding planes. The partially open fractures and incipient fractures are usually at steep angles to bedding planes, and thus provide areas of weakness (planes of preferred breakage) across the shortest dimension of the rock. These tabular rock fragments broke the easiest with the rock hammer, due to the planes of preferred breakage across the bedding planes. Squarer or thicker bedded rock fragments were much more difficult to break with a rock hammer. The tabular nature of the rock fragments is also important, since they tend to align themselves with their long dimension parallel to the road surface. This allows the Roto Trimmer to impact them nearly square to their thinnest dimension (which also contains the planes of preferred breakage across it).

Rounded alluvial and glacial cobbles and boulders were identified as having low potential for processing by the Roto Trimmer, since the planes of preferred breakage had already been broken during water transportation. What remained were hard rounded objects that tended to roll ahead of the equipment and were very difficult to break. These materials were difficult to break with a rock hammer.

Rounded residual granitic boulders were also identified as having low potential for processing by the Roto Trimmer, due to their rounded nature and wide spacing of fractures. Inplace granitic bedrock was also identified as having low potential for processing due to the massive character of the rock and the wide fracture spacing. These materials were difficult to break with a rock hammer.

The Los Angeles Abrasion Test results had a wide range (19 percent to 42 percent) and are more of an indicator of the wear characteristics of the gravel-size pieces than they are a good predictor of the breakability of the cobble and boulder size rock fragments.

Equipment performance during the contract was verified by the field evaluations.

The best method for determining material suitability, for processing by the Roto Trimmer, is field evaluation of the geology.

Results on Native Surfaced Roads

Roughness (rideability)

One of the methods chosen to evaluate the effectiveness of the Roto Trimmer processing was to measure the relative improvement in the ride of the project roads. Before processing, the roads were extremely rough due to the numerous cobbles, boulders, and bedrock sections. The roads could not be graded and smoothed out due to the rock.

A Cox Roughness Meter was used to obtain before and after roughness counts on four of the project roads. Three nonproject roads were used to obtain average roughness counts to represent a smooth aggregate surfaced road, a moderately rough aggregate surfaced road, and a rough aggregate surfaced road. A project road represented the average count for an extremely rough native surfaced road.

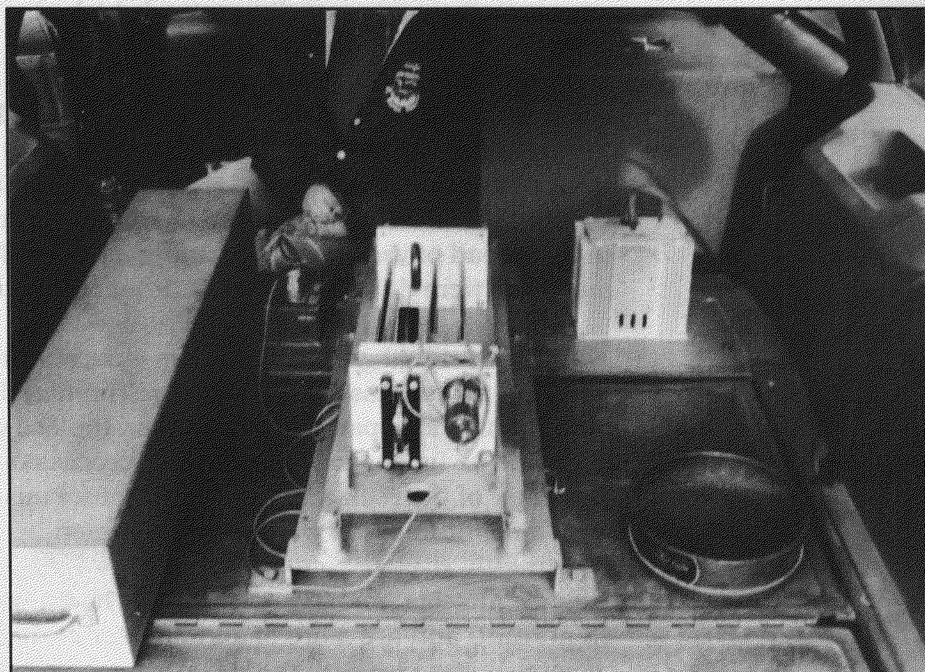


Photo 5.—Deflection measuring mechanism.

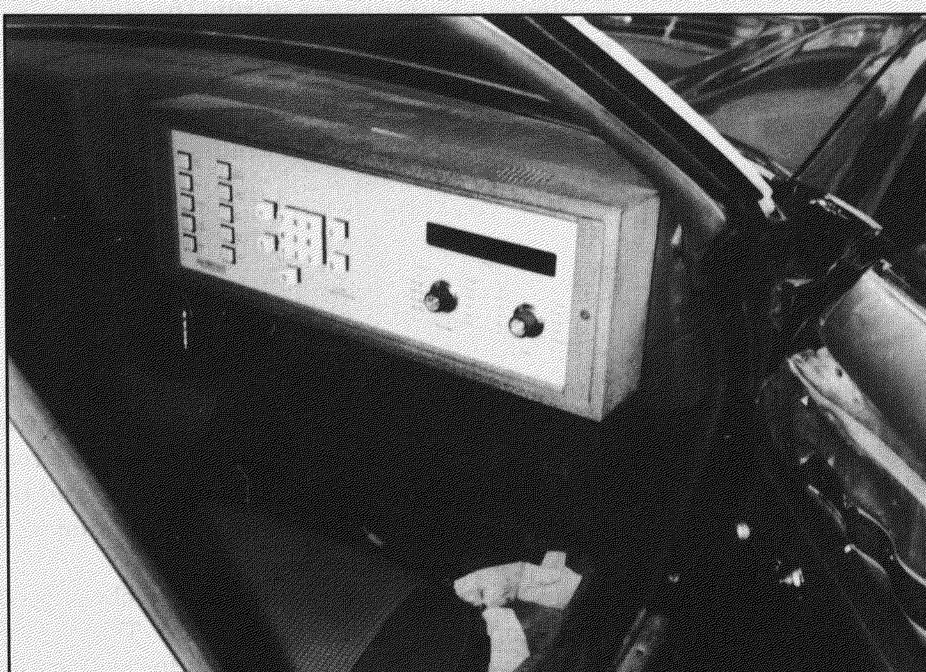


Photo 6.—Roughness recorder.

Three of the roads had major improvements in their roughness counts (rideability). Two of the roads had their roughness counts reduced by 48 percent and one had its count reduced by 67 percent. The roughness counts reflect the riding comfort of the road. Before processing by the Roto Trimmer, the roads had extremely harsh rides with maximum speed

Table 1.—Roughness data summary

Road	Ave. Before Counts/Mile	Equivalent Surface	Ave. After Counts/Mile	Equivalent Surface	% Counts Reduced
Loop Cr.	20,946	Rough agg. surface	10,865	Mod. rough agg. surface	48%
E.F. Gold Cr.	15,055	Rough agg. surface	7,843	Mod. rough agg. surface	48%
Bird Cr.	8,134	Mod. rough agg. surface	7,638	Mod. rough agg. surface	6%
Can Cr.	23,112	Extremely rough native surface	7,544	Rough agg. surface	67%

of 5 to 10 miles per hour. The speed was primarily controlled by the road's roughness. After processing by the Roto Trimmer, the roads had much smoother surfaces with obtainable speeds of 10 to 20 miles per hour. Now the speed is primarily controlled by the alignment, not the running surface.

The Bird cr. road had little improvement in the roughness counts, due to the presence of a small amount of residual crushed aggregate cushion. The road was graded few days prior to obtaining the before roughness counts. This brought the small amount of residual cushion back over the rough areas and smoothed out the ride (counts). This was the only road that had a residual aggregate cushion.

Gradation

To determine the relative breakdown of material sizes, 22 test sections were established on 24.7 miles of road. A problematic sampling and testing plan was developed to establish the approximate before and after processing gradations at the test sections. Each test section was 8 feet by 2 feet wide, and 6 inches deep. The long dimension was parallel to the road direction and usually in the cut side wheel track.

Before Processing

Before processing by the Roto Trimmer, the material in 12 of the test sections contained 20 percent to 70 percent plus 3-inch cobble- and boulder-size rock fragments. The maximum size recorded was 18 inches. However, the maximum size was normally about 12 inches. The rock fragments were usually tabular in shape. Silt made up one-half or more of the minus #4 material. Thus, the cobbles and boulders were in a bed of fine sand and silt.

Photo 7.—E.F. Gold Cr. TS #2 before processing.

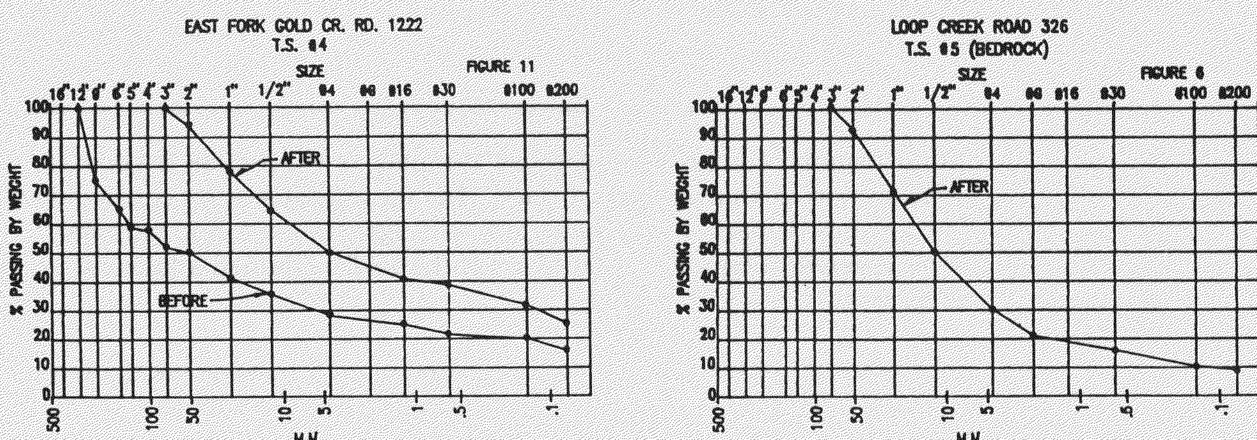
Ten of the test sections were in subgrade areas of inplace bedrock. Sampling was not possible previously in these sections, and they were identified as being inplace bedrock.

After Processing

After processing by the Roto Trimmer equipment, the material in all of the test sections had been reduced to essentially 3-inch minus material. Some of the oversize material that did not break down ended up along the side of the road. This was not a major portion of the original plus 3-inch material. The majority of the gravel size pieces of rock displayed one or more fresh fractured faces.

True depth measurements were difficult, since the roadways were shaped after processing. However, the finished material depths in the test sections were approximately 4 inches in the bedrock sections and 6 to 8 inches in the cobble and boulder sections.

Photo 8.—Can Cr. Road TS #6 after processing.



Typical Gradation Curves

Results on Bituminous Surfaced Roads

Two bituminous surfaced roads were processed by the Roto Trimmer equipment.

One thousand feet of Road #218 were processed to determine if a useable aggregate surface could be manufactured. The structural section consisted of 1/4-inch to 3/4-inch bituminous macadam over a crushed aggregate base. The material was easily broken up and mixed, which produced an acceptable aggregate surfacing.

Table 2.—Test section gradation summary.

Road Name	Test Section Number	Material Type	Maximum Size Before Processing	Maximum Size After Processing
Loop Cr.	1	Residual belt soil	9 inches	3 inches
Loop Cr.	2	Residual belt soil	16 inches	3 inches
Loop Cr.	3	Bedrock	–	3 inches
Loop Cr.	4	Residual belt soil	13 inches	4 inches
Loop Cr.	5	Bedrock	–	3 inches
E.F. Gold Cr.	1	Residual belt soil	18 inches	4 inches
E.F. Gold Cr.	2	Residual belt soil	13 inches	4 inches
E.F. Gold Cr.	3	Residual belt soil	12 inches	4 inches
E.F. Gold Cr.	4	Residual belt soil	12 inches	3 inches
E.F. Gold Cr.	5	Bedrock	–	2 inches
E.F. Gold Cr.	6	Bedrock	–	4 inches
Bird Cr.	2	Bedrock	–	3 inches
Bird Cr.	3	Bedrock	–	4 inches
Bird Cr.	4	Residual belt soil	16 inches	4 inches
Can Cr.	1	Residual belt soil	12 inches	3 inches
Can Cr.	2	Residual belt soil	10 inches	3 inches
Can Cr.	3	Residual belt soil	12 inches	3 inches
Can Cr.	4	Residual belt soil	14 inches	4 inches
Can Cr.	5	Bedrock	–	4 inches
Can Cr.	6	Bedrock	–	4 inches
Lakeview	1	Bedrock	–	4 inches
Lakeview	2	Bedrock	–	4 inches

Roto Trimmer equipment processed 1.4 miles of Road #258 to convert this section to an aggregate surface. The structural section consisted of a double BST, part of which was over an aggregate base and part was over a native subgrade. Some or all of the BST contained a latex additive.

The presence of the latex additive required more time to break the material down to an aggregate size. The segment without the base was more difficult to process than the segment with the aggregate base. However, the end result was an acceptable aggregate surface.

Costs

Native Surfaced Roads

The cost per mile for the native surfaced roads reflects the amount, size, and breakage characteristics of the cobbles, boulders, and bedrock sections in the road surface.

The costs per mile varied from $5,259 to $7,301, averaging $6,007 per mile.

Cost per cubic yard to produce this 3–4-inch minus aggregate on the road varied from $2.87 to $3.98, averaging $3.38 per cubic yard.

The Roto Trimmer aggregate cost is compared to the cost of covered this roads with an equivalent thickness of pit run or crushed aggregate, as follows:

Pit run aggregate	=	$14,664 per mile
Roto trim aggregate	=	$ 6,007 per mile
Difference	=	$ 8,657 per mile

Crushed aggregate	=	$25,662 per mile
Roto trim aggregate	=	$ 6,007 per mile
Difference	=	$19,655 per mile

Bituminous Surfaced Roads

The costs for processing the bituminous surfaced roads varied from $2,510 to $5,045 per mile. There is not enough sample length to identify cost trends, but these costs probably reflect the range for similar materials.

Copies of the full report are available from:

USDA Forest Service
Idaho Panhandle National Forest
3815 Schreiber Way
Coeur d'Alene, Idaho 83814

ATTN: J. Northrup DG: J. Northrup: R01F04A

Portable Generator

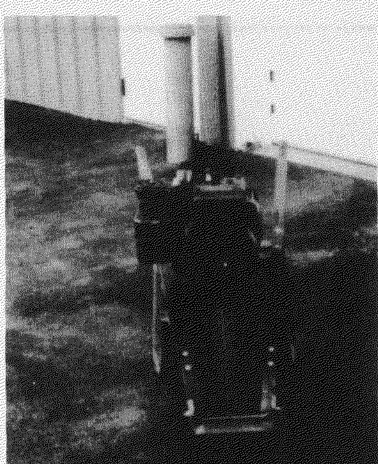
Editor's Note

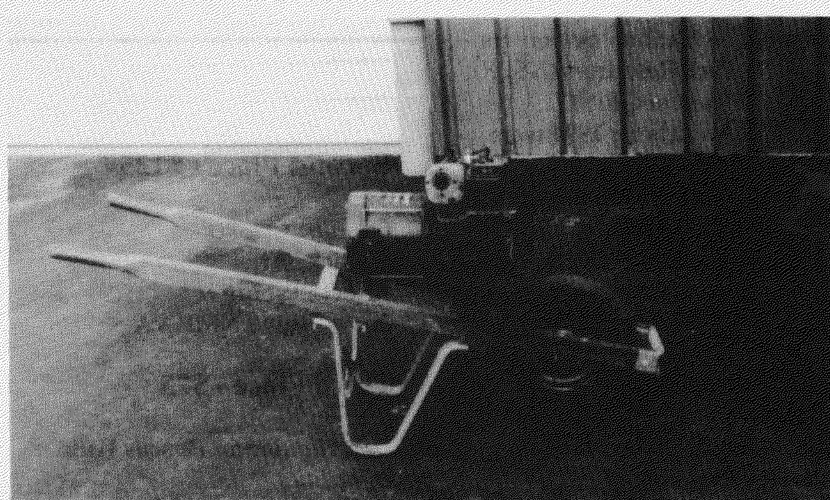
This article is being republished with the permission of the National Park Service. It was originally published in Volume 38, number 4 of *GRIST.*

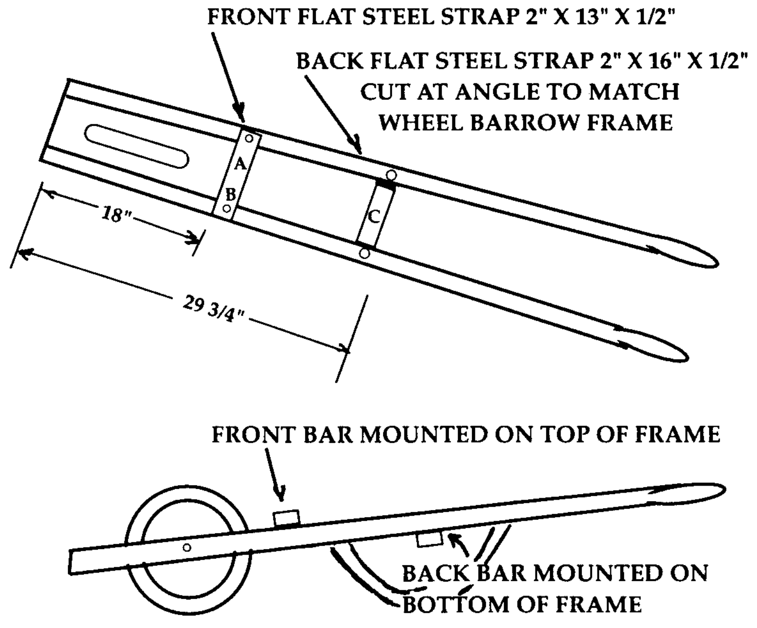
Scott D. Straub, Land Management Specialist with Pennsylvania Power and Light Company in Holtwood, Pennsylvania, shares this clever method of making a generator portable. He mounted a 1700-watt/ 120-volt gasoline-powered generator on a wheelbarrow frame, which allows the generator to be moved about easily where needed.

This idea developed when small power tools were needed to perform trail work in remote or backcountry areas. In most cases, hiking while physically carrying all the necessary items was the only way to get to particular areas needing work. Now, backpacks are used for carrying tools and the generator mounted on the wheel barrow is pushed easily along the trails.

Our special thanks to Len Fisher and Scott Straub from Pennsylvania Power & Light Company for sharing this idea with *GRIST* subscribers and readers.







The generator was removed from the original mount with the springs left attached to the generator. The springs were reattached to the 2" flat steel bars at points A, B & C.

No costs were involved except rainy day time.
If you buy a wheel barrow frame, it would cost approximately $30.

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Administrative Distribution

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